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By *Vu Quang Trinh, Hai Hong Trinh, Tam Huy Nguyen, and Giang Phung*

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WP Nº 24-019

3rd Quarter 2024

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Vu Quang Trinh [a,*], Hai Hong Trinh [b], Tam Huy Nguyen [c], Giang Phung [d],

[a] *Newcastle University Business School, Newcastle University, UK*
[b] *School of Economics and Finance, Massey University, New Zealand*
[c] *Nottingham Business School, Nottingham Trent University, UK*
[d] *ISC Paris Business School, France*

Abstract

This study offers cross-country (G7) evidence that eco-innovation (or green innovation, measured by its Refinitive score and a comprehensive index) is negatively and significantly associated with the corporate cost of debt. The results are intensified for firms with more prolonged eco-innovation engagement, as reflected by the eco-innovation years. The study also uncovers that a greater eco-innovation degree facilitates firms to reduce their carbon risk, affecting creditors' lending decisions by lowering debt costs. Furthermore, the lower borrowing cost underneath higher eco-innovation are more likely to be acquired in financially undistressed and constrained businesses. Our extended analysis further shows that climate governance quality reduces the beneficial impact of eco-innovation on the firm's cost of debt. The research offers timely policy implications on eco-innovation, which constitutes an essential consideration in creditors' lending decisions, aligning with the neo-institutional theory in response to increasing global environment-related pressures.

Keywords: *Eco-innovation; G7; Cost of debt; Carbon emissions; Financial distress; Financial constraints; Climate governance*

JEL classification: C23; G01; G30; L50; M41

<u>* Corresponding author</u>

Dr Vu Trinh
Associate Professor in Accounting & Finance
Newcastle University Business School, Newcastle University, United Kingdom
Address: Frederick Douglass Centre, Newcastle Helix, 2 Science Square, Newcastle upon Tyne, NE4 5TG, United Kingdom. Tel: +44 (0) 191 208 2593
Email: vu.trinh@newcastle.ac.uk

1. Introduction

We examine the effects of green (environmental) innovation policies (or eco-innovation)[1] on a firm's cost of debt for G7 countries[2]. Our study is motivated by the leading role of G7 in deploying numerous actions showing their strong commitment to the Paris Climate Agreement, Conference of Parties (COP21)[3] (see Wang *et al.*, 2020), requiring enterprises operating in those nations to contribute to the process via notable carbon emission mitigation measures and support. The considerable changes in recent legislative/regulatory developments and a special focus on environmental protection activities appear to force corporate executives to employ eco-innovation as one of their effective and long-term policies to lower production costs and increase a green competitive advantage (Zaman *et al.*, 2021; Leonidou *et al.*, 2013, Ambec & Lanoie, 2008), especially when consumers expect attempts from businesses to encourage sustainable practice (Kesidou & Demirel, 2012). Such environment-focused innovation entails a coordinated set of novel solutions to products/processes (Ballot et al., 2015; Hullova et al., 2016), market approach, and organisational structure (Battisti & Stoneman, 2010; García-Granero et al., 2020; Vasileiou et al., 2022), which reduces a firm's negative environmental impacts while improving its financial performance and competitiveness from a lifecycle perspective[4] (Hartmann *et al.*, 2022).

Neo-Schumpeterian theorists (Hanusch & Pyka, 2006) attribute productivity growth to firms' ability to adopt innovative and efficient technologies available in the market (technological catch-

[1] According to the EU project, i.e., '*Measuring Eco-Innovation*', eco-innovation is defined as "*the production, application or exploitation of a good, service, production process, organizational structure, or management or business method that is novel to the firm or user and which results, throughout its life cycle, in a reduction of environmental risk, pollution and the negative impacts of resource use (including energy use) compared to relevant alternatives*" (Horbach et al., 2012, p. 113).
[2] The UK, US, Japan, Canada, France, Italy, and Germany
[3] Upon recognising the need for an effective and progressive response to the urgent threat of climate change, the Paris Agreement (UNFCCC, 2015), signed at the COP21, aims to strengthen global efforts to limit the temperature increase to 1.5°C above the pre-industrial level. This can be accomplished through increasing adaptability and resilience to the adverse impacts of climate change and enabling finance flows toward low greenhouse gas (GHG) emissions and climate-resilient development.
[4] https://www.unep.org/eco-innovation

up) and to firms' ability to innovate (technological pass-through), which also applies to eco-innovation. Some studies have found favourable effects of eco-innovation on various corporate outcomes, such as sustainable corporate culture entailed by superior performance (Gupta & Kumar, 2013; Eiadat *et al.*, 2008; Vasileiou *et al.*, 2022, Orlitzky et al., 2003) or mitigated financial constraints (Zhang *et al.*, 2020). The policy diminishes harmfulness to the environment and has positive impacts on adopting organisations, a win-win situation (Horbach, 2008). It is crucial to fostering sustainable and innovative growth due to its wide-ranging benefits for the economy and the environment (European Commission, 2012).

However, the association between eco-innovation policy and the lenders' decisions on their loans in terms of cost of debt is largely underexplored. There also lacks evidence on underlying channels explaining such a relation. The firm's cost of debt is an essential research matter because bank credit is the primary source of enterprises' funding for most economies (Chen *et al.*, 2016) and central to economic growth (Daher, 2017). A lower cost of debt constitutes lower cost of capital, which facilitates business investments and results in a superior economic performance. Some studies have uncovered environment-related factors driving the cost of debt, e.g., corporate social responsibility (CSR) (Ge & Liu, 2015), carbon risk (Jung *et al.*, 2018; Zhou *et al.*, 2018), and sustainability practices (Gracia & Siregar, 2021). One notable finding is that debtholders favour socially responsible firms because CSR can lessen environmental violation and litigation risk (Nandy & Lodh, 2012) and establish their corporate reputation (Diamond, 1989), thereby lowering likelihood of default. Eliwa *et al.* (2021) find that lending institutions incorporate firms' environmental (E), social (S), and governance (G) information to evaluate the default risk and reputation risk of the borrowers in their lending decision. The "E" element (environmental-related policies) can lessen a firm's regulatory risks and enhance its reputation, increasing the debtholders' confidence in their loans and motivating them to accept a lower return. Environmental innovation is among those "E" policies; thereby, it can be one-factor driving debtholders' lending decisions.

The focus on eco-innovation, distinguished from general ESG, offers a valuable contribution to sustainability and policy research (e.g., Eiadat *et al.*, 2008; Konara *et al.*, 2021). It not only deals with a firm's environmental protection efforts but also measures its actual effectiveness in pollution mitigation through innovative products and services. Moreover, it demonstrates a longer-term environmental protection commitment and policy performance (Carrión-Flores & Innes, 2010; Haque & Ntim, 2018) in which environmental or litigation risks can be minimised (Zhang *et al.,* 2020; Zhang *et al.*, 2017). More importantly, an effective eco-innovation reflects high-quality ecological management and helps firms reduce risks and acquire new markets through innovative processes. Therefore, we assert that analysis of our specific environment-focused policy like eco-innovation significantly differs from that of the general "E" or ESG, especially when such investment covers both environment and innovation characteristics.

Intuition advances that a higher quality of eco-innovation might convey better deals from debtholders. The theoretical framework of neo-institution (Meyer & Rowan, 1977) illustrates the effect of eco-innovation on a firm's borrowing cost from two perspectives: legitimisation (moral and social view) and efficiency (economic view). In response to the increasing pressure of climate change risk, the legitimisation perspective implies that firms may symbolically comply with environmental regulations to gain or maintain organisational legitimacy (Suchman, 1995) and reputation (Diamond, 1989). From the efficiency viewpoint, a firm is engaged in environmental activities such as eco-innovation projects to ameliorate their eco-friendly products and services, lessen the cost, and control climate change risks (e.g., carbon risk), which will economically serve the interests of firm shareholders and creditors, as well as the wider environment and humanity

(Arena *et al.*, 2018; Haque & Ntim, 2020). Although lenders cannot observe the intrinsic corporate quality, a better firm could always formulate signalling mechanisms/devices (e.g., environmental policy transparency represented by eco-innovation scores) to reduce information asymmetry and minimise losses to debtholders (Derrien *et al.*, 2016), thus obtaining better borrowing deals. Consequently, we anticipate that eco-innovation tends to reduce the cost of debt.

Our study combines the mosaic of green policies with the existing understanding, completing the full picture of policy implications. Specifically, we further exploit green policy implications at a profound level by theorising and empirically analysing potential channels through which eco-innovation could affect a firm's cost of debt. The eco-innovation policy can decrease carbon intensity, financial distress and financial constraints, which may assure debtholders to lower the cost of debt to businesses. Prior evidence (Jung *et al.*, 2018; Zhou *et al.*, 2018; Zhang *et al.*, 2020) only shows such a connection between the channel(s) and the cost of debt but ignore clarifying how to gain the benefits (lower carbon risk, lower financial distress and constraints) from adopting eco-innovation.

We test our conjecture using a cross-country sample of 38,680 firm-year observations over 2000-2020 formed by listed non-financial firms from the benchmark equity indexes of the G7, including the UK, US, Japan, Canada, France, Italy, and Germany. As anticipated, our results show a negative association between eco-innovation and a firm's cost of debt. This confirms the primary hypothesis that high eco-innovation scores significantly reduce the cost of debt in G7's major listed firms. Besides, with increased awareness of climate change risks, people are getting more cautious of 'greenwashing' (Marquis *et al.*, 2016). We, therefore, examine the creditors' view of this phenomenon and find that prolonged eco-innovation engagement through a firm's eco-innovation age helps it secure a lower cost of debt, as it signifies both richer experience and higher commitment which increases trust from debt providers. Furthermore, our additional analyses suggest that the negative association between eco-innovation and the cost of debt is more pronounced in the cases of high carbon risk, financially undistressed and financially constrained firms. Possibly, creditors have confidence that the former, with eco-innovation, can overcome their difficulties in accessing loan markets and other financial challenges. This may not be the case with financial distress situations because the risk reflects a higher propensity to bankruptcy; thereby, risky and costly long-term investment activities (with uncertain outcomes) like eco-innovation should be under control. One could argue that the firms may need to survive first before taking costly environmental actions. Debtholders might also fear that their money could not be returned if the firms are bankrupted. As such, the beneficial impact of eco-innovation on the cost of debt is less pronounced in firms with higher levels of financial distress.

We also contribute to the eco-innovation-cost of debt nexus literature by investigating the moderating effect of climate (sustainable) governance system on such association. To do so, we employ a composite climate governance index with three components (i.e., *board-level environmental committee*, *sustainability reporting*, and *climate incentives*), which is an effective demonstration of a firm's strong commitment to addressing climate challenges as outlined in prior studies (e.g., Bui et al., 2020; Albitar et al., 2023). The transition from traditional to climate governance may affect corporate financing strategies as well as the evaluations of the lenders on the firm's loans. For example, the existence of an environmental committee is likely to push for the firm's environmental protection strategy that enhances corporate ability and motivations to combat climate change and pollution issues. Similarly, the board could utilise climate-based compensation packages for managers to incentivise their self-interest in implementing policies and actions to mitigate carbon emissions. This aligns with CSR arguments on the positive effect of social and environmental-based compensation on sound social and environmental performance (Campbell et al., 2007). Taken together, we examine whether a firm with a better climate governance mechanism is relevant to the debt-cost-reducing effect of eco-innovation. The moderating relation could be two-directional: positive if there is a *substitution* impact or negative if there is a *complementing* effect. Our findings support the *substitution* effect (or absence of *complementing* effect), in which climate governance quality reduces the negative impact of eco-innovation on the firm's cost of debt. That means a firm could only need to use one of the strategies, either climate governance or eco-innovation, to reduce the cost of debt.

To address potential endogeneity, measurement errors, and selection bias issues, we adopt various rigorous methods in our study. To mitigate the risk of time-invariant endogeneity, we employ fixed effect method, absorbing firm and year fixed effects, as demonstrated by Rjiba et al. (2020) and Albitar et al. (2023). This approach reduced multicollinearity and estimation bias while capturing omitted variable bias. We also took measures to enhance the accuracy of our measurements for eco-innovation, cost of debt, and other variables in the model. With our careful construction of the eco-innovation index, the use of eco-innovation score from Refinitiv, and alternative measures for cost of debt (*actual* and *estimated* average interest rate), we believe that these effects of possible residual measurement errors have been minimised, following the insights of Albitar et al. (2023). Finally, to address the potential for simultaneity bias in our study, where higher eco-innovation could lead to lower borrowing costs, or lower borrowing costs could facilitate more eco-innovation, we applied a set of endogeneity techniques. These include the difference-in-difference (DID) approach using a propensity score matched sample, Three-stage Least Squares (3SLS), and instrumental variables based on country-level CO_2 emission levels per capita. Additionally, we employ Two-step Heckman and Entropy Balancing techniques to account for potential sample selection bias, as recommended by Albitar et al. (2023). By employing these comprehensive methodologies, we have taken significant steps to address endogeneity, measurement errors, and selection bias concerns, enhancing the robustness and reliability of our study's findings.

Our study offers significant contributions and implications. To the best of our knowledge, we provide the first evidence on whether and how businesses can fetch a better deal from debtholders by adopting better eco-innovation policy, with credit for cross-country evidence (G7). By doing so, we enrich the literature with some considerable findings related to eco-innovation policy adopted by businesses from the debtholders' perspective rather than shareholders. In that way, we offer new insights into policy implications from this essential angle. We are also the first to examine conditions on the eco-innovation-cost of debt nexus including carbon intensity, financial distress, financial constraints, environmental regulations evolution, and eco-innovation experiences. Specifically, our work initiates the line of research on the relationship between eco-innovation and corporate cost of debt, contributing to the strands of research on determinants of the cost of debt and complementing eco-innovation and sustainability literature (e.g., Chatterjee et al., 2023; Imes and Anderson, 2021; Chen et al., 2020; Ramus, 2002; Horbach, 2008; Hartmann & Uhlenbruck, 2015; Konara *et al.*, 2021; Hartmann *et al.*, 2022; Vasileiou et al., 2022). Prior studies examine specific characteristics of corporate governance, such as director limited liability and indemnification provisions (Bradley & Chen, 2011), board independence (Bradley & Chen, 2015), and their influence on firms' credit rating and bond spread. Chakravarty and Rutherford (2017) and Trinh *et al.* (2020) find a negative relationship between directors' busyness and the cost of debt and equity capital for firms and banks, respectively. Others focus more on CSR (Ge & Liu, 2015; Eliwa *et al.*, 2021), environmental performance *(Eichholtz et al.*, 2019) and the cost of bonds. Some recent attempts examine carbon risk's impact on the cost of debt under carbon constraints and find a positive association (Jung *et al.*, 2018) or a U-shaped relationship (Zhou *et al.*, 2018). However, these studies consider general corporate governance and CSR/ESG effects without looking particularly at eco-innovation policy – a vital economic performance driver in climate change (Horváthová, 2012; Przychodzen & Przychodzen, 2015). Our paper has therefore sought insight into this increasingly important policy factor. It contributes to existing eco-innovation research streams by confirming its significant role in debtholder's lending decisions.

We also complement the economic impacts of eco-innovation (i.e., increasing profitability: Vasileiou et al., 2022) by proposing and empirically testing conditions that shed light on how eco-innovation influences the cost of debt, giving managers and lenders a comprehensive understanding of their debt financing relationships. Our results are essential and offer important policy recommendations to various stakeholders [e.g., policy regulators, businesses, managers, creditors, and investors] regarding the importance of eco-innovation activities.

The next section presents literature review, theories and hypotheses. *Section 3* describes our sample. *Section 4* reports the variables, empirical models, methodology, and descriptive statistics, univariate and trend analyses. *Section 5* presents the main empirical results, which are followed by additional testing and robustness checks (*Section 6*). Finally, *Section 7* concludes our paper.

2. Literature review, theoretical framework and hypothesis development

2.1. Theoretical background

Prior studies show a lack of evidence on the impact of eco-innovation policy on firms' cost of debt. Therefore, we develop our hypotheses based upon neo-institutional theory (NIT), literature related to CSR performance in the relationship with the cost of debt (Eliwa *et al.*, 2021; Haque & Ntim,

2020) and the economic contribution of eco-innovation policies (Kesidou and Demirel, 2012; Vasileiou et al., 2022). The NIT is a multi-dimensional theory that explains the behaviour of a business in response to institutional pressure from legitimacy and efficiency perspectives (Haque & Ntim, 2020). Specifically, firms tend to respond to institutional pressure (such as government regulations, global standards, or social expectations) based on two motives: legitimisation (moral and social view) and efficiency (economic standpoint) (Meyer & Rowan, 1977).

On the one hand, the legitimisation perspective suggests that firms may respond to the institutional pressure of climate change from government (coercive pressure) by symbolically following and complying with climate change regulations to gain or maintain organisational legitimacy (Suchman, 1995). In this case, a firm may try to demonstrate its commitment to environmental management activities (i.e., start or consider investing in eco-innovation projects, set up a CSR committee) to prove its good citizenship to a wide range of stakeholders (i.e., lenders, investor, community). For example, Kesidou & Demirel (2012) point out that demand factors and environmental regulations drive firms' investment in eco-innovation.

On the other hand, the efficiency view argues that a firm is engaged in environmental innovation policies (e.g., has an eco-innovation strategy, invests significantly in eco-innovation projects) in response to normative and mimetic pressures to improve their eco-friendly products or service or to reduce the cost and/or restrain risks related to climate change (i.e., carbon risk). This improvement in environmental performance will serve not only the interests of firm lenders and shareholders but also the larger environment and humanity (Haque & Ntim, 2020; Mazouz & Zhao, 2019; Arena *et al.*, 2018).

2.2. Eco-innovation and cost of debt

A business borrowing cost is given by a credit provider depending essentially on three items: (1) the risk-free return; (2) the various provisions and restrictions contained in the indenture (e.g., maturity date, coupon rate, call terms, seniority in the event of default, sinking fund, etc.); and (3) the firm's probability of default (Merton, 1974). Among the three aforementioned items, at the firm level, lenders traditionally make credit decisions based on *financial performance* and *the financial position* of the borrowing firms to estimate their default risk, as indicated in the first generation of reduced-form models (Altman, 1968; Beaver, 1966, 1968). However, due to climate change and commitment to slow down global warming, firms are under institutional pressures to lower their impact on the environment and ensure their sustainable development. Accordingly, *financial indicators* may no longer be sufficient for debt providers to make credit decisions (Hoepner *et al.*, 2016).

Recent credit provisions should be assessed under *non-financial indicators* (i.e., ESG) (Caragnano *et al.*, 2020) or environment risk management (Sharfman & Fernando, 2008). By investigating ESG and credit decisions in 15 EU countries, Eliwa *et al.* (2021) find that lending institutions reward both ESG performance and disclosure with lower debt costs. Under China's context, Li *et al.* (2022) investigate the implications of ESG practices of listed firms and find that higher ESG ratings mitigate firms' default risk. For practical purposes, in an attempt to advance global standards to help achieve sustainable development objectives and facilitate the assessment of borrowers' creditworthiness, i.e., the capacity and willingness of borrowers to meet financial commitments, the two largest global credit rating agencies, Moody's and S&P,[5] have integrated

[5] Credit ratings 2019 market shares in non-US countries were 71% and 68%, and in the US were 93% and 92%, respectively (Hung et al., 2022). Investors rely on multiple ratings, and most bonds are rated by both S&P and Moody's (Bongaerts et al., 2012).

ESG factors in their calculations, respectively in January 2019[6] and October 2021[7]. This decision is pivotal since rating methodology changes affect firms' capital structure and investment decisions (Kisgen, 2006, 2019).

It is worth noting that credit rating agencies consider the materiality of ESG factors in their ratings analysis (Moody's, 2021), i.e., factors that can materially influence the creditworthiness of a rated entity or issue with sufficient visibility and certainty (S&P, 2021). Specifically, for environmental factors, these agencies include climate (carbon) transition risk, physical risk, natural capital, waste and pollution, and water management. Notably, due to the impact of greenhouse gas emissions and climate change, firms face carbon risks (i.e., regulatory, physical, and business risks), impacting their business operation and investment decisions (Labatt & White, 2011). As a result, environmental risk management has significantly impacted financing provision. Prior studies suggest that debt providers (i.e., financial institutions) incorporate firms' ecological consciousness in their corporate lending decisions (Nandy & Lodh, 2012). Furthermore, Du *et al.* (2017) find a negative association between corporate environmental performance and the cost of debt, confirming that lenders consider ecological performance throughout their lending decisions.

Meanwhile, some studies document a compensation for higher environmental risk-bearing by debt providers via a robust positive association between a firm's or its customers' climate risk exposure and loan spreads (Javadi & Masum, 2021) or a higher cost of debt financing for firms with high greenhouse gas emissions (Kumar & Firoz, 2018). Firms facing stringent environmental regulations incur higher interest rates, have fewer participants in their loan syndicates, higher

[6] https://www.moodys.com/researchdocumentcontentpage.aspx?docid=PBC1288235 (page 7)
[7] https://www.spglobal.com/_assets/documents/ratings/research/100701190.pdf

bankruptcy risk, and lower credit ratings implying lenders' concerns about the increase in environmental liabilities resulting from regulations (Fard *et al.*, 2020). In addition, debt providers may also face "reputational downturns with financing environmentally irresponsible companies, thus impairing their future operations, their market competitive position and their long-term ability to retain existing customers and attract new ones" (Caragnano *et al.*, 2020, p. 2).

The question now is how firms can improve their environmental performance. Eco-innovation is considered as the most cost-effective way to ease environmental pressure without compromising business competitiveness (see more details in the studies of García-Granero et al., 2020; Hartmann & Uhlenbruck, 2015). Furthermore, many studies have focused on ecological innovation practices and reported a significant positive impact on firms' environmental performance (Li, 2014). For example, Lee & Min (2015) show a significant relationship between eco-innovation (proxied by green research and development investment), reduced carbon emissions, and improved financial performance at the firm level whilst Vasileiou et al. (2022) suggest that eco-process innovations help firms to perform better. Therefore, we expect that eco-innovation can help decrease environment-related risks and provide new opportunities (Zeidan *et al.*, 2015), leading to a better credit rating and, hence, a lower cost of debt (Driss *et al.*, 2019). From the neo-institutional theory perspective and the findings of prior studies, we propose our first hypothesis that:

> **Hypothesis 1 (H_1): Eco-innovation is negatively and significantly associated with corporate cost of debt.**

2.3. High Carbon Risk (HCR) vs Low Carbon Risk (LCR) firms

We further look into conditions that debt providers evaluate the effectiveness of the eco-innovation investment in making their lending decisions. The first is carbon intensity level (or, carbon risk), due to the significant influences of reduced carbon risk on a lower cost of debt. For example, Jung *et al.* (2018) examine whether lenders incorporate carbon risk into their lending decisions through the cost of financing. They find a positive association between the cost of debt and carbon risk for firms failing to respond to the carbon disclosure project survey. The finding indicates that creditors consider carbon risk part of the client's default and reputation risk assessment. As a result, more eco-friendly firms get a more favourable loan contract than other firms (see Nandy & Lodh, 2012).

Furthermore, although there are limited studies investigating the association between eco-innovation and carbon risk, recent work by Churchill *et al.* (2019) has examined the effects of research and development (R&D) on carbon dioxide emissions in G7 countries. They find that environmental pollution can be reduced by adopting innovative technologies for a cleaner environment. In addition, Lee and Min (2015) also explore the influences of eco-innovation (proxied by green R&D investment) on carbon emissions and find that eco-innovation investment is negatively related to carbon emissions. These findings indicate that adopting eco-innovation results in improved environmental performance and reduced organisational carbon risk.

After several environmental protection agreements have been internationally and legally signed by many countries, including G7 (e.g., 1997 Kyoto Protocol; 2015 Paris Agreement), firms (including both borrowers and lenders) have been facing increased environmental protection pressures from their government, society, and other players in the marketplace. In line with the perspective of NIT and existing empirical evidence, we theoretically assert that firms may have social and economic motives (caused by normative and mimetic pressures) to enhance their environmental performance by investing more in eco-innovation to reduce carbon risk, which, in turn, is related to a more favourable lending provision from creditors. Accordingly, we hypothesise that eco-innovation investment is more likely to reduce a firm's cost of debt in the case of high carbon risk firms, comparing to their low carbon risk peers. This leads to our second hypothesis in an alternative form:

> **Hypothesis 2 (H_2): The negative association between eco-innovation and the cost of debt is more pronounced in the case of high carbon risk firms.**

2.4. Financially Distressed (FD) vs Financially Undistressed (UD) firms

The second proposed condition for the association between eco-innovation and corporate cost of debt is financial distress risk. According to Opler & Titman (1994, p. 1015), financial distress is seen as "costly because it creates a tendency for firms to do things that are harmful to debtholders and nonfinancial stakeholders". Therefore, creditors usually have to consider the financial distress risk of a firm before making their lending decisions. Habib *et al.* (2020) summarise several factors influencing firm financial distress, including firm-level factors, such as R&D investments and corporate financing policies (Kane *et al.*, 2005); corporate governance (Hsu and Wu, 2014); and macro factors, such as economic conditions (Tinoco & Wilson, 2013). When firms are in financial distress, raising funds from external parties, including investors and lenders, may be more challenging. Financially distressed firms also face higher interest costs from borrowing as compensation for the likelihood of default risk (Habib *et al.*, 2020).

Prior studies suggest that firms with higher CSR performance are less likely to experience financial distress (Al-Hadi *et al.*, 2019; Chang *et al.*, 2013). Also, financial distress may be influenced by the involvement of a company in environmental activities (Alshahrani et al., 2022). Recent studies argue that eco-innovation can bring several positive impacts to organisations. For example, eco-innovation can enhance a firm's financial performance (Przychodzen & Przychodzen, 2015; Vasileiou et al., 2022), resulting in a more significant increase in stock returns

(Szutowski, 2020) and alleviating financial constraints (Zhang *et al.*, 2020). However, eco-innovation investment carries high costs, risks, and outcome uncertainties due to the requirement of long-term commitment, such as the financial and human resources and extensive support of stakeholders (see Adner, 2006). Therefore, we argue that the beneficial effect of eco-innovation on the cost of debt might be more substantial when the firm faces a lower degree of financial distress. In that lower level of distress, firms may be able to invest in long-term projects, such as environmental innovation projects, to retain the support of stakeholders (i.e., fund providers) to boost the financial performance of businesses. In contrast, the extreme level of financial distress may put debtholders at higher risks when lending money, and eco-innovation investment of those firms may even add more risks to the current extreme risks rather than being beneficial. Therefore, we hypothesise that eco-innovation should help firms alleviate financial distress, strengthen their financial health and hence, reduce their cost of debt; however, this effect is more pronounced in the case of financially undistressed firms. We establish our third hypothesis as follows:

> **Hypothesis 3 (H_3): The negative association between eco-innovation and the cost of debt is more pronounced in the case of financially undistressed firms.**

2.5. Financially Constrained (FC) vs Financially Unconstrained (UC) firms

Although eco-innovation may only help a company reduce financial distress if the company's financial distress level is low, this may not be the case with financial constraints (third condition). Specifically, financially constrained firms may find it challenging to cover eco-innovation expenses because of their insufficient internal resources (i.e., cash flow shortage) and lack of access to outside capital markets. However, increased awareness of environmental protection may alter this situation. Prior studies suggest that banks and financial institutions support government policies concerning green financing (i.e., green bonds) to help corporations with environmentally friendly projects (Yang *et al.*, 2020). In addition, Zhang *et al.* (2020) find that eco-innovation, including management innovation and green production innovation, can significantly reduce corporate financial constraints in Chinese firms. These findings suggest that eco-innovation is a bridge for financially constrained firms to access international capital markets, such as international banks and financial institutions supporting green policies and awareness. In that sense, more eco-innovation engagement can mitigate a firm's environmentally regulatory risks and satisfy their lenders, enabling higher financially constrained firms to access more capital sources. However, this may not be necessary for companies with low financial constraints because these firms can better access financial markets, so the beneficial effect of eco-innovation may be marginal. Our prediction on the case of financial constraints differs from financial distress because while the latter reflects the likelihood of bankruptcy requiring firms to control risky activities like eco-innovation, the former only reflects the firm's restrictions to access financial sources but not the extreme default risks or low performance. We, therefore, propose the fourth hypothesis:

> **Hypothesis 4 (H_4): The negative association between eco-innovation and the cost of debt is more pronounced in the case of financially constrained firms.**

3. Data and Sample

We start our sample by extracting listed stocks from the benchmark equity indexes of G7, including S&P 1500 for the US, FTSE All-Share for the UK, Nikkei 225 for Japan, S&P/TSX composite for Canada, CAC40 for France, FTSE MIB Index for Italy, and DAX40 for Germany. Using the benchmark equity indexes helps represent the sample countries' whole stock market with minimised missing observations for our selected variables. For instance, the S&P Composite 1500 Index is the US's stock market index made by Standard & Poor's, comprising all stocks listed in the three leading equity indexes, S&P Midcap 400, S&P 500, and S&P SmallCap 600, which covers approximately 90% of the US stock market capitalisation. This results in our initial sample of 2,690 listed stocks with 56,469 observations for the period 2000–2020. Following the literature on corporate finance and governance (Chen *et al*., 2020; Trinh *et al.*, 2021; Upadhyay & Öztekin, 2021; Zaman *et al.*, 2021), we only keep non-financial firms, which leads to our final sample of 38,680 firm-year observations from 2000 to 2020 for our empirical analysis.

Following prior studies using cross-country evidence (Gillan, Koch, & Starks, 2021), we collect data for our main eco-innovation variables and other CSR-related factors such as carbon risk and climate governance from Thompson Reuters' Refinitiv Eikon (formerly known as ASSET4). Furthermore, we retrieve financial, accounting, and market data from Refinitiv's DataStream. In addition, our study extracts country-level development and governance quality data for G7 countries from the World Development Indicators and Governance indicators database, which are WDIs[8] and WGIs[9] of the World Bank - WB, respectively.

4. Empirical Models

4.1. Measures for Cost of Debt

Following the literature on the cost of debt financing (Eliwa *et al.*, 2021; Jung *et al.*, 2018; La Rosa *et al.*, 2018; Ni & Yin, 2018; Regenburg & Seitz, 2021), we employ the commonly used measure for capturing Cost of Debt (COD), which is a firm's interest expense on debt that proxies the use of capital's service charge of a firm before its capitalised interest reduction, including the firm's interest expense on short-term debt, long-term debt and capitalised lease obligations as well

[8] For WDIs-WB, please visit https://databank.worldbank.org/source/world-development-indicators
[9] For WGIs-WB, please visit https://databank.worldbank.org/source/worldwide-governance-indicators

as any amortisation expense related to the firm's debt issuance. Besides this measure of COD, we also employ the *estimated* average interest rate (*Interest Rate*)[10], which equals to *Interest Expense on Debt* divided by the sum of (*Short Term Debt & Current Portion of Long Term Debt* and *Long Term Debt*), all multiplied by 100. The detailed definition and calculation of COD measures are presented in Appendix A.

4.2. Measures for Eco-Innovation

We employ two alternative proxies for a firm's environmental innovation performance: *Eco-Score* and *Eco_Index*[11]. First, we use the firm's environmental innovation score (*Eco-Score*), also known as the environmental innovation category score, which reflects a firm's efficiency in mitigating its environmental costs and burdens for the firm's customers via applying newly developed environmental technologies, eco-oriented products and/or processes, and consequently making new market opportunities. The *Eco-Score* scores range from 0 to approximately 100. The higher the score, the more eco-conscious a firm is in designing its products and providing services to customers. This eco-innovation category has recently been mentioned and employed in the prior literature, such as in Arena *et al.* (2018), He *et al.* (2018), Nadeem *et al.* (2020), Zaman *et al.* (2021) and Albitar et al. (2023).

Second, we employ an alternative measure of eco-innovation by creating a comprehensive index (*Eco_Index*) including five components (collected from Eikon/Refinitiv database): *Environmental product (EP); Environmental asset under management (EAM); Product environmentally responsible use (PER); Renewable/clean energy product (REP);* and *Eco-design*

[10] In Appendix F, we also used 5-year average interest rate (Interest_5years) for a firm
[11] In unreported tests, we also capture the firm's efforts in promoting eco-innovation by employing innovation intensity calculated by the ratio of innovation expenditures and sales/revenues (Krieger and Zipperer, 2022; Albitar et al., 2023).

product (EdP) (see Albitar et al., 2023). *EP* is measured by a dummy variable which denotes a value of one if the firm reports on one or more product line or service which was designed to affect the environment positively, and zero otherwise. *EAM* is also an indicator taking value of one if the firm reports on assets under management that use environmental screening during their selection process of investment, and zero otherwise. We further include *PER*, a component denoting the value of one if the firm reports on product features or services promoting responsible, efficient, cost-effective and environmentally preferable use, and zero otherwise; *REP*, a component receiving a value of one if the firm develops products or technologies for use in the clean renewable energy sector, and zero otherwise; and EdP which denotes a value of one if the firm reports on specific products designed for reuse and recycling, and zero otherwise. Our *Eco_Index* is the sum of those five components and therefore, it should have a range of (0-5).

4.3. Control variables

Our control variables include the vectors of corporate governance and firm-level and country-level characteristics. Including a comprehensive set of controls allows us to thoroughly examine the relationship between corporate eco-innovation and a firm's cost of debt.

Following prior research on the impacts of corporate governance on a firm's cost of debt and other performance indicators (e.g., Trinh *et al.*, 2021), we control for board size (*LnBSize:* the natural logarithm of the total number of directors on board), board independence (*%Ind:* the percentage of independent directors on board), CEO Duality (*Dual:* taking the value of 1 if the chair and CEO are the same persons and 0 otherwise), board gender diversity (*%Female:* the percentage of female directors on board), top-management compensation (*ExCom/TA:* the compensation paid to top senior executives scaled by total assets); board-specific skills (*%Skills:* the percentage of directors with specific industrial skills), board meeting (*LnMeeting:* the natural logarithm of the number of board meetings per year), and the presence of CSR committee (*CSR committee:* denoting the value of 1 if the firm has a CSR committee and 0 otherwise).

We also include commonly used firm-level accounting and financial controls, which are potentially associated with a firm's cost of debt. In consideration of the literature on empirical finance (Brogaard *et al.*, 2017; Dan *et al.*, 2021;), we include firm size (*Ln[assets]:* the natural logarithm of total assets), financial leverage (*Debt/Equity:* the ratio of debt and equity), market-to-book value (*Market/Book:* the percentage of the book value of equity and market value of equity), profitability (*ROA:* the return on assets), quick ratio (*Quick ratio:* the ratio of current assets and current liabilities), earnings before income taxes, depreciation and amortization (*EBTDA/assets:* earnings before income taxes, depreciation and amortization scaled by total assets), tangibility (*Fixed/Assets:* the ratio of fixed assets and total assets), operating income (*Operating income growth:* the growth rate of operating income), and operating cash flows (*Operating net cash flow/Assets:* the ratio of operating net cash flow and total assets).

Lastly, we capture potential variations in country-level characteristics by including GDP (gross domestic product) growth per capita (*GDP Capita Growth:* the annual growth rate of a country's GDP per capita), inflation rate (*Inflation:* an annual country's inflation rate), country R&D expenditure to GDP (*R&D/GDP:* the ratio of research and development expenditure and GDP), Trade (% of GDP) (*Trade/GDP:* the ratio of trade measured by the sum of exports and imports of goods and services and GDP), urbanisation (*Urban population growth:* an annual urban population growth), country governance quality (*Country governance quality:* an average index constructed by six sub-categories comprising the Control of Corruption, Government Effectiveness, Political Stability and Absence of Violence/Terrorism, Regulatory Quality, Rule of Law, and Voice and Accountability). These factors are widely used in previous studies for cross-country evidence (Campbell et al., 2011; Miller *et al.*, 2021; Nadarajah *et al.*, 2021; Tsang *et al.*, 2021).

For our channels analyses, we further consider the following factors: firm-level carbon intensity (Bolton & Kacperczyk, 2021), measured by a firm's total carbon emission scaled by its revenues; the modified Altman Z-score as the proxy for firm financial distress risk (Nguyen & Phan, 2020); and corporate financial constraints using the SA index as the combination of firm asset size and firm age and the WW index as a linear function of a firm's cash flow to total assets, sales growth, total long-term debt to assets, firm size (log of total assets), dividend, and sectoral sales growth. The higher SA and WW indexes indicate the higher financial constraints for a firm which impact its innovative efficiency (Li, 2011). Appendix A presents detailed definitions and measurements of all variables used in our research.

4.4. Empirical model

For the examination of eco-innovation in relation to a firm's cost of debt, we follow the study of Correia (2016) to employ a feasible and computationally efficient estimator of linear models with multi-way (i.e., multiple levels of) fixed effects given some advantages over the ordinary least square (OLS). Typically, this method could address a linear model with arbitrarily many fixed effects with many dimensions, and hence, it overcomes several disadvantages of existing estimators which had slow convergence properties, particularly with large and complex datasets. Furthermore, the estimator is also employed as a building block for nonlinear and other estimators, and further leverages existing methods (e.g., the estimation of relative condition numbers) to assess the estimation's robustness. In Stata 18, we employ the command of *reghdfe*. We propose the following baseline regression model:

$$\mathrm{COD_{it}} = \beta_0 + \beta_1 \mathrm{Eco\_Innovation_{it-1}} + \beta_2 \mathrm{Governance_{it-1}} + \beta_3 \mathrm{Firm_{it-1}} + \beta_4 \mathrm{Country_{ct}} + YearFE + FirmFE + \varepsilon_{ijt} \quad \text{(Eq. 1)}$$

where i and t imply firm i in year t. Eq. (1) presents our baseline, empirical estimation model using panel data of 38,680 firm-year observations. $\mathrm{COD_{i,t}}$ is our main dependent variable proxying for the corporate cost of debt. $\mathrm{Eco\_Innovation_{i,t-1}}$ indicates our main independent variable measuring environmental eco-innovation score and index for our sample firms. On the right-hand side of the baseline model, Eq. (1) also consists of the three main vectors of selected independent variables, which are 1) governance controls, 2) financial controls, and 3) Country controls, which were elaborated on earlier in Section 5.3, together with firm and year fixed effects.

Regarding finance and capital structure literature, in particular for dealing with endogeneity and autocorrelation, we fit Eq. (1) in its dynamic function for our analysis where all the governance and firm-level financial controls are lagged by one year at t-1 (Campello & Giambona, 2013; Brav, 2009; Faccio & Xu, 2015; Fama & French, 2002; Kieschnick & Moussawi, 2018). In line with the previous studies, we implement a winsorisation at the 1st and 99th percentiles for our variables (except dummies) to mitigate the potential effects of extremely biased estimated values caused by outliers in the sample.

4.5. Summary statistics and correlation matrix

Tables 1 and 2 provide the summary statistics and correlation matrix for the variables used in our empirical models. The first two variables in Table 1 are the main dependent variables, which measure a firm's cost of debt, including the actual interest expense on debt (*COD*) and estimated interest rate (*Interest*). These proxies are presented as a percentage value that captures a firm's cost of debt financing. We find that the firms' cost of debt (*COD*) has a mean (median) value of 0.061% (0.049%), ranging from the 0% for the minimum to 0.6% for the maximum value. The average (median) of the other alternative proxy, i.e., *Interest* is 5.47% (4.9%). The mean (median) value of the sample firms' eco-innovation score (*Eco_Score*) and Eco-innovation index (*Eco_Index*) is 25.9 (31.9; from the minimum value of 0 to the maximum value of 97) and 1.116 (1.327; from the minimum value of 0 to the maximum value of 5). Table 2 shows no serious multicollinearity issues among independent variables, which is supported by unreported VIF.

[Insert ***Table 1 and 2***]

4.6. Univariate analysis

We begin our analysis by looking into its statistical association with the cost of debt. Our first evidence of such an effect is reported in ***Table 3***. In this table, we perform two-sample *t*-tests of the differences in firm cost of debt between high eco-innovators and low eco-innovators in the pre-2015 and post-2015 (COP21) periods. High eco-innovators include firms with either a positive eco-innovation score (PES) or a high eco-innovation score (HES) using the mean *Eco-Score* (the median is zero). Hence, low eco-innovators have either a zero Eco-Score score (ZES) or a low Eco-Score score (LES) using the mean *Eco-Score*.

We observe opposite trends in the corporate cost of debt of high and low eco-innovators following the COP21. More specifically, we find that high eco-innovators, i.e., PES (HES), reduce their cost of debt by 1.8% (2%). In contrast, low eco-innovators, i.e., ZES (LES) increase their cost of debt by 0.1% (0.1%), even though the differences are statistically insignificant. As a result, the corporate cost of debt financing gap between these two groups, i.e., PES versus ZES (or HES versus LES), widens to 1.9% (or 2.2%), which signifies a considerable rise from that of the pre-2015 period. Our univariate evaluation gives initial evidence of a negative relation between eco-innovation and the cost of debt following the COP21.

[Insert ***Table 3***]

4.7. Trend analysis

We next assess the impact of eco-innovation on a firm's cost of debt using trend analysis. Specifically, we consider the cost of debt financing levels by eco-innovation score interval categories. In other words, we partition our eco-innovation measure into equal increments and then observe the changes in the firm's cost of debt corresponding to each increasing increment category. We report the results in ***Table 4***. We break the *Eco-Score* into ten score-segment categories: below 10, 10–19.99, 20–29.99, 30–30.99, etc. We find that, in general, as the scores of eco-innovation increase, the average cost of debt reduces. Economically, the mean cost of debt measure reduces by about 41.3% if the eco-innovation score increases from below 10 (0.063) to the range of 90–99.99 (0.037).

We also find that the most significant reduction in the cost of debt is 22.2% when the eco-innovation scores begin increasing from below 10 (0.063) to the range of 20–29.99 (0.049). It is possibly a crucial turning point of eco-innovation activities, which was greatly valued by debtholders. At this point (from nothing to something), firms appear to be judged to be 'high growing' eco-innovators; hence, they were offered the more attractive cost-of-debt financing options. Debtholders (e.g., banks) may expect a more significant impact of such a growing eco-innovation activities level in the future because it remarks on the revolution of the business from non-environmentally friendly to environmentally friendly firms.

[Insert ***Table 4***]

5. Main Investigations

5.1. Eco-innovation and corporate cost of debt

As stated in Eq. (1), we *relate* the level of eco-innovation, corporate governance, firm and country characteristics, and year-level differences *to* the corporate cost of debt using the Feasible Estimators for Linear Models with two-way Fixed Effect (absorb for year and firm). We report the results in ***Table 5***, with models on *COD* (1-6) and *Interest Rate* (7-12). Models 1, 4, 7 and 10 test the association between eco-innovation and cost of debt for full sample. We then split the entire sample into subsamples of *less eco-experience* (i.e., *Eco_age*<=12: Models 2, 5, 8 and 11) and *more eco-experience* (i.e., *Eco_age*>12: Models 3, 6, 9 and 12) using the median value (cutoff of 12) of eco-innovation age (i.e., *Eco_age*: experience of the companies in engaging eco-innovation activities as reflected in their eco-innovation years). Our sample statistics reveal a maximum of 19 eco-innovation years, which partially implies a long-term awareness and actual actions of firms in G7 countries in environmental protection. In this table, we report results on two alternative measures of eco-innovation: Eco-innovation score (Eco_Score_{t-1}) and Eco-innovation Index (Eco_Index_{t-1}).

Across all models for entire sample, we find consistent results that the eco-innovation level (Eco_Score_{t-1} and Eco_Index_{t-1}) in the year [*t-1*] is negatively and significantly associated with the cost of debt (*COD* and *Interest Rate*) in the year [*t*], supporting our first hypothesis H_1. The relation is also economically significant: (i) a 1% increase in eco-innovation score (index) leads to a reduction of 0.009% (0.002%) in the firm cost of debt financing (COD); (2) a 1% increase in eco-innovation score (index) leads to a reduction of 0.331% (0.111%) in the firm’s interest rate

(*Interest Rate*). When we split the sample based on the *Eco_age*, we find that our main results are driven by the sub-sample of *more eco-experience firms* (i.e., *Eco_age*>12: Models 3, 6, 9 and 12).[12] This implies that debtholders appear to give more credits to eco-experienced firms engaging in eco-innovation for a number of years (e.g., >12 years in our sample tests). Possibly, a longer time/period that a firm has engaged in eco-innovation could partly demonstrate their longer-term commitment (and perhaps with some good performance) in implementing and pursuing eco-innovation activities (which is costly).

[Insert ***Table 5***]

5.2. Conditions

Our results thus far suggest that an increase in eco-innovation scores leads to a decrease in the corporate cost of debt financing. This section performs several tests to examine the conditions for the main hypothesis 1 set out in the hypotheses section. Their results provide empirical evidence supporting our theoretical justification of the innovation-debt cost nexus.

5.2.1. High Carbon Risk (HCR) vs Low Carbon Risk (LCR) firms

Hypothesis 2 ($\boldsymbol{H_2}$) proposes that the negative association between eco-innovation and the cost of debt is more pronounced in the case of high carbon risk firms. We re-estimate the relationship between eco-innovation and the cost of debt (in Table 5) conditional on the level of firms' carbon risk. We follow literature (e.g., Juhyun *et al.,* 2016; Kim *et al.*, 2015) to measure *carbon risk* using

[12] In unreported tests, we add *Eco_Innovation Age* as a control variable in empirical models. We find a consistent result compared with our main ***Table 5.*** We also examine and compare the relationship between eco-innovation and the cost of debt in two sub-samples, i.e., high experienced (HEE) versus low experienced eco-innovators (LEE). We classify HEE and LEE using either median values (12 years) of Eco_Innovation Age (> median for HEE and < median for LEE) or Quantiles (Q4 for HEE: 17 years and above; and Q1 for LEE: 5 years and below). Results show that a negative and significant relationship between eco-innovation and the cost of debt in HHE, and a negative but non-significant relationship in LEE.

the ratio of carbon emissions and operating income (*Carbon/Income*). A higher value of the ratio suggests a higher carbon risk.

Table 6 (Panels A and B) presents results for subsamples of firms sorted on the degree of carbon risk using median value of *Carbon/Income* as the cutoff (Panel A) or using quantile analysis (Panel B). Firms with high carbon risk (HCR) are those with *Carbon risk* either above the median value or the 75th percentile (Q4) value. Firms with low carbon risk (LCR) are those with *Carbon risk* either below the median value or the 25th percentile (Q1) value. To the extent that eco-innovation can mitigate the carbon risk, leading to reduced cost of debt, we expect a negative and statistically significant relationship between eco-innovation and carbon risk and a stronger negative association between eco-innovation and cost of debt for firms faced with a higher carbon risk. For both panels, we find consistent results that the main findings are driven by HCR firms.[13] The results indicate that reducing the cost of debt of firms with a higher level of eco-innovation is more pronounced for HCR firms than their LCR peers. This implies that firms with high carbon risks can reduce their debt financing cost by enhancing their eco-innovation rating. All results[14] provide evidence supporting $\boldsymbol{H_2}$.

[Insert ***Table 6***]

5.2.2. Financially Distressed (FD) vs Financially Undistressed (UD) firms

We next hypothesise that the negative association between eco-innovation and the cost of debt is more pronounced in the case of financial undistressed firms ($\boldsymbol{H_3}$). Financial distress risk is

[13] In unreported tests, we find that eco-innovation significantly reduces carbon risk.

[14] In unreported tests, we propose the 4-step mediation models of Baron and Kenny (1976). Step 1: The effect of eco-innovation on the cost of debt (without carbon risk). Step 2: The impact of eco-innovation on carbon risk. Step 3: The effect of carbon risk on the cost of debt. Step 4: The impact of eco-innovation on the cost of debt (adding carbon risk). In step 4, we add to step 1 the carbon risk variable to check if the level of significance for the eco-innovation variable changes. If the significance level of eco-innovation found in step 1 becomes insignificant in step 4, we can conclude a full mediating effect of carbon risk. On the other hand, if such a level only reduces, we can claim a partial mediating impact. We find supportive results for partial mediating effect of carbon risk

measured by the modified Altman Z-score (MacKie-Mason, 1990) in the natural logarithm form (*Ln[Z-score]*). It is computed by the sum of {3.3**EBIT/Assets*; 1.0**Sales/Assets*; 1.4**Retained/Assets*; 1.2**WCap/Assets*}. *EBIT/Assets* represents the earnings before interests and taxes over total assets. *Sales/Assets* represents the total sales over total assets. *Retained/Assets* represents the retained earnings over total assets; *WCap/Assets* represents the working capital over total assets. A higher value of *Ln[Z-score]* suggests a lower distance to default or lower financial distress risk.

The results presented in ***Table 7*** show the association between eco-innovation and the cost of debt conditional on the level of financial distress risk. We also use either median (Panel A) or top/bottom quartiles (Panel B) to classify financially distressed (FD: *Ln[Z-score]* < median; Q1) firms and financially un-distressed (UD: *Ln[Z-score]* > median; Q4) firms. We find that the reduced cost of debt due to a higher level of eco-innovation is significant in the sub-sample of UD firms but shows no statistical significance in FD firms. This implies that debtholders appear to highly value the beneficial impact of eco-innovation of the firms with lower degree of financial distress only. They may believe that only UD firms, which exposed a lower financial distress risk, would be able to pursue the long-term and costly eco-innovation activities, and in turn, reduces the interest premium requirement on their loan. Overall, our evidence is consistent with $\boldsymbol{H_3}$.

[Insert ***Table 7***]

5.2.3. Financially Constrained (FC) vs Financially Unconstrained (UC) firms

Eco-innovation is a high-cost investment with uncertain outcomes. Therefore, financially constrained firms may find it difficult to cover such expenses because of their insufficient internal cash flow and lack of access to outside capital markets. However, increased awareness of environmental protection may alter this situation. For instance, the debtholders, especially banks, may like to support businesses, including financially constrained firms, in their environmental innovation, which increases their access to external debt markets with cheaper costs. Meanwhile, the support from external debt markets to financially unconstrained firms in eco-innovation may remain similarly or slightly improved because those businesses have sufficient resources to take loans with a negotiated, reasonable rate. Following this proposition, we predict that the negative relationship between eco-innovation and firm cost of debt is more intensified for financially constrained firms than their financially unconstrained counterparts.

To examine this hypothesis 4 ($\boldsymbol{H_4}$), we sort firms into two sub-samples using the median value or quantile analysis of alternative financial constraint measures: financially constrained (FC) firms and financially unconstrained (UC) firms. Consistent with previous studies (e.g., Nguyen & Phan, 2020; Agrawal & Matsa, 2013; Hadlock & Pierce, 2010; Whited & Wu, 2006), we employ two financial constraint proxies[15] including the size-age (*SA*) index, and Whited-Wu (*WW*) index. *SA* index[16] is determined based on the combination of asset size and firm age (i.e., *SA* Index = -0.737**Ln[assets]* + 0.043**Ln[assets]*^{2} – 0.040**Age*). *WW* index is computed using the following formula: (*WW* Index = -0.091**Cash flow to assets* – 0.062**Dividend pay* + 0.021**Long-term debt to assets* – 0.044* *Ln[assets]* + 0.102**firm's SIC industry sales growth* – 0.035**firm sales growth*). FC firms comprise those that are of higher SA values (SA Index > median; Q1 SA Index), and higher WW values (WW Index >median; Q1 WW Index), and the remaining firms are classifed as UC. SA and WW Indices are comprehensive measures for financial constraints because they consider several aspects.

[15] In unreported tests, we also use firm characteristics variable to classify FC and UC: Ln[assets], Dividend pay, and Operating cash flow. Ln[assets] is a proxy for the firm size. Dividend pay is a binary variable taking the value of 1 if the firm-year pays cash dividend and 0 otherwise. Operating cash flow is the ratio of operating cash flow (i.e., after-tax earnings plus depreciation) and the book value of total assets. FC firms comprise those that are of a smaller size (Ln[assets] < median), have zero cash dividends (Dividend pay = 0), low operating cash flow to total assets (Operating cash-flow < median). Results are consistent.

[16] We do not use the cap of assets and age because our sample is cross-country.

The results are reported in ***Table 8a*** (*SA Index*) and ***Table 8b*** (*WW Index*). Generally, we find consistent results on *SA* index and *WW* index that the negative and/or larger significance/magnitude coefficients of *Eco_Innovation* and *Eco_Index* in the year [*t-1*] on the cost of debt (*COD* and *Interest Rate*) in the year [*t*] are found in FC firms than for UC firms. Overall, our findings provide strong evidence for $\boldsymbol{H_4}$ across all financial constraint, cost of debt and eco-innovation measures.

[Insert ***Table 8***]

6. Additional tests: Moderating effect of climate governance and its decomposition

Existing studies find the vital role of corporate governance on the cost of debt (e.g., Trinh et al., 2020) because governance mechanism and quality reflect the corporate distribution of rights and responsibilities and involve the allocation of power and resources to various firm actors as well as managing their inevitable tension (see Aguilera et al., 2021; Albitar et al., 2023). Resource-based view argues that board independence can influence long-term financial and other resources in carbon mitigation and environmental policies. However, the existence of an environmental committee is likely to push for the firm's environmental protection strategy. Eventually, the committee could institutionalise climate change governance, which enhances corporate ability and motivations to combat climate change and pollution issues. Furthermore, the board could utilise climate-based compensation packages that are expected to incentivise self-interested managers to participate in policies and actions to diminish carbon emissions. This aligns with CSR arguments on the positive effect of social and environmental-based compensation on sound social and environmental performance (Campbell et al., 2007).

As such, when firms integrate climate change issues at the board level into their traditional corporate governance system, they can show a solid commitment to tackling climate change (Bui et al., 2020). We posit that the debtholders might highly value such environmental-oriented corporate governance because it forms a firm's resources and capability that encourages and enables the company to engage in carbon mitigation and other climate change issues. We, therefore, expect a moderating role of climate change governance (or climate governance or sustainable governance) on the associations between eco-innovation and the cost of debt. The moderating relation could be two-directional: positive if there is a ***substitution*** impact (i.e., firms with higher eco-innovation may be less likely to fetch a better deal from the debtholders because the latter had already looked at the climate governance quality. That implies, to reduce the cost of debt, a better climate-governed firm may not necessarily engage in higher eco-innovation) or negative if there is a ***complementing*** effect (i.e., firms with higher eco-innovation may be more likely to fetch a better deal from the debtholders, and such an effect is more pronounced in the better climate-governed firms because debtholders may trust that a better climate governance system can effectively manage the eco-innovation activities).

To test our arguments, we create a composite climate governance index (*CliGovInx*) from three components: board-level environmental committee (i.e., *Env_committee*: taking the value of one if the firm has a board-level environmental committee, and zero otherwise); sustainability reporting (i.e., *Sus_report*: taking the value of one if the firm publishes a sustainability report and zero otherwise); climate incentives (i.e., *Climate_incentive*: taking the value of one if the firm provides incentives for individual management of issues and matters relevant to climate change, and zero otherwise). The composite index, therefore, reflects the climate governance strength of a firm, with a range of (0-3). This is consistent with Bui et al.'s (2020) and Albitar et al. (2023)

studies. We then interact *CliGovInx* and its three components with the Eco-innovation score and index.

We report the moderating results of climate governance and its components on the association between eco-innovation and corporate cost of debt in ***Table 9***. For brevity, we report results on the model with the dependent variable measured by *COD*. The independent variable is eco-innovation, measured by the firm's environmental innovation score (*Eco_Innovation*) and index (*Eco_Index*). We find a negative association between eco-innovation and the cost of debt across all models, but such results become positive for the interaction terms. Our findings support the substitution effect, in which climate governance quality reduces the negative impact of eco-innovation on the firm's cost of debt.

[Insert ***Table 9***]

7. Endogeneity and sample selection bias tests

There is a possible correlation between eco-innovation (and other explanatory variables) and the ***error term*** in our regression model, which results in an endogeneity problem. In term of theory, endogeneity is caused by three sources: omitted variables, measurement error, and simultaneity (see Fall, 2008; Roberts and Whited, 2013). First, omitted variable bias (*ovb*) refers to the inability to observe a number of factors relevant to firm behaviour (which are unobservable for various reasons such as non-public information), which appear in the error term. The *ovb* leads to endogeneity when such observable variables (error terms) are correlated with eco-innovation and other included explanatory factors, causing inference to break down. We have mitigated the risk of potential time-invariant endogeneity threat by using fixed effects (see Rjiba et al., 2020; Albitar et al., 2023) (i.e., two-way fixed effects absorbing for firm and year fixed effects).[17] The method has reduced the risk of multicollinearity as well as estimation bias and capture the *ovb*.

Second, measurement errors (*mer*) are caused by the discrepancy between the true variable of interest and the proxy, or by the imperfection of the variable measurement. Although we have attempted to find better measures for eco-innovation (e.g., score; index and components), cost of debt (e.g., *actual* and *estimated* average interest rate) as well as other variables in our model, it is possible that the *mer* still persists. If the measurement error is in the cost of debt, the zero conditional mean assumption might not be violated and hence, there is no endogeneity problem. If the measurement error is in the eco-innovation, such issue may be a matter. Based on our careful construction of the eco-innovation index and the ready-to-use proxy for eco-innovation score from Refinitiv, we believe that the effects of measurement errors have been minimised. This is consistent with the study of Albitar et al. (2023).

Third, simultaneity bias (*sb*) may be likely to occur in our study because it can plausibly be argued either that eco-innovation causes the firm's cost of debt or that cost of debt causes eco-innovation. For example, firms with higher eco-innovation enjoy a lower rate of borrowing costs. In contrast, it is also possible that firms with lower cost of debts can save more money and hence, engage more in eco-innovation activities (which may be normally costly). Therefore, eco-innovation variable can be jointly determined with the cost of debt, typically through an equilibrium mechanism (see Fall, 2008). To address the *sb*, we have employed a set of endogeneity techniques including the difference-in-difference (DID) using (propensity score matched) PSM-matched sample (Nguyen & Phan, 2020) and Three-stage Least Squares – 3SLS (Trinh, 2022). We

[17] In unreported tests, we also employed the OLS with robust standard errors and firm and year fixed effects. The results are largely compatible with our primary analysis for which eco-innovation exerts a negative association with corporate cost of debt.

further use Two-step Heckman (Albitar et al., 2023) and Entropy Balancing (Albitar et al., 2023) to control for potential sample selection bias[18].

7.1. Difference-in-difference regression using PSM-matched sample

We first address the *sb* by employing the framework of difference-in-differences (DID) using the 2015 United Nations Climate Change Conference (COP21), including the 6th Annual Sustainable Innovation Forum 2015[19] as an exogenous shock. We chose this event because it negotiated the Paris Agreement, a global agreement (including G7 as leading countries) on the mitigation of climate change. Some studies have examined the impact of the COP21 on the achievement of carbon dioxide emissions targets and the environmental performance of businesses. They suggest that the COP21 positively impacts the performance and disclosure of carbon dioxide emissions in both developed countries (Haque & Ntim, 2020; 2018) and emerging countries (Gracia & Siregar, 2021). Consequently, the improvement of environmental performance significantly reduces a firm's debt cost (Eliwa *et al.*, 2021; Gracia & Siregar, 2021). Therefore, we argue that the COP21 is an exogenous event that enhances the impact of eco-innovation on the cost of debt. It has 'forced' firms to engage more in environmental protection activities driven by the international agreement of their government(s) in lowering the speeds of climate change and minimising its consequences. As such, activities related to eco-innovation should be significantly influenced by the COP21. We

[18] As we have run the DID using PSM-matched sample, we do not report the results on PSM technique. However, the unreported PSM has helped us to further solve endogeneity that may result from the model misspecification.

[19] https://www.cop21paris.org/ The Paris Agreement signed at the Conference of Parties (COP21) in 2015 was an important event to enhance global understanding of climate change and bring forward many actions and programmes to reduce its impact. As the key players of COP21, most G7 countries have taken the necessary steps to demonstrate their commitment to the Paris Agreement (Wang et al., 2020). However, controlling CO2 emissions is still a challenging mission for G7 countries, and as of 2019, G7 countries account for nearly 24.58% of worldwide CO2 emissions. It includes 14.34% for the US, 3.47% for Japan, 2.16% for Germany, 1.54% for Canada, 1.11% for the UK, and 0.98% for France and Italy (Wang et al., 2020). Therefore, the G7 countries continue to have more policies and regulations to support environmental innovation projects, such as green energy projects and net-zero carbon emission plans, because innovation effectively transforms a nation's economic structure and decreases CO2 emissions (Lee & Min, 2015).

expect a significant increase in both awareness of severe climate changes and actual actions of businesses around the world to respond to environmental issues.

We adopt DID regression using the propensity score matching (PSM) sample as this technique can minimise the effects of endogeneity and sample selection bias (see, among others, Nguyen & Phan, 2020). Furthermore, we anticipate that cost of debt of eco-innovators (compared to non-eco-innovators) is most likely to be affected by the COP21. We hence define treated firms as those that have an eco-innovation score (Treated = $Eco\_Score_{t-1} > 0$ *[Year = 2015]*) in 2015 or have an eco-index (Treated = $Eco\_Index_{t-1} > 0$ *[Year = 2015]*) and control firms as the remaining ones. This requires us to create a dummy variable of the eco-innovators (Treated), taking the value of 1 if the observation is eco-innovators, and 0 otherwise.

In the first stage, we run the probit model of the Treated dummy on a comprehensive list of control variables, following previous studies on eco-innovation. We obtain the predicted probability of a firm being a treated one. In the second stage, each treated firm will then be matched with a control firm using four methods[20]: (i) 1:1 matching without replacement; (ii) 1:1 matching with replacement; (iii) nearest neighbour (n=2); and (iv) nearest neighbour (n=3). In the third stage, we run the some PSM analyses (unreported[21]) and conduct the DID analysis employing the PSM sample. We report these results in ***Table 11***, with Panels A–D covering the above matching techniques. In models 1, 3, 5, and 7, regressions include *treated* and *post2015*, while the remaining models exclude them. Across all regressions, we find that the interaction term coefficients, i.e., *treated*post2015* are consistently negative and statistically significant. The results imply that

[20] The quality of matching via diagram will be provided upon request.

[21] We find negative and significant differences (Δ) between the sub-samples of treated and control firms after propensity matching. We test the average treatment effects (ATE) with four nearest-neighbour matching methods. We also test the average treatment effect on the treated (ATT) with the 1:1 nearest-neighbour matching and bootstrapping of standard errors (with replications of 100 or 1,000 or 10,000). Similarly, we find the observed negative and significant differences (Δ) between the treated and control firms after propensity matching. These results suggest an effective lower cost of debt of high eco-innovators.

treated firms (high eco-innovators) exhibit a lower cost of debt after the COP21. Our results are also robust across different alternative measures for the cost of debt.

However, the assumption of the DID approach leads to an absence of the shock induced by the COP21, and the situation that the cost of debt of the treated and control firms move similarly (or a pre-treatment parallel assumption) (see Nguyen & Phan, 2020). Therefore, our DID results may become invalid if treated and control firms are systematically dissimilar and their cost of debt financing moves in distinct ways even in the absence of the COP21. In unreported tests, following the research design of Nguyen and Phan (2020), we also run the dynamic models[22], which can validate the assumption of a pre-treatment parallel trend. We also present the Figure 1 to show the parallel trends, and conduct the parallel trend test. All methods support our DID findings.

[Insert ***Table 11***]

7.2. Three-stage Least Squares (3SLS)

Although our estimations have already accounted for unobservable and constant heterogeneity such as managerial style and decisions, financial and business policies as well as other firm-specific features, our explanatory variables, especially the main independent variable of interest (i.e., eco-innovation score/index) may be determined simultaneously with the firm's cost of debt

[22] We construct the dynamic model by creating time indicator variables: $COP2015^{-4}$, $COP2015^{-3}$, $COP2015^{-2}$, $COP2015^{-1}$, $COP2015^{0}$, $COP2015^{+1}$, $COP2015^{+2}$, $COP2015^{+3}$, and $COP2015^{+4}$, which denote four years before the COP21, three years before the COP21, two years before the COP21, one year before the COP21, the year of COP21 (2015), one year after the COP21, two years after the COP21, three years after the COP21, and four years after the COP21, respectively. We also generate the *Treated* variable which takes the value of 1 if *Eco_Innovation* is above the mean (high eco-innovation score) and 0 otherwise (low eco-innovation score). We next introduce interaction terms between *Treated* in the year *[t]* and each of those time indicators to capture the changes in the cost of debt (*COD*) in the year *[t]* of the treated firms relative to those of control firms in the corresponding years. We find insignificant and/or significant positive coefficients of the interaction variables, comprising *Treated**$COP2015^{-4}$, *Treated**$COP2015^{-3}$, *Treated**$COP2015^{-2}$, *Treated**$COP2015^{-1}$, and *Treated* *$COP2015^{0}$, which implies that the treated and control firms follow pre-treatment parallel trends in the cost of debt. After the COP21, we find more significant and/or negative coefficients of *Treated**$COP2015^{+1}$, *Treated**$COP2015^{+2}$, *Treated**$COP2015^{+3}$, and *Treated* *$COP2015^{+4}$, which suggests a stronger negative effect of eco-innovation on the cost of debt in the post-COP21 years

resulting in possible simultaneity bias (*sb*). We address this issue by adopting the Three-Stage Least-Square (3SLS)[23] estimations and instrumental variables (IVs) method (Elyasiani and Zhang, 2015; Mollah and Zaman, 2015; Trinh et al., 2021). To do so, we must select the proper IV for Eco-innovation, which is challenging in finance studies. We argue that country-level CO2 emission levels per capita (IV[***LnCO2/Capita***]) is a good IV because it is likely to correlate with eco-innovation (e.g., firms headquartered in countries exposing higher levels of CO2 emission per capita tend to be correlated with a lower level of eco-innovation) but unlikely to correlate with the firm-level cost of debt. We believe that in our study setting and sampled firms, the IV can only indirectly affect the cost of debt via eco-innovation. The country-level CO2 emission per capita is less likely to endogenously influence individual firms' cost of debt. Based on this selection of the 3SLS method and suitable IV, we estimate the following simultaneous equation models:

$$\begin{cases} \mathrm{COD}_{it} = \beta_0 + \beta_1 \mathrm{Eco\_Innovation}_{it-1} + \beta_2 \mathrm{Governance}_{it-1} + \beta_3 \mathrm{Firm}_{it-1} + \beta_4 \mathrm{Country}_{ct} + YearFE \\ \qquad + FirmFE + \varepsilon_{ijt} \quad \text{(Eq. 2a)} \\ \mathrm{Eco\_Innovation}_{it} \\ \qquad = \beta_0 + \beta_1 \mathrm{IV}[LnCO2/Capita]_{it-1} + \beta_2 \mathrm{Governance}_{it-1} + \beta_3 \mathrm{Firm}_{it-1} + \beta_4 \mathrm{Country}_{ct} \\ \qquad + YearFE + FirmFE + \varepsilon_{ijt} \quad \text{(Eq. 2b)} \end{cases}$$

Table 11 reports the 3SLS results. We find that across all first stages (Models 1, 3, 5, and 7), our IV, i.e., IV[***LnCO2/Capita***], is negatively correlated with both eco-innovation measures (i.e.,

[23] We also utilise the two-stage least square (2SLS) and obtain consistent results with 3SLS. Prior studies have emphasised that the latter is more efficient than the former as it includes an additional step (i.e., seemingly unrelated regression - SUR) that considers the correlations between equations in the same way that SUR generalises the traditional OLS approach. In other words, the 3SLS involves the steps that are described in the 2SLS models plus the simultaneous solution of all equations employing the generalized least squares (Trinh, 2022).

Eco_Score and *Eco_Index*). We use the F-test (p-value) to test the strength of the IV in the first stage regression (see Wooldridge, 2009; Elyasiani and Zhang, 2015) and find that the p-value for the F-test is 0.000 supporting the strength of our chosen IV. Unfortunately, we are unable to use the Sargan procedure to confirm the validity of the IV directly because our model is exactly identified with only one IV for our endogenous variable (Eco-innovation). However, this is still in line with the research design of Elyasiani and Zhang (2015). In the third stage of 3SLS regression (Models 2, 4, 6, and 8), we consistently find a negative association between eco-innovation measures and a firm's cost of debt. Our 3SLS results show the robustness of our main findings after treating for endogeneity problem.

[Insert ***Table 11***]

7.3. Two-step Heckman

We control for sample selection bias by implementing two alternative techniques (see Albitar et al., 2023): *Heckman Two-step* and *Entropy Balancing*. For the former (*Heckman*), we conduct a probit model in the first stage, in which we employ treated eco-innovation ($HighEscore^{Treated}$ and $HighIndex^{Treated}$) as our dependent variables and other governance, board and country characteristics as the control factors in the models. The dummies $HighEscore^{Treated}$ and $HighIndex^{Treated}$ are created using the mean values of original variables, i.e., *Eco_Innovation* (0.26) and *Eco_Index* (1.12), as the cut-off. Specifically, $HighEscore^{Treated}$ denotes a value of one if the mean *Eco_Innovation* equals or is higher than 0.26 and zero otherwise. Similarly, $HighIndex^{Treated}$ denotes a value of one if the mean *Eco_Index* equals or is higher than 1.12 and zero otherwise. We then estimate the inverse Mills ratio (*imr*) by utilising the estimated parameters and include the *imr* as an additional independent factor in the second stage estimation. We report the Heckman results in ***Table 12***, Panel A (Models 1-4). We find a consistently negative and statistically significant relationship between $HighEscore^{Treated}$ and $HighIndex^{Treated}$ and firm cost of debt measures (i.e., *COD* and *Interest Rate*).

[Insert ***Table 12***]

7.4. Entropy balancing

We further generate an alternative sample by employing the entropy balancing technique, which is also used to solve endogeneity concerns (see Hainmueller and Xu, 2013; Albitar et al., 2023). The approach has some advantages; typically, the model dependence for the subsequent estimation of treatment effects can be mitigated if we use entropy balancing (Hainmueller, 2012). We indeed create dummy factors from the original eco-innovation variables, comprising both treatment and control groups (i.e., we can reweight the latter to match the covariate moments in the former). We generate the treatment by employing the top quantile values of *Eco_Innovation* (Q4: 0.5) and *Eco_Index* (Q4: 2). We assign the value of one for the treatment (*Eco_Innovation* >=0.5 or *Eco_Index* >=2) and zero for the control group. We then examine the baseline research model and report the results in ***Table 12***, Panel B (Models 5-8). Our findings are robust to the main table and indicate a negative association between eco-innovation and corporate cost of debt. Taken together, we find support for our main hypothesis 1 after capturing the potential effects of endogeneity and sample selection bias.

In unreported tests, our results are also robust across different alternative measures for the cost of debt and various contexts such as industry, country and economic policy uncertainty analyses.

8. Concluding remarks

This study examines the association between eco-innovation investment policies and a firm's cost of debt. Using underlying neo-institutional theory and a sample of G7 countries, we find that firms with extensive environmental innovation policies (i.e., higher levels of eco-innovation investment) exhibit a lower cost of debt financing. This result suggests that debtholders and credit providers show their interest and support for the eco-innovation policies of borrowers by providing loans and credits to firms with lower interest rates. Although investment in eco-innovation is risky and may require substantial financial and non-financial resources, our results show an incremental change in eco-innovation investment over time, and more investment in eco-innovation leads to a lower cost of borrowing. The finding supports the recent discussion that credit provisions are now assessed under extra considerations of non-financial performance (Caragnano *et al.*, 2020) or environment risk management (Sharfman & Fernando, 2008) because financing environmentally irresponsible companies will impair debt providers' reputation and future competition (Caragnano *et al.*, 2020).

Interestingly, we find that the negative link between eco-innovation and the cost of debt is more pronounced in the firms having richer eco-innovation experience, as reflected by their eco-innovation engagement years. Possibly, those firms may commit to eco-innovation projects as part of their long-term development policies to enhance operational efficiency and economic benefit (Haque & Ntim, 2020). As such, the more prolonged eco-innovation engagement through a firm's eco-innovation age indicates richer experiences and may boost their success probability in environmental performance, which consequently results in a positive impact on firm financial performance (Zaman *et al.*, 2021; Przychodzen & Przychodzen, 2015) and secures cheaper loans from debtholders.

Furthermore, our results show that the negative relationship between eco-innovation and corporate cost of debt is more intensified in high carbon risk firms than their low carbon risk counterparts. This result is consistent with prior studies (e.g., Jung *et al*., 2018) that financial institutions consider carbon risk as a part of the client's default and reputation risk assessment (Jung *et al*., 2018). It is also in line with Lee and Min (2015), showing that investment in green R&D activities leads to lower carbon emissions. Our results extend the findings by Vasileiou et al. (2022) that eco-process innovations help firms to perform better. Furthermore, our findings go beyond those studies by exploring other potential conditions driving the negative effect of eco-innovation on the cost of debt, including financial distress risk and financial constraints. We find that the lower cost of debt due to high eco-innovation is more intensified in the financially undistressed firms than their distressed peers. We also confirm a more nuanced negative relationship between eco-innovation and the cost of debt for financially constrained firms than for unconstrained firms.

In addition, we examine the impact of climate governance on the relationship between green innovation and debt costs, using a composite climate governance index with three components (board-level environmental committee, sustainability reporting, and climate incentives) - effective demonstration of a firm's strong commitment to addressing climate challenges. Our findings support the *substitution* effect (or absence of *complementing* effect), in which climate governance quality reduces the negative impact of eco-innovation on the firm's cost of debt. By employing several comprehensive methodologies (i.e., two-way fixed effects, difference-in-difference approach using a propensity score matched sample, Three-stage Least Squares, Two-step Heckman and Entropy Balancing techniques), we have taken significant steps to address endogeneity, measurement errors, and selection bias concerns, enhancing the robustness and reliability of our study's findings.

Findings from our research have several contributions and implications. Notably, in response to the rising pressure of global climate change, certain firms have demonstrated their strong commitment to environmental innovation as a long-term sustainable development policy. As a result, they are compensated by the significant support from credit providers with a lower cost of debt. Managers who still overestimate environmental compliance cost should also consider offsetting productivity benefits from innovation (Porter & Linde, 1995), in particular a lowered cost of debt which has become even more significant since Paris Agreement 2015. Especially, firms facing high financial distress risk or financial constraints can seize the opportunity of restructuring their business toward a meaningful level of investment in eco-innovation as it will pave the way for new products, processes, marketing and organisational dimensions, granting access to more affordable debt financing that helps revive the firms. These implications are fundamental since they demonstrate that eco-innovation can support firms beyond the legitimacy needs of conforming to regulations or society’s expectation of green management to reach efficiency gains from it (i.e., lowered cost of debt, superior performance). Our findings also imply the considerable role of government and financing providers in regulating, supporting, and enhancing the development of eco-innovation, from creating pressure on local businesses to helping them finance environmental innovation projects. From a policymakers’ point of view, encouraging and supporting eco-innovation investments in firms, particularly financially distressed and constrained ones, constitute well-grounded tools to reconcile environmental and economic objectives to achieve sustainable development goals.

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Data sources:

- ✓ Thompson Reuters' Refinitiv Eikon (formerly known as ASSET4).
- ✓ Refinitiv's DataStream
- ✓ World Development Indicators and Governance indicators database, which are WDIs and WGIs of the World Bank - WB, respectively.

Table 1:
Descriptive Statistics

Stats	N	Mean	Std.	Min	p25	Median	P75	Max
COD	29836	0.061	0.073	0.000	0.031	0.049	0.068	0.600
Interest	30055	5.470	3.384	1.030	3.080	4.900	6.920	14.690
Eco_Innovation	21477	0.259	0.319	0.000	0.000	0.000	0.500	0.970
Eco_Index	20909	1.116	1.327	0.000	0.000	0.000	2.000	5.000
Eco_age	38680	11.106	6.180	0.000	5.000	12.000	17.000	19.000
SA Index	33455	-3.208	1.421	-7.020	-4.025	-3.165	-2.291	0.146
WW Index	29545	-60.105	12.304	-63.122	-62.725	-62.658	-62.586	-0.530
Ln[Z-score]	30687	0.451	0.735	-7.764	0.123	0.589	0.927	1.662
Carbon risk	11849	3.756	10.759	-15.119	0.149	0.520	2.364	71.765
CliGovInx	21106	1.295	1.079	0.000	0.000	1.000	2.000	3.000
LnBSize	21422	2.302	0.283	1.609	2.079	2.303	2.485	3.045
%Ind	14835	0.474	0.206	0.000	0.364	0.500	0.615	0.889
Dual	38680	1.837	0.835	1.000	1.000	2.000	3.000	3.000
%Female	21192	0.158	0.122	0.000	0.077	0.143	0.250	0.500
ExCom/TA	18079	4.780	6.567	0.050	1.000	2.562	5.765	40.744
%Skills	19026	0.575	0.219	0.000	0.429	0.571	0.727	1.000
LnMeeting	19524	2.082	0.399	1.386	1.792	2.079	2.303	3.091
CSR committee	38680	1.847	0.843	1.000	1.000	2.000	3.000	3.000
Ln[assets]	33993	14.791	1.873	9.893	13.490	14.771	16.108	19.008
Debt/Equity	33863	0.793	1.910	-7.713	0.111	0.489	1.054	11.414
Market/Book	31334	0.030	0.042	-0.135	0.013	0.021	0.035	0.265
ROA	33400	0.056	0.099	-0.435	0.027	0.059	0.099	0.331
Quick ratio	33584	1.511	1.649	0.120	0.680	1.040	1.640	11.170
EBTD/Assets	33193	0.122	0.113	-0.390	0.078	0.119	0.173	0.450
Fixed/Assets	33785	0.297	0.237	0.006	0.105	0.230	0.436	0.910
Operating income growth	33539	0.104	1.502	-6.688	-0.174	0.065	0.288	8.791
Operating net cash flow/Assets	33831	0.096	0.086	-0.276	0.056	0.092	0.138	0.350
GDP Capita Growth	38680	0.976	2.030	-6.260	0.802	1.502	1.981	4.079
Inflation	38680	1.648	1.126	-1.622	1.165	1.850	2.235	4.594
R&D/GDP	34997	2.457	0.517	1.301	1.975	2.632	2.765	3.340
Trade/GDP	38680	37.411	16.191	20.447	26.294	29.983	52.724	82.765
Urban population growth	38680	0.965	0.356	-0.120	0.872	1.031	1.144	2.093
Country governance quality	38680	1.316	0.170	0.635	1.240	1.277	1.404	1.661

This table reports summary statistics of all variables, which are winsorized at the 1st and 99th percentiles. The sample includes 38,680 firm-year observations over the period of 2002-2020.

Table 2:

Pearson Correlation Matrix

		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]	[21]	[22]	[23]	[24]	[25]
1.	*Eco_Innovation*	1																								
2.	*Eco_Index*	0.82***	1																							
3.	*LnBSize*	0.27***	0.23***	1																						
4.	*%Ind*	0.08***	0.09***	0.02**	1																					
5.	*Dual*	-0.01	-0.01	0.06***	-0.11***	1																				
6.	*%Female*	0.07***	0.06***	0.03***	0.22***	-0.004	1																			
7.	*ExCom/TA*	-0.22***	-0.21***	-0.33***	-0.03***	-0.03***	-0.05***	1																		
8.	*%Skills*	-0.06***	-0.04***	-0.17***	-0.04***	0.01	-0.21***	0.10***	1																	
9.	*LnMeeting*	0.11***	0.11***	0.06***	0.04***	-0.11***	-0.09***	-0.10***	0.09***	1																
10.	*CSR committee*	0.37***	0.38***	0.24***	0.15***	0.78***	0.15***	-0.28***	-0.06***	0.18***	1															
11.	*Ln[assets]*	0.36***	0.32***	0.57***	0.08***	0.52***	0.07***	-0.63***	-0.16***	0.14***	0.61***	1														
12.	*Debt/Equity*	0.03***	0.03***	0.08***	0.04***	0.04***	0.03***	-0.12***	-0.03***	0.05***	0.07***	0.19***	1													
13.	*Market/Book*	-0.06***	-0.07***	-0.05***	0.01	0.06***	0.11***	0.15***	-0.03***	-0.10***	0.02***	-0.05***	0.53***	1												
14.	*ROA*	-0.04***	-0.05***	-0.05***	-0.04***	0.09***	0.05***	0.07***	-0.02**	-0.17***	0.06***	0.06***	-0.05***	0.15***	1											
15.	*Quick ratio*	-0.12***	-0.08**	-0.2***	-0.02***	-0.12***	-0.07***	0.30***	0.10***	-0.07***	-0.16***	-0.32***	-0.13***	0.04***	-0.08***	1										
16.	*EBTD/Assets*	-0.07***	-0.09***	-0.05***	-0.06***	0.06***	0.01*	0.09***	-0.01*	-0.17***	0.02***	0.02***	-0.06***	0.17***	0.90***	-0.09***	1									
17.	*Fixed/Assets*	-0.05***	-0.06***	0.05***	0.04***	0.04***	-0.03***	-0.19***	0.01	0.05***	0.11***	0.16***	0.10***	-0.11***	-0.05***	-0.21***	0.01*	1								
18.	*Operating income growth*	-0.01	-0.01	-0.01	-0.01	-0.02***	-0.03***	0.00	-0.005	-0.02***	-0.03***	0.01	-0.01	0.02***	0.08***	0.01	0.09***	-0.01	1							
19.	*Operating net cash flow/Assets*	-0.10***	-0.11***	-0.10***	-0.03***	0.11***	0.06***	0.16***	0.02**	-0.16***	0.06***	0.03***	-0.07***	0.16***	0.67***	-0.09***	0.75***	0.06***	0.05***	1						
20.	*GDP Capita Growth*	-0.07***	-0.10***	0.02**	-0.10***	-0.13***	-0.11***	0.02**	0.02**	-0.12***	-0.20***	-0.08***	-0.03***	0.03***	0.07***	0.01*	0.09***	-0.01	0.06***	0.00	1					
21.	*Inflation*	-0.17***	-0.17***	-0.16***	0.01	-0.16***	0.22***	0.01	-0.07***	-0.18***	-0.18***	-0.21***	-0.06***	0.08***	0.09***	0.02***	0.09***	-0.04***	0.01	0.06*	0.15***	1				
22.	*R&D/GDP*	0.15***	0.16***	0.17***	-0.05***	0.17***	-0.16***	0.07***	0.07***	0.03***	0.05***	0.18***	0.02***	-0.02***	-0.05***	0.03***	-0.03***	-0.10***	-0.01	-0.01	-0.05***	-0.33***	1			
23.	*Trade/GDP*	0.04***	0.02***	0.01	0.05***	-0.05***	0.07***	-0.1***	-0.12***	0.05***	0.14***	0.00	-0.00	-0.02***	0.002	-0.05***	-0.01**	0.12***	-0.00	-0.04*	0.01	0.08***	-0.74***	1		
24.	*Urban population growth*	-0.27***	-0.33***	-0.15***	0.02***	-0.23***	0.02***	0.02***	-0.02***	-0.23***	-0.33***	-0.24***	-0.01*	0.02***	0.008	0.03***	0.03***	0.05***	0.01**	0.02***	0.11***	0.14***	-0.17***	-0.05***	1	
25.	*Country governance quality*	-0.07***	-0.09***	-0.05***	-0.05***	-0.23***	-0.15***	-0.08***	0.06***	0.03***	-0.13***	-0.19***	-0.05***	-0.02***	-0.01*	0.01**	0.01*	0.14***	0.02***	-0.03***	0.26***	0.15***	-0.44***	0.56***	0.2***	1
N		38680																								

This table reports the Pearson correlation matrix among all main independent and control variables, which are winsorized at the 1st and 99th percentiles. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3:
Univariate analysis

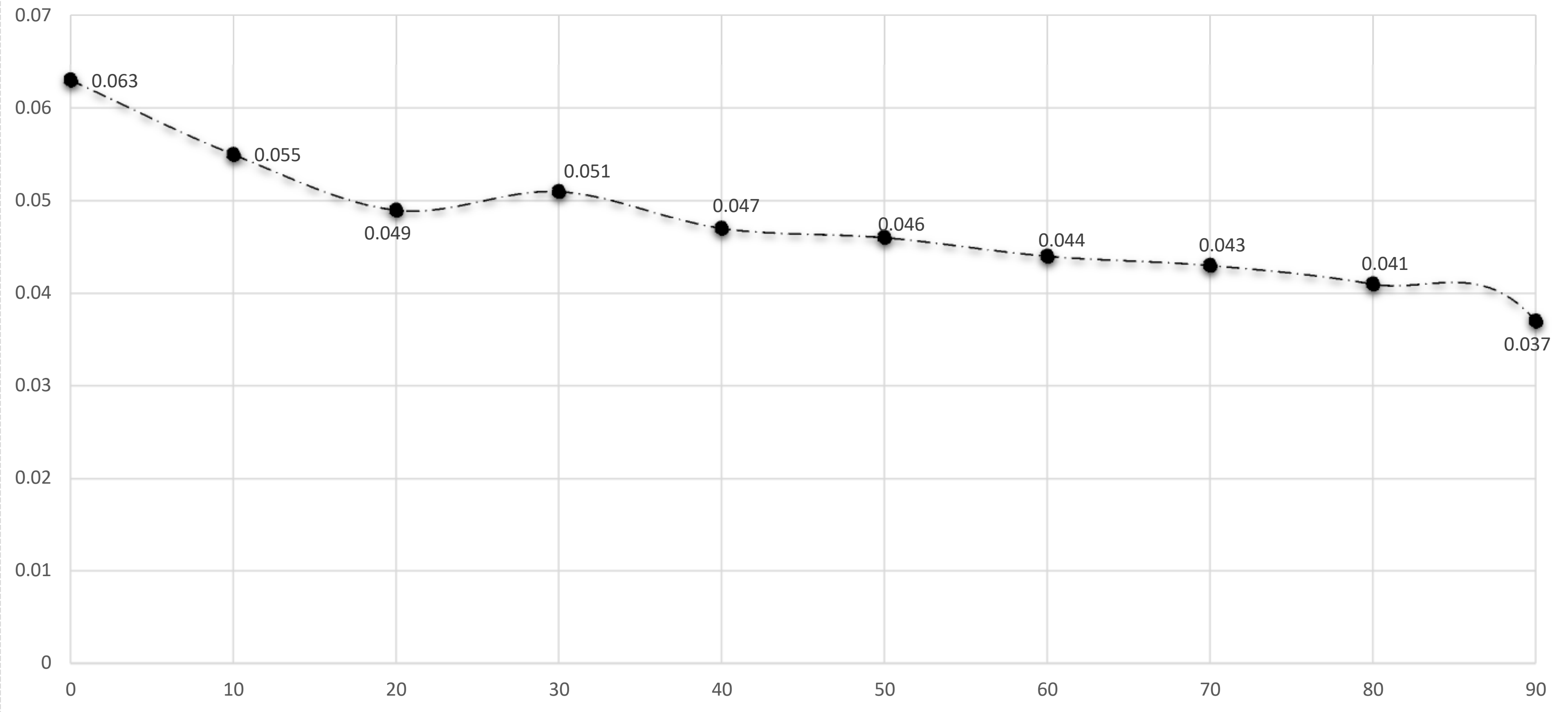
	Positive Eco-Score [PES]		**Zero** Eco-Score [ZES]		t-test [PES-ZES]	
COD	*Mean*	*Std.*	*Mean*	*Std.*	*Mean diff.*	*t-stat.*
Pre-2015	0.065	0.077	0.063	0.068	0.002	**1.427***
Post-2015	0.047	0.061	0.063	0.076	-0.016	**-10.453*****
Mean diff. [Post-Pre]	-0.018		0.001		**-0.019*****	
t-stat.	**-17.064*****		**0.450**			

	High Eco-Score [HES]		**Low** Eco-Score [LES]		t-test [HES-LES]	
COD	*Mean*	*Std.*	*Mean*	*Std.*	*Mean diff.*	*t-stat.*
Pre-2015	0.066	0.078	0.062	0.068	0.004	**3.601*****
Post-2015	0.046	0.058	0.061	0.076	-0.015	**-10.521*****
Mean diff. [Post-Pre]	-0.020		0.001		**0.022*****	
t-stat.	**-17.967*****		**0.685**			

This table reports the univariate analysis showing the mean, standard deviation, and t-test results of mean difference [PES-ZES; HES-LES] in cost of debt (COD) between firms with positive [PES] and zero eco-innovation scores [ZES], and between firms with high [HES] and low eco-innovation scores [LES], in the pre- and post-2015 (COP21) periods. Appendix A presents all detailed descriptions of the variables. ***, ** and * denotes 1%, 5% and 10% significance levels.

Table 4:
Cost of Debt Financing Levels by Eco-Innovation Score Interval Categories

Eco_Score Level	<10	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	>99	Sum
N	10222	732	1148	1244	809	1789	987	962	1234	829	0	19,956
%	51.22%	3.67%	5.75%	6.23%	4.05%	8.96%	4.95%	4.82%	6.18%	4.15%	0.00%	100%
COD	***0.063***	***0.055***	***0.049***	***0.051***	***0.047***	***0.046***	***0.044***	***0.043***	***0.041***	***0.037***	-	



This table reports the categorical analysis, which shows the cost of debt financing levels by eco-innovation score intervals.

Table 5:
Feasible Estimators for Linear Models with Multi-Way Fixed Effect: Eco-Innovation and Corporate Cost of Debt

*This table reports the Feasible Estimators for Linear Models with Multi-Way Fixed Effect on the association between eco-innovation and corporate cost of debt. Two dependent variables: (1) firm cost of debt (COD), measured by the ratio of corporate interest expenses on debt and the average of interest-bearing debt; (2) Interest Rate measured by estimated average interest rate for a firm. The independent variable is eco-innovation, measured by the firm's environmental innovation score and index. Control variables include corporate governance, firm characteristics and country characteristics. All corporate governance and firm characteristics are lagged by one year. Appendix A presents all detailed descriptions of the variables. P-values are reported in square brackets. ***, ** and * denotes 1%, 5% and 10% significance levels.*

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
	COD	*COD*	*COD*	*COD*	*COD*	*COD*	*Interest Rate*	*Interest Rate*	*Interest Rate*	*Interest Rate*	*Interest Rate*	*Interest Rate*
VARIABLES	*Full Sample*	**Eco_age (<=12)**	**Eco_age (>12)**	*Full Sample*	**Eco_age (<=12)**	**Eco_age (>12)**	*Full Sample*	**Eco_age (<=12)**	**Eco_age (>12)**	*Full Sample*	**Eco_age (<=12)**	**Eco_age (>12)**
Eco_Score $_{t-1}$	**-0.009*****	-0.004	**-0.010*****				**-0.331****	0.651	**-0.414*****			
	[0.004]	[0.736]	[0.001]				[0.013]	[0.198]	[0.002]			
Eco_Index $_{t-1}$				**-0.002****	-0.002	**-0.002****				**-0.111*****	0.188	**-0.141*****
				[0.027]	[0.472]	[0.019]				[0.002]	[0.138]	[0.000]
LnBSize $_{t-1}$	0.008	-0.010	0.011**	0.008	-0.017	0.011**	0.063	-1.417**	0.289	0.032	-1.328**	0.255
	[0.100]	[0.519]	[0.043]	[0.108]	[0.247]	[0.036]	[0.772]	[0.029]	[0.208]	[0.883]	[0.039]	[0.274]
%Ind $_{t-1}$	-0.001	0.009	-0.002	-0.001	0.008	-0.002	-0.261*	0.602	-0.320*	-0.239	0.666	-0.309*
	[0.838]	[0.457]	[0.571]	[0.828]	[0.525]	[0.617]	[0.098]	[0.248]	[0.053]	[0.137]	[0.206]	[0.066]
Dual $_{t-1}$	0.006***	-0.011*	0.008***	0.005**	-0.010*	0.007***	0.087	-0.139	0.112	0.073	-0.168	0.109
	[0.005]	[0.083]	[0.000]	[0.018]	[0.095]	[0.002]	[0.334]	[0.612]	[0.238]	[0.429]	[0.539]	[0.263]
%Female $_{t-1}$	0.008	0.037	0.001	0.006	0.042	-0.001	-0.278	-1.741	-0.163	-0.268	-2.094*	-0.132
	[0.425]	[0.205]	[0.905]	[0.527]	[0.142]	[0.942]	[0.495]	[0.156]	[0.705]	[0.517]	[0.092]	[0.764]
ExCom/TA $_{t-1}$	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.013	0.004	-0.020*	-0.013	0.006	-0.020*
	[0.554]	[0.276]	[0.949]	[0.721]	[0.584]	[0.776]	[0.151]	[0.783]	[0.072]	[0.152]	[0.699]	[0.082]
%Skills $_{t-1}$	0.001	0.007	-0.000	0.000	0.011	-0.001	0.269*	0.856*	0.209	0.259*	1.030**	0.177
	[0.858]	[0.545]	[0.917]	[0.889]	[0.325]	[0.849]	[0.064]	[0.080]	[0.167]	[0.080]	[0.037]	[0.252]
LnMeeting $_{t-1}$	-0.001	-0.003	-0.000	-0.001	-0.003	-0.000	0.030	0.184	-0.005	0.020	0.114	-0.001
	[0.613]	[0.527]	[0.899]	[0.700]	[0.636]	[0.918]	[0.753]	[0.418]	[0.960]	[0.836]	[0.622]	[0.994]
CSR committee $_{t-1}$	-0.004**	-0.006	-0.004**	-0.004**	-0.007	-0.004*	0.004	0.046	-0.002	0.029	-0.013	0.030
	[0.026]	[0.426]	[0.046]	[0.026]	[0.324]	[0.053]	[0.961]	[0.883]	[0.982]	[0.733]	[0.967]	[0.734]
Ln[assets] $_{t-1}$	-0.011***	-0.022***	-0.010***	-0.011***	-0.021***	-0.010***	-0.169**	0.291	-0.257***	-0.181**	0.405	-0.296***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.043]	[0.239]	[0.004]	[0.035]	[0.103]	[0.001]
Debt/Equity $_{t-1}$	0.000	0.001	0.000	0.000	0.001	0.000	0.070***	0.117**	0.054**	0.072***	0.110**	0.056**
	[0.552]	[0.362]	[0.927]	[0.513]	[0.339]	[0.921]	[0.002]	[0.018]	[0.037]	[0.002]	[0.028]	[0.033]
Market/Book $_{t-1}$	-0.031	-0.051	-0.021	-0.031	-0.057	-0.020	-2.998***	-4.065*	-2.561**	-3.014***	-3.986*	-2.524**
	[0.180]	[0.317]	[0.413]	[0.182]	[0.245]	[0.453]	[0.002]	[0.059]	[0.021]	[0.003]	[0.064]	[0.026]

ROA $_{t-1}$	0.026	0.027	0.032	0.031*	0.061	0.030	-0.731	-3.643*	-0.241	-0.129	-2.533	0.332
	[0.164]	[0.557]	[0.114]	[0.098]	[0.165]	[0.150]	[0.351]	[0.059]	[0.780]	[0.874]	[0.192]	[0.711]
Quick ratio $_{t-1}$	0.001	0.002	0.000	0.001	0.001	0.000	-0.162***	-0.169*	-0.162***	-0.156***	-0.163*	-0.148***
	[0.248]	[0.431]	[0.917]	[0.225]	[0.583]	[0.814]	[0.000]	[0.076]	[0.000]	[0.000]	[0.093]	[0.002]
EBTD/Assets $_{t-1}$	-0.028	0.003	-0.043**	-0.022	-0.019	-0.029	-1.374*	-0.406	-1.519*	-1.786**	-1.230	-1.870**
	[0.113]	[0.952]	[0.027]	[0.221]	[0.663]	[0.142]	[0.068]	[0.825]	[0.067]	[0.021]	[0.512]	[0.029]
Fixed/Assets $_{t-1}$	-0.004	-0.052	0.004	-0.000	-0.070*	0.009	-0.815*	-3.354**	-0.527	-0.724	-2.332	-0.551
	[0.687]	[0.151]	[0.736]	[0.979]	[0.051]	[0.420]	[0.065]	[0.028]	[0.253]	[0.107]	[0.136]	[0.240]
Operating income growth $_{t-1}$	0.000	-0.001	0.001	0.000	0.000	0.000	0.026	0.026	0.027	0.037*	0.076	0.023
	[0.445]	[0.407]	[0.223]	[0.440]	[0.996]	[0.425]	[0.237]	[0.588]	[0.278]	[0.088]	[0.111]	[0.347]
Operating NCF/Assets $_{t-1}$	-0.003	-0.070**	0.015	-0.009	-0.071**	0.007	-1.031*	-0.082	-1.151*	-1.043*	-0.175	-1.225*
	[0.851]	[0.036]	[0.327]	[0.522]	[0.026]	[0.682]	[0.088]	[0.954]	[0.087]	[0.089]	[0.902]	[0.074]
GDP Capita Growth	0.000	-0.017*	0.001	-0.000	-0.015*	0.001	-0.018	-0.005	-0.044	-0.049	0.181	-0.070
	[0.851]	[0.095]	[0.535]	[0.969]	[0.091]	[0.644]	[0.768]	[0.991]	[0.474]	[0.438]	[0.642]	[0.284]
Inflation	0.001	0.016	0.001	0.001	0.013	0.001	0.099*	0.315	0.069	0.083	-0.011	0.072
	[0.534]	[0.113]	[0.571]	[0.481]	[0.116]	[0.552]	[0.086]	[0.446]	[0.249]	[0.168]	[0.976]	[0.251]
R&D/GDP	0.023	0.177*	0.004	0.024	0.202**	0.003	1.720**	4.692	1.324*	1.693**	6.751*	1.200
	[0.160]	[0.053]	[0.831]	[0.154]	[0.012]	[0.875]	[0.012]	[0.223]	[0.061]	[0.018]	[0.054]	[0.107]
Trade/GDP	-0.000	-0.004*	0.001	-0.000	-0.003	0.001	0.011	0.044	0.014	0.008	0.116	0.008
	[0.783]	[0.094]	[0.288]	[0.942]	[0.222]	[0.250]	[0.556]	[0.676]	[0.503]	[0.686]	[0.220]	[0.715]
Urban population growth	0.016*	0.051	0.011	0.016**	0.062**	0.011	0.469	1.479	0.369	0.508	2.207*	0.354
	[0.052]	[0.106]	[0.221]	[0.045]	[0.031]	[0.236]	[0.171]	[0.267]	[0.322]	[0.148]	[0.079]	[0.356]
Country governance quality	-0.007	-0.220**	0.024	-0.014	-0.198**	0.016	1.436	-1.564	1.676	1.390	-0.689	1.577
	[0.763]	[0.012]	[0.337]	[0.563]	[0.018]	[0.535]	[0.159]	[0.668]	[0.119]	[0.185]	[0.850]	[0.155]
Year FE	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Firm FE	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Constant	0.158**	0.392	0.108	0.159**	0.248	0.121	1.304	-8.680	3.052	1.827	-19.898	4.405
	[0.033]	[0.277]	[0.163]	[0.037]	[0.434]	[0.132]	[0.679]	[0.567]	[0.356]	[0.575]	[0.151]	[0.199]
Observations	8,647	1,810	6,837	8,349	1,742	6,606	8,607	1,791	6,816	8,311	1,722	6,588
R-squared	0.534	0.591	0.524	0.540	0.599	0.530	0.554	0.625	0.538	0.556	0.619	0.543
Wald Chi 2 [p-value]	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***

Table 6:
High Carbon Risk (HCR) vs Low Carbon Risk (LCR)

*This table reports the Feasible Estimators for Linear Models with Multi-Way Fixed Effect of the carbon risk channel of the association between eco-innovation and corporate cost of debt. Two dependent variables: (1) firm cost of debt (COD), measured by the ratio of corporate interest expenses on debt and the average of interest-bearing debt; (2) Interest Rate measured by estimated average interest rate for a firm. The independent variable is eco-innovation, measured by the firm's environmental innovation score and index. Panel A and B report results of cost of debt on the eco-innovation for subsamples of firms sorted on the degree of carbon risk (using median values as the cutoff or using quantile analysis). Firms with high carbon risk (HCR) are those with Carbon risk either above the median values of Carbon risk or the 75th percentile (Q4) value. Firms with low carbon risk (LCR) are those with Carbon risk either below the median values of Carbon risk or the 25th percentile (Q1) value. Control variables include corporate governance, firm characteristics, and country characteristics. All corporate governance and firm characteristics are lagged by one year. Appendix A presents all detailed descriptions of the variables. P-values are reported in square brackets. ***, ** and * denotes 1%, 5% and 10% significance levels.*

Panel A: Using median values of *Carbon risk* as the cutoff								
VARIABLES	[1] HCR (>Median)	[2] HCR (>Median)	[3] HCR (>Median)	[4] HCR (>Median)	[5] LCR (<Median)	[6] LCR (<Median)	[7] LCR (<Median)	[8] LCR (<Median)
	COD	*COD*	*Interest Rate*	*Interest Rate*	*COD*	*COD*	*Interest Rate*	*Interest Rate*
Eco_Score $_{t-1}$	**-0.009****		**-0.509*****		-0.006		0.189	
	[0.015]		[0.002]		[0.390]		[0.451]	
Eco_Index $_{t-1}$		**-0.003*****		**-0.155*****		0.001		0.156**
		[0.007]		[0.000]		[0.551]		[0.027]
Constant	0.205**	0.224**	1.067	0.849	0.212	0.148	-1.528	-1.120
	[0.020]	[0.014]	[0.786]	[0.835]	[0.210]	[0.401]	[0.810]	[0.865]
Observations	6,150	5,954	6,129	5,933	2,345	2,247	2,331	2,235
R-squared	0.557	0.561	0.563	0.561	0.563	0.572	0.621	0.637
Panel B: Quantile Analysis								
VARIABLES	[1] HCR (Q4 *Carbon risk*)	[2] HCR (Q4 *Carbon risk*)	[3] HCR (Q4 *Carbon risk*)	[4] HCR (Q4 *Carbon risk*)	[5] LCR (Q1 *Carbon risk*)	[6] LCR (Q1 *Carbon risk*)	[7] LCR (Q1*Carbon risk*)	[8] LCR (Q1 *Carbon risk*)
	COD	*COD*	*Interest Rate*	*Interest Rate*	*COD*	*COD*	*Interest Rate*	*Interest Rate*
Eco_Score $_{t-1}$	**-0.012*****		**-0.588*****		-0.010		0.143	
	[0.009]		[0.002]		[0.492]		[0.765]	
Eco_Index $_{t-1}$		**-0.003*****		**-0.203*****		0.000		0.104
		[0.007]		[0.000]		[0.965]		[0.430]
Constant	0.162	0.165	0.085	-0.535	0.009	-0.090	-5.524	-7.104
	[0.138]	[0.140]	[0.986]	[0.912]	[0.979]	[0.788]	[0.616]	[0.535]
Observations	4,993	4,820	4,975	4,801	1,087	1,051	1,071	1,037
R-squared	0.560	0.564	0.573	0.570	0.606	0.619	0.631	0.649
Control included	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year/Firm FE	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Wald Chi 2 [p-value]	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***

Table 7:
Financially Distressed Firms (FD) vs Financially Undistressed Firms (UD)

*This table reports the results of the association between eco-innovation and corporate cost of debt for subsamples of firms sorted on the degree of Financial Distress Risk. Two dependent variables: (1) firm cost of debt (COD), measured by the ratio of corporate interest expenses on debt and the average of interest-bearing debt; (2) Interest Rate measured by estimated average interest rate for a firm. The independent variable is eco-innovation, measured by the firm's environmental innovation score and index. Panel A and B report results of cost of debt on the eco-innovation for subsamples of firms sorted on the degree of Financial Distress Risk (using median values of Ln[Z-score as the cutoff or using quantile analysis). Financially distressed firms (FD) are those with Ln[Z-score] either below the median values or the 25th percentile (Q1) value. Financially undistressed firms (UD) are those with Ln[Z-score] either above the median values or above the 75th percentile (Q4) value. Control variables include corporate governance, firm characteristics, and country characteristics. All corporate governance and firm characteristics are lagged by one year. Appendix A presents all detailed descriptions of the variables. P-values are reported in square brackets. ***, ** and * denotes 1%, 5% and 10% significance levels.*

Panel A: Using median values of *Ln[Z-score]* as the cutoff								
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
VARIABLES	FD	FD	FD	FD	UD	UD	UD	UD
	(<Median)	(<Median)	(<Median)	(<Median)	(>Median)	(>Median)	(>Median)	(>Median)
	COD	*COD*	*Interest Rate*	*Interest Rate*	*COD*	*COD*	*Interest Rate*	*Interest Rate*
Eco_Score $_{t-1}$	0.003		0.144		**-0.023*****		**-0.915*****	
	[0.382]		[0.360]		[0.000]		[0.000]	
Eco_Index $_{t-1}$		0.001		0.017		**-0.005*****		**-0.244*****
		[0.382]		[0.707]		[0.001]		[0.000]
Constant	0.118	0.081	1.592	3.999	0.246*	0.242	7.301	5.402
	[0.116]	[0.266]	[0.657]	[0.288]	[0.093]	[0.108]	[0.198]	[0.350]
Observations	4,058	3,864	4,051	3,859	4,394	4,299	4,365	4,269
R-squared	0.472	0.495	0.601	0.602	0.578	0.577	0.602	0.601
Panel B: Quantile Analysis								
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
VARIABLES	FD	FD	FD	FD	UD	UD	UD	UD
	(Q1 *Ln[Z-score]*)	(Q1 *Ln[Z-score]*)	(Q1 *Ln[Z-score]*)	(Q1 *Ln[Z-score]*)	(Q4 *Ln[Z-score]*)	(Q4 *Ln[Z-score]*)	(Q4 *Ln[Z-score]*)	(Q4 *Ln[Z-score]*)
	COD	*COD*	*Interest Rate*	*Interest Rate*	*COD*	*COD*	*Interest Rate*	*Interest Rate*
Eco_Score $_{t-1}$	0.005		0.234		**-0.032*****		**-1.207*****	
	[0.220]		[0.239]		[0.001]		[0.000]	
Eco_Index $_{t-1}$		0.001		0.038		**-0.008*****		**-0.429*****
		[0.241]		[0.508]		[0.004]		[0.000]
Constant	0.106	0.090	-3.577	-2.225	0.547**	0.531*	17.577*	11.808
	[0.239]	[0.309]	[0.445]	[0.659]	[0.044]	[0.057]	[0.064]	[0.221]
Observations	2,050	1,930	2,054	1,936	2,283	2,232	2,247	2,195
R-squared	0.558	0.602	0.610	0.609	0.619	0.618	0.640	0.642
Control included	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year/Firm FE	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Wald Chi 2 [p-value]	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***

Table 8a:

Financially constrained (FC) firms vs Financially unconstrained firms (UC): Using Size-Age (SA) Index as the Measure of Financial Constraints

*This table reports the results of the association between eco-innovation and corporate cost of debt for subsamples of firms sorted on the degree of SA Index. Two dependent variables: (1) firm cost of debt (COD), measured by the ratio of corporate interest expenses on debt and the average of interest-bearing debt; (2) Interest Rate measured by estimated average interest rate for a firm. The independent variable is eco-innovation, measured by the firm's environmental innovation score and index. Panel A and B report results of cost of debt on the eco-innovation for subsamples of firms sorted on the degree of constraints (using median values of SA Index as the cutoff or using quantile analysis). Financially constrained (FC) firms are those with size-age (SA Index) either below the median values or the 25th percentile (Q1) value. Financially unconstrained firms (UC) are those with size-age (SA Index) either above the median values or the 75th percentile (Q4) value. Control variables include corporate governance, firm characteristics, and country characteristics. All corporate governance and firm characteristics are lagged by one year. Appendix A presents all detailed descriptions of the variables. P-values are reported in square brackets. ***, ** and * denotes 1%, 5% and 10% significance levels.*

Panel A: Using median values of *SA Index* as the cutoff

VARIABLES	[1] FC (<Median)	[2] FC (<Median)	[3] FC (<Median)	[4] FC (<Median)	[5] UC (>Median)	[6] UC (>Median)	[7] UC (>Median)	[8] UC (>Median)
	COD	*COD*	*Interest Rate*	*Interest Rate*	*COD*	*COD*	*Interest Rate*	*Interest Rate*
***Eco_Score** $_{t-1}$*	**-0.007***		**-0.431*****		-0.005		-0.002	
	[0.064]		[0.006]		[0.412]		[0.992]	
***Eco_Index** $_{t-1}$*		**-0.003*****		**-0.176*****		0.002		0.035
		[0.002]		[0.000]		[0.299]		[0.599]
Constant	0.138	0.149*	-4.143	-3.593	0.352**	0.335**	14.356**	14.351**
	[0.104]	[0.096]	[0.275]	[0.367]	[0.013]	[0.018]	[0.020]	[0.021]
Observations	5,873	5,643	5,852	5,625	2,714	2,644	2,696	2,627
R-squared	0.534	0.535	0.556	0.557	0.623	0.632	0.598	0.601

Panel B: Quantile Analysis

VARIABLES	[1] FC (Q1 *SA Index*)	[2] FC (Q1 *SA Index*)	[3] FC (Q1 *SA Index*)	[4] FC (Q1 *SA Index*)	[5] UC (Q4 *SA Index*)	[6] UC (Q4 *SA Index*)	[7] UC (Q4 *SA Index*)	[8] UC (Q4 *SA Index*)
	COD	*COD*	*Interest Rate*	*Interest Rate*	*COD*	*COD*	*Interest Rate*	*Interest Rate*
***Eco_Score** $_{t-1}$*	**-0.009****		**-0.373****		-0.009		-0.076	
	[0.016]		[0.029]		[0.202]		[0.805]	
***Eco_Index** $_{t-1}$*		**-0.005*****		**-0.222*****		0.000		0.015
		[0.000]		[0.000]		[0.825]		[0.856]
Constant	0.219**	0.279***	0.328	3.663	0.364**	0.360**	15.338*	14.857*
	[0.023]	[0.008]	[0.942]	[0.452]	[0.037]	[0.043]	[0.055]	[0.066]
Observations	3,334	3,187	3,338	3,192	1,580	1,548	1,574	1,542
R-squared	0.569	0.574	0.578	0.583	0.608	0.608	0.579	0.583
Control included	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year/Firm FE	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Wald Chi 2 [p-value]	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***

Table 8b:

Financially constrained (FC) firms vs Financially unconstrained firms (UC): Using Whited-Wu Index (WW) Index as the Measure of Financial Constraints

*This table reports the results of the association between eco-innovation and corporate cost of debt for subsamples of firms sorted on the degree of WW Index. Two dependent variables: (1) firm cost of debt (COD), measured by the ratio of corporate interest expenses on debt and the average of interest-bearing debt; (2) Interest Rate measured by estimated average interest rate for a firm. The independent variable is eco-innovation, measured by the firm's environmental innovation score and index. Panel A and B report results of cost of debt on the eco-innovation for subsamples of firms sorted on the degree of constraints (using median values of WW Index as the cutoff or using quantile analysis). Financially constrained (FC) firms are those with Whited-Wu index (WW Index) either below the median values or the 25th percentile (Q1) value. Financially unconstrained firms (UC) are those with Whited-Wu index (WW Index) either above the median values or the 75th percentile (Q4) value. Control variables include corporate governance, firm characteristics, and country characteristics. All corporate governance and firm characteristics are lagged by one year. Appendix A presents all detailed descriptions of the variables. P-values are reported in square brackets. ***, ** and * denotes 1%, 5% and 10% significance levels.*

Panel A: Using median values of *WW Index* as the cutoff

VARIABLES	[1] FC (<Median)	[2] FC (<Median)	[3] FC (<Median)	[4] FC (<Median)	[5] UC (>Median)	[6] UC (>Median)	[7] UC (>Median)	[8] UC (>Median)
	COD	*COD*	*Interest Rate*	*Interest Rate*	*COD*	*COD*	*Interest Rate*	*Interest Rate*
Eco_Score $_{t-1}$	-0.011***		-0.309**		0.003		-0.768**	
	[0.002]		[0.032]		[0.606]		[0.050]	
Eco_Index $_{t-1}$		-0.002**		-0.109***		-0.002		-0.292***
		[0.029]		[0.005]		[0.257]		[0.009]
Constant	0.155*	0.149*	3.555	3.734	0.124	0.173	-19.557*	-18.144
	[0.060]	[0.080]	[0.305]	[0.297]	[0.505]	[0.385]	[0.074]	[0.119]
Observations	7,811	7,546	7,767	7,504	654	627	658	631
R-squared	0.534	0.540	0.552	0.554	0.694	0.695	0.709	0.708

Panel B: Quantile Analysis

VARIABLES	[1] FC (Q1 *WW Index*)	[2] FC (Q1 *WW Index*)	[3] FC (Q1 *WW Index*)	[4] FC (Q1 *WW Index*)	[5] UC (Q4 *WW Index*)	[6] UC (Q4 *WWIndex*)	[7] UC (Q4 *WW Index*)	[8] UC (Q4 *WW Index*)
	COD	*COD*	*Interest Rate*	*Interest Rate*	*COD*	*COD*	*Interest Rate*	*Interest Rate*
Eco_Score $_{t-1}$	-0.010***		-0.357***		-0.001		-0.434***	
	[0.002]		[0.007]		[0.746]		[0.009]	
Eco_Index $_{t-1}$		-0.002**		-0.111***		-0.000		-0.109**
		[0.025]		[0.002]		[0.664]		[0.020]
Constant	0.153**	0.150*	1.883	2.405	-0.014	-0.008	-4.014	-2.817
	[0.040]	[0.050]	[0.554]	[0.464]	[0.898]	[0.943]	[0.353]	[0.540]
Observations	8,517	8,225	8,477	8,187	2,479	2,386	3,039	2,934
R-squared	0.533	0.539	0.555	0.556	0.662	0.668	0.625	0.628
Control included	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year/Firm FE	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Wald Chi 2 [p-value]	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***

Table 9:
Moderating Effect of Climate Governance and its Decomposition

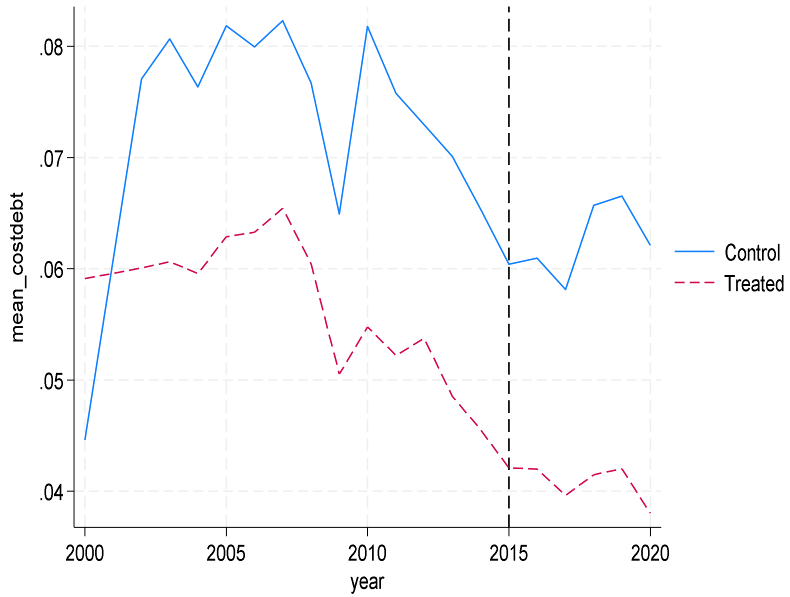
*This table reports the results of the climate governance and its components on the association between eco-innovation and corporate cost of debt. Dependent variable is measured by firm cost of debt (COD - which is the ratio of corporate interest expenses on debt and the average of interest-bearing debt). The independent variable is eco-innovation, measured by the firm's environmental innovation score (Eco_Innovation $_{t-1}$) and index (Eco_Index $_{t-1}$). Control variables include corporate governance, firm characteristics, and country characteristics. All corporate governance and firm characteristics are lagged by one year. Appendix A presents all detailed descriptions of the variables. P-values are reported in square brackets. ***, ** and * denotes 1%, 5% and 10% significance levels.*

	Panel A: EcoIn $_{t-1}$ = Eco_Innovation $_{t-1}$				*Panel B: EcoIn $_{t-1}$ = Eco_Index $_{t-1}$*			
VARIABLES	[1] COD	[2] COD	[3] COD	[4] COD	[5] COD	[6] COD	[7] COD	[8] COD
EcoIn $_{t-1}$	-0.020***	-0.018***	-0.013***	-0.012***	-0.004***	-0.004***	-0.004***	-0.002**
	[0.000]	[0.000]	[0.007]	[0.001]	[0.001]	[0.001]	[0.003]	[0.021]
CliGovInx $_{t-1}$	-0.004***				-0.003**			
	[0.009]				[0.012]			
*Eco_Innovation $_{t-1}$ * CliGovInx $_{t-1}$*	**0.006*****				**0.002*****			
	[0.005]				[0.008]			
Env_committee $_{t-1}$		-0.015				-0.016		
		[0.750]				[0.731]		
*Eco_Innovation $_{t-1}$ * Env_committee $_{t-1}$*		**0.013*****				**0.004*****		
		[0.009]				[0.007]		
Sus_report $_{t-1}$			-0.006***				-0.007***	
			[0.009]				[0.002]	
*Eco_Innovation $_{t-1}$ * Sus_report $_{t-1}$*			**0.006**				**0.003****	
			[0.221]				[0.033]	
Climate_incentive $_{t-1}$				-0.003				-0.001
				[0.203]				[0.718]
*Eco_Innovation $_{t-1}$ * Climate_incentive $_{t-1}$*				**0.009****				**0.001**
				[0.048]				[0.471]
Control included	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Year/Firm FE	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Constant	0.154**	0.135	0.157**	0.164**	0.153**	0.132	0.154**	0.160**
	[0.042]	[0.264]	[0.038]	[0.029]	[0.045]	[0.280]	[0.043]	[0.035]
Observations	8,432	8,482	8,436	8,498	8,349	8,349	8,349	8,349
R-squared	0.540	0.540	0.540	0.540	0.540	0.540	0.540	0.540
Wald Chi 2 [p-value]	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***

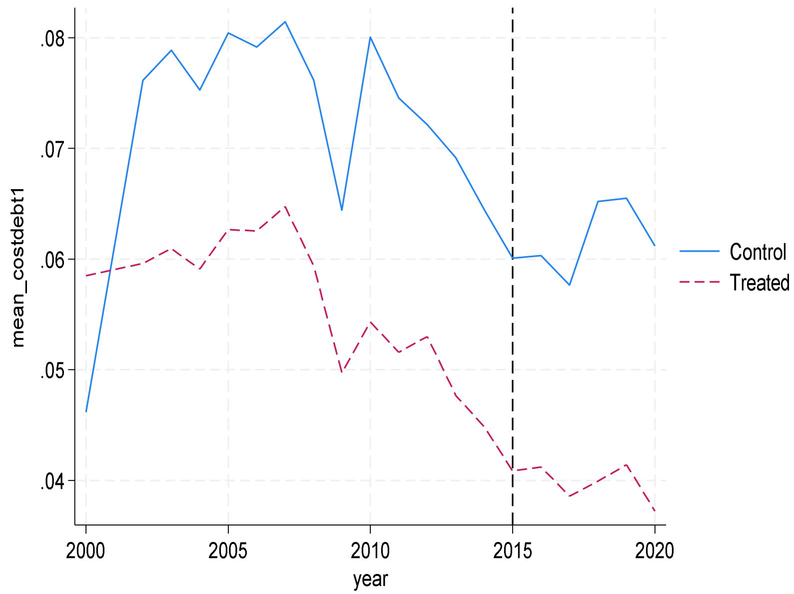
Table 10:
Difference-in-difference Regression using PSM-matched sample: The Paris Agreement COP 21 (2015)
*This table reports the robustness results of the difference-in-difference regression using the PSM-matched sample. The exogenous shock is the Paris Agreement COP21 in 2015. Control variables include corporate governance, firm characteristics, and country characteristics. Appendix A presents all detailed descriptions of the variables. P-values are reported in square brackets. ***, ** and * denotes 1%, 5% and 10% significance levels.*

	Panel A: 1:1 matching without replacement		Panel B: 1:1 matching with replacement		Panel C: Nearest neighbour (n=2)		Panel D: Nearest neighbour (n=3)	
	Treated = *Eco_Innovation* $_{t-1}$ > 0 *[Year = 2015]*							
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
VARIABLES	*COD*	*COD*	*COD*	*COD*	*COD*	*COD*	*COD*	*COD*
treated*post2015	**-0.007*****	**-0.011*****	**-0.005*****	**-0.010*****	**-0.007*****	**-0.010*****	**-0.006*****	**-0.010*****
	[0.002]	[0.000]	[0.003]	[0.000]	[0.001]	[0.000]	[0.001]	[0.000]
post2015	-0.009***		-0.010***		-0.009***		-0.009***	
	[0.000]		[0.000]		[0.000]		[0.000]	
treated	0.003*		0.002*		0.003**		0.003**	
	[0.066]		[0.093]		[0.044]		[0.034]	
Control included	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Constant	0.130***	0.102***	0.150***	0.135***	0.148***	0.136***	0.149***	0.137***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	12,740	12,740	14,610	14,610	11,347	11,347	12,008	12,008
R-squared	0.038	0.034	0.047	0.040	0.048	0.041	0.047	0.040
Wald Chi 2 [p-value]	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	Treated = *Eco_Index* $_{t-1}$ > 0 *[Year = 2015]*							
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
VARIABLES	*COD*	*COD*	*COD*	*COD*	*COD*	*COD*	*COD*	*COD*
treated*post2015	**-0.008*****	**-0.012*****	**-0.003***	**-0.011*****	**-0.003***	**-0.011*****	**-0.005*****	**-0.011*****
	[0.000]	[0.000]	[0.092]	[0.000]	[0.051]	[0.000]	[0.005]	[0.000]
post2015	-0.008***		-0.013***		-0.013***		-0.012***	
	[0.000]		[0.000]		[0.000]		[0.000]	
treated	0.003**		-0.000		0.001		0.002*	
	[0.048]		[0.971]		[0.480]		[0.096]	
Control included	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Constant	0.138***	0.115***	0.135***	0.116***	0.135***	0.115***	0.132***	0.113***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	13,298	13,298	13,298	13,298	11,110	11,110	11,805	11,805
R-squared	0.042	0.038	0.052	0.041	0.052	0.041	0.052	0.042
Wald Chi 2 [p-value]	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***

Figure 1: Parallel Trend



(Treated are firms whose *Eco_Innovation* $_{t-1}$ > *0 in Year = 2015*)



(Treated are firms whose *Eco_Index* $_{t-1}$ > *0 in Year = 2015*)

Table 11:

Instrument Variables Approach: Three-stage Least Squares (3SLS)

*This table reports the robustness results of the 3SLS method. The selected Instrument Variable (IV) is the natural logarithm of country-level CO2 emissions per capita. Control variables include corporate governance, firm characteristics, and country characteristics. Appendix A presents all detailed descriptions of the variables. P-values are reported in square brackets. ***, ** and * denotes 1%, 5% and 10% significance levels.*

VARIABLES	[1] Eco_Innovation	[2] COD	[3] Eco_Index	[4] COD	[5] *Eco_Innovation*	[6] *Interest Rate*	[7] *Eco_Index*	8] *Interest Rate*
	1st Stage	3rd stage	1st Stage	3rd stage	1st Stage	3rd stage	1st Stage	3rd stage
Eco_Score $_{t-1}$		**-0.005****				**-0.401*****		
		[0.027]				[0.000]		
Eco_Index $_{t-1}$				**-0.002****				**-0.107*****
				[0.011]				[0.000]
IV[***LnCO2/Capita*** $_{t-1}$]	**-0.052****		**-0.263*****		**-0.054*****		**-0.266*****	
	[0.011]		[0.002]		[0.009]		[0.002]	
LnBSize $_{t-1}$	0.073***	-0.002	0.067	-0.004	0.075***	0.231	0.075	0.201
	[0.000]	[0.497]	[0.329]	[0.338]	[0.000]	[0.128]	[0.271]	[0.195]
%Ind $_{t-1}$	0.042***	0.006*	0.316***	0.006*	0.041***	0.069	0.313***	0.091
	[0.007]	[0.077]	[0.000]	[0.084]	[0.010]	[0.635]	[0.000]	[0.543]
Dual $_{t-1}$	0.014**	0.005***	0.094***	0.005***	0.015**	0.077	0.094***	0.105
	[0.043]	[0.001]	[0.001]	[0.002]	[0.035]	[0.234]	[0.001]	[0.113]
%Female $_{t-1}$	0.115***	-0.013*	-0.093	-0.016**	0.119***	-1.358***	-0.080	-1.463***
	[0.000]	[0.064]	[0.468]	[0.019]	[0.000]	[0.000]	[0.536]	[0.000]
ExCom/TA $_{t-1}$	-0.001	0.001***	-0.009***	0.001***	-0.001*	0.034***	-0.011***	0.034***
	[0.143]	[0.000]	[0.003]	[0.000]	[0.073]	[0.000]	[0.001]	[0.000]
%Skills $_{t-1}$	-0.036**	-0.002	-0.145**	-0.002	-0.035**	0.029	-0.151**	0.029
	[0.020]	[0.561]	[0.023]	[0.573]	[0.023]	[0.840]	[0.018]	[0.841]
LnMeeting $_{t-1}$	-0.013	0.003	-0.124***	0.003	-0.012	0.166**	-0.122***	0.165**
	[0.154]	[0.100]	[0.001]	[0.151]	[0.160]	[0.041]	[0.001]	[0.049]
CSR committee $_{t-1}$	0.116***	0.002	0.611***	0.003*	0.116***	0.177***	0.614***	0.239***
	[0.000]	[0.222]	[0.000]	[0.082]	[0.000]	[0.008]	[0.000]	[0.001]
Ln[assets] $_{t-1}$	0.039***	-0.004***	0.119***	-0.004***	0.039***	-0.235***	0.117***	-0.252***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Debt/Equity $_{t-1}$	-0.007***	-0.001***	-0.011	-0.001**	-0.007***	0.050**	-0.010	0.061***
	[0.001]	[0.009]	[0.267]	[0.019]	[0.002]	[0.016]	[0.295]	[0.005]
Market/Book $_{t-1}$	0.127	0.010	-0.533	0.005	0.116	-4.268***	-0.535	-4.719***
	[0.183]	[0.621]	[0.179]	[0.817]	[0.222]	[0.000]	[0.177]	[0.000]
ROA $_{t-1}$	0.293***	-0.001	1.639***	0.007	0.301***	-3.035***	1.645***	-2.256***

	[0.001]	[0.947]	[0.000]	[0.716]	[0.000]	[0.000]	[0.000]	[0.006]
Quick ratio $_{t-1}$	-0.006*	0.002***	0.005	0.001**	-0.004	-0.019	0.010	-0.023
	[0.055]	[0.004]	[0.666]	[0.041]	[0.220]	[0.493]	[0.428]	[0.404]
EBTD/Assets $_{t-1}$	-0.199**	0.005	-1.126***	0.006	-0.200**	0.268	-1.110***	-0.243
	[0.012]	[0.763]	[0.001]	[0.730]	[0.012]	[0.716]	[0.001]	[0.751]
Fixed/Assets $_{t-1}$	-0.115***	-0.007**	-0.514***	-0.008***	-0.116***	-0.071	-0.518***	-0.131
	[0.000]	[0.025]	[0.000]	[0.010]	[0.000]	[0.570]	[0.000]	[0.305]
Operating income growth $_{t-1}$	-0.000	-0.001	-0.005	-0.001	-0.000	-0.008	-0.005	0.006
	[0.967]	[0.265]	[0.684]	[0.409]	[0.928]	[0.744]	[0.665]	[0.832]
Operating NCF/Assets $_{t-1}$	-0.081	-0.022	-0.836***	-0.027*	-0.089	-2.653***	-0.892***	-2.676***
	[0.208]	[0.125]	[0.002]	[0.065]	[0.171]	[0.000]	[0.001]	[0.000]
GDP Capita Growth	-0.005*	-0.001	-0.015	-0.001	-0.004*	-0.163***	-0.014	-0.161***
	[0.050]	[0.203]	[0.121]	[0.275]	[0.058]	[0.000]	[0.133]	[0.000]
Inflation	-0.016***	0.005***	-0.132***	0.005***	-0.016***	0.386***	-0.130***	0.370***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
R&D/GDP	0.117***	0.000	0.618***	0.001	0.117***	-0.273	0.624***	-0.370
	[0.000]	[0.954]	[0.000]	[0.854]	[0.000]	[0.223]	[0.000]	[0.110]
Trade/GDP	0.004***	-0.000	0.020***	0.000	0.004***	-0.022***	0.020***	-0.026***
	[0.000]	[0.993]	[0.000]	[0.956]	[0.000]	[0.003]	[0.000]	[0.001]
Urban population growth	-0.080***	0.030***	-0.341***	0.032***	-0.080***	2.183***	-0.332**	2.211***
	[0.010]	[0.000]	[0.009]	[0.000]	[0.010]	[0.000]	[0.011]	[0.000]
Country governance quality	-0.095*	-0.005	-0.750***	-0.008	-0.100*	-0.132	-0.773***	-0.139
	[0.097]	[0.644]	[0.002]	[0.469]	[0.082]	[0.752]	[0.001]	[0.750]
Constant	-0.841***	0.066***	-2.139***	0.069***	-0.833***	7.141***	-2.118***	7.700***
	[0.000]	[0.007]	[0.000]	[0.007]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	8,774	8,774	8,428	8,428	8,738	8,738	8,396	8,396
R-squared	0.179	0.040	0.198	0.040	0.180	0.095	0.200	0.097
Wald Chi 2 [p-value]	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***

Table 12:
Two-step Heckman vs Entropy Balancing

*This table reports the robustness results of the Two-step Heckman vs Entropy Balancing method. Control variables include corporate governance, firm characteristics, and country characteristics. Appendix A presents all detailed descriptions of the variables. P-values are reported in square brackets. ***, ** and * denotes 1%, 5% and 10% significance levels.*

	Panel A: Two-step Heckman				Panel B: Entropy balancing			
	[1]	[2]	[3]	[4]	[5]	[6	[7]	[8]
VARIABLES	*COD*	*COD*	*Interest Rate*	*Interest Rate*	*COD*	*COD*	*Interest Rate*	*Interest Rate*
HighEscore^{Treated}	**-0.005*****		**-0.229*****		**-0.003****		**-0.214*****	
	[0.007]		[0.001]		[0.016]		[0.000]	
HighIndex^{Treated}		**-0.003****		**-0.247*****		**-0.003****		**-0.245*****
		[0.048]		[0.000]		[0.034]		[0.000]
LnBSize $_{t-1}$	-0.009*	-0.006	-0.222	0.207	-0.002	-0.004	0.023	-0.164
	[0.099]	[0.102]	[0.338]	[0.169]	[0.640]	[0.195]	[0.887]	[0.342]
%Ind $_{t-1}$	-0.001	0.017***	-0.565***	0.551**	0.012**	0.014***	0.445**	0.612***
	[0.772]	[0.004]	[0.003]	[0.025]	[0.010]	[0.001]	[0.012]	[0.001]
Dual $_{t-1}$	0.006***	0.006***	0.109	0.071	0.001	0.001	-0.025	-0.013
	[0.007]	[0.000]	[0.198]	[0.283]	[0.417]	[0.423]	[0.712]	[0.861]
%Female $_{t-1}$	-0.003	-0.007	-0.720*	-1.322***	-0.002	-0.006	-1.206***	-1.314***
	[0.781]	[0.312]	[0.098]	[0.000]	[0.813]	[0.450]	[0.000]	[0.000]
ExCom/TA $_{t-1}$	0.001***	0.001**	0.035***	0.036***	0.001**	0.001***	0.033**	0.052***
	[0.002]	[0.017]	[0.004]	[0.004]	[0.020]	[0.000]	[0.015]	[0.000]
%Skills $_{t-1}$	0.003	-0.007*	0.286*	-0.187	-0.006**	-0.003	-0.274*	-0.202
	[0.497]	[0.059]	[0.063]	[0.254]	[0.046]	[0.314]	[0.067]	[0.192]
LnMeeting $_{t-1}$	-0.001	-0.000	-0.199**	-0.002	0.001	0.001	0.021	0.021
	[0.645]	[0.987]	[0.033]	[0.987]	[0.672]	[0.652]	[0.818]	[0.824]
CSR committee $_{t-1}$	-0.014*	0.014*	-0.732**	0.653**	0.002	0.004***	0.280***	0.407***
	[0.099]	[0.073]	[0.030]	[0.046]	[0.222]	[0.009]	[0.000]	[0.000]
Ln[assets] $_{t-1}$	-0.009***	-0.002	-0.988***	-0.225***	-0.004***	-0.003***	-0.335***	-0.315***
	[0.001]	[0.105]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Debt/Equity $_{t-1}$	0.001	-0.002***	0.038	0.002	-0.002***	-0.001***	-0.013	0.009
	[0.174]	[0.002]	[0.187]	[0.930]	[0.000]	[0.002]	[0.522]	[0.689]
Market/Book $_{t-1}$	-0.067**	0.007	-3.455***	-3.873***	0.031	0.012	-2.605***	-3.971***
	[0.015]	[0.752]	[0.002]	[0.000]	[0.157]	[0.561]	[0.006]	[0.000]
ROA $_{t-1}$	-0.018	0.027	-2.005*	-0.296	-0.002	0.003	-1.093	-0.755
	[0.534]	[0.288]	[0.088]	[0.781]	[0.924]	[0.844]	[0.320]	[0.464]
Quick ratio $_{t-1}$	0.004***	0.003***	0.074*	0.021	0.001	0.001	-0.037	-0.012
	[0.000]	[0.000]	[0.094]	[0.457]	[0.214]	[0.233]	[0.376]	[0.771]

EBTD/Assets $_{t-1}$	0.044**	0.011	2.110**	-0.051	0.041**	0.035**	1.405	1.212
	[0.043]	[0.596]	[0.019]	[0.953]	[0.039]	[0.044]	[0.158]	[0.193]
Fixed/Assets $_{t-1}$	0.013	-0.017**	0.558	-0.263	-0.001	-0.002	0.453***	0.317**
	[0.311]	[0.032]	[0.298]	[0.426]	[0.711]	[0.519]	[0.000]	[0.010]
Operating income growth $_{t-1}$	-0.000	0.000	-0.008	0.010	-0.000	-0.001	0.022	-0.001
	[0.966]	[0.902]	[0.722]	[0.697]	[0.630]	[0.321]	[0.494]	[0.974]
Operating NCF/Assets $_{t-1}$	0.009	-0.046***	3.079***	-1.971***	-0.047**	-0.062***	-2.930***	-2.859***
	[0.555]	[0.007]	[0.000]	[0.005]	[0.014]	[0.000]	[0.000]	[0.000]
GDP Capita Growth	0.001	-0.001	0.020	-0.121***	-0.002***	-0.001**	-0.181***	-0.168***
	[0.717]	[0.350]	[0.719]	[0.000]	[0.002]	[0.011]	[0.000]	[0.000]
Inflation	0.004**	0.002	0.252***	0.241***	0.004***	0.003***	0.310***	0.284***
	[0.044]	[0.339]	[0.001]	[0.006]	[0.000]	[0.000]	[0.000]	[0.000]
R&D/GDP	0.016	0.004	0.196	-0.680	-0.023***	-0.024**	-1.675***	-1.262**
	[0.330]	[0.737]	[0.770]	[0.220]	[0.006]	[0.012]	[0.001]	[0.015]
Trade/GDP	-0.001**	0.000	-0.055***	-0.029*	0.000	0.001**	-0.017	0.000
	[0.043]	[0.288]	[0.007]	[0.069]	[0.160]	[0.035]	[0.194]	[0.976]
Urban population growth	0.025*	0.016	0.953*	1.421***	0.023***	0.026***	1.605***	1.764***
	[0.059]	[0.230]	[0.075]	[0.009]	[0.000]	[0.000]	[0.000]	[0.000]
Country governance quality	-0.029	0.005	0.886	0.998	0.042**	0.027	2.467***	2.034**
	[0.229]	[0.801]	[0.364]	[0.258]	[0.020]	[0.110]	[0.004]	[0.025]
imr	-0.026	0.025	-2.059**	0.751				
	[0.216]	[0.114]	[0.018]	[0.254]				
Constant	0.265**	-0.032	23.895***	5.892**	0.072	0.072*	9.679***	8.097***
	[0.015]	[0.623]	[0.000]	[0.028]	[0.110]	[0.095]	[0.000]	[0.000]
Observations	9,773	9,878	9,703	9,809	9,878	9,878	9,809	9,809
R-squared	0.511	0.047	0.554	0.092	0.053	0.055	0.143	0.127
Wald Chi 2 [p-value]	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***

Appendix A:
Variable Definition

Variable	Definition [Code]	Sources
COD	Cost of Debt, measured by a firm's interest expense on debt that exhibits the service expense for the firm's use of capital before the reduction for capitalization of interest. COD consists of (but is not limited to) a firm's interest expense on short-term debt, long-term debt and its capitalization of lease obligation as well as the amortisation expense which is related to the firm's debt issuance [WC01251].	*Thompson Reuters' DataStream [TRDS]*
Interest	Estimated average interest rate for a firm, calculated as follows [WC08356]: *Estimated average interest rate = Interest Expense on Debt / (Short Term Debt & Current Portion of Long Term Debt + Long Term Debt) * 100*.	*Thompson Reuters' DataStream [TRDS]*
Eco_Score	Environmental Innovation Score, used to proxy a firm's capability to mitigate environment-related costs and burdens for its customers; thereby generating potential opportunities for the firm's businesses via the application of new environmental technologies into its eco-oriented products and services [TRESGENPIS]. The environmental innovation score for a firm is ranging from 0 to 100.	*Thompson Reuters' DataStream [TRDS]*
Eco_Index	A composite eco-innovation index including five components: Environmental product (EP); Environmental asset under management (EAM); Product environmentally responsible use (PER); Renewable/clean energy product (REP); and Eco-design product (EdP). EP denotes a value of one if the firm reports on one or more product line or service which was designed to affect the environment positively, and zero otherwise. EAM denotes a value of one if the firm reports on assets under management that use environmental screening during their selection process of investment, and zero otherwise. PER denotes the value of one if the firm reports on product features or services promoting responsible, efficient, cost-effective and environmentally preferable use, and zero otherwise. REP denotes a value of one if the firm develops products or technologies for use in the clean renewable energy sector, and zero otherwise. EdP denotes a value of one if the firm reports on specific products designed for reuse and recycling, and zero otherwise.	*Thompson Reuters' DataStream [TRDS] and Authors' calculation*
Carbon risk	Carbon intensity risk is computed as the total of a firm's total carbon dioxide (CO_2) and CO_2 equivalents emission in tonnes [ENERDP023] scaled by the firm's total revenues in USD in million [WC1001].	*Thompson Reuters' Refinitiv Eikon [formerly ASSET4]*
Ln[Z-score]	The logarithm value of Altman Z-score introduced by MacKie-Mason (1990) for measuring a firm's likelihood of bankruptcy in a specific year.	*Thompson Reuters' DataStream [TRDS] and Authors' calculation*
SA Index	Following Hadlock and Pierce (2010), the use of the SA index as our measure of a firm's financial constraints is estimated as the aggregate combination of a firm's asset size and firm age. The SA index is calculated as follows: $SA\ index = (-0.737 * Size) + (0.043 * Size^2) - (0.040 * Age)$. Where: Size is the logarithm value of a firm's book value of assets and Age is the total number of years the firm is listed.	*Thompson Reuters' DataStream [TRDS] and Authors' calculation*
WW Index	Another measure of a firm's financial constraints risk is the WW index which was introduced by Whited and Wu (2006). The WW index is estimated as follows: the WW index = -0.091*CF – 0.062*DIVPOS + 0.021*TLTD – 0.044*LNTA + 0.102*ISG – 0.035*SG. Where: *CF is the cash flow for a firm [WC04860] scaled by its total assets [WC02999]. DIVPOS is a dummy variable that is set equal to one if a firm pays cash dividends in a financial year and set equal to zero otherwise [DY]. TLTD is a firm's total long-term debt scaled by its total assets [WC03251]. LNTA is the logarithm value of a firm's total assets [WC02999]. ISG is the growth rate of an industry based on the 4-digit Standard*	*Thompson Reuters' DataStream [TRDS] and Authors' calculation*

	Industrial Classification (SIC Code 1) [WC07021] provided by Thompson Reuters' DataStream (TRDS). SG is the growth rate of a firm's sales/total revenues [WC1001].	
LnBSize	The logarithm value of the total numbers of a firm's board members at the fiscal year-end [CGBSDP060].	*Thompson Reuters' DataStream [TRDS]*
%Ind	Percentage of a firm's independent board members [CGBSO07V].	*Thompson Reuters' DataStream [TRDS]*
Dual	Dummy variable, which denotes the value of 1 if a firm's CEO simultaneously acts as the chairman of the board and 0 otherwise[CGBSO09V].	*Thompson Reuters' DataStream [TRDS]*
%Female	A firm's percentage of females on board, also known as a proxy for board gender diversity for a firm [CGBSO03V].	*Thompson Reuters' DataStream [TRDS]*
ExCom/TA	Senior executives (top-management)' compensation is the total amount of compensation paid to a firm's all senior executives [CGCPDP054] reported by the firm scaled by its total assets [WC02999].	*Thompson Reuters' DataStream [TRDS]*
%Skills	Percentage of a firm's board members who have either a strong financial background or an industry-specific background [CGBSO04V].	*Thompson Reuters' DataStream [TRDS]*
LnMeeting	The logarithm value of a firm's number of board meetings within a specific year.	*Thompson Reuters' DataStream [TRDS]*
CSR committee	Dummy variable, which denotes the value of 1 if a firm has a CSR committee or team which could be either a senior management committee or its board level that has responsibility for making decisions on the firm's CSR strategy, and 0 otherwise [CGVSDP005].	*Thompson Reuters' DataStream [TRDS]*
Ln[assets]	The logarithm value of a firm's total assets [WC02999]	*Thompson Reuters' DataStream [TRDS]*
Debt/Equity	Leverage proxy for a firm calculated as the percentage of total debt to its equity [WC08231]. The leverage ratio is calculated using the following formula: *Debt/Equity = (Long Term Debt + Short Term Debt & Current Portion of Long Term Debt) / Common Equity * 100.*	*Thompson Reuters' DataStream [TRDS]*
Market/Book	Market-to-Book value for] which is estimated as the firm's market value of the common (ordinary) equity scaled by its common (ordinary) equity reported in the firm's balance sheet [MTBV] with the item code in Worldscope is 03501.	*Thompson Reuters' DataStream [TRDS]*
ROA	Return on assets for capturing a firm's profitability [WC08326] using the following formula: *ROA = (Net Income – Bottom Line + ((Interest Expense on Debt-Interest Capitalized) * (1-Tax Rate))) / Average of Last Year's and Current Year's Total Assets * 100.*	*Thompson Reuters' DataStream [TRDS]*
Quick ratio	Quick ratio for a firm's liquidity ratio [WC08101] which is calculated as: *Quick ratio = Cash & Equivalents + Receivables (Net)) / Current Liabilities-Total.*	*Thompson Reuters' DataStream [TRDS]*
EBTD/Assets	Earnings before income taxes, depreciation and amortization for a firm scaled by its total assets].	*Thompson Reuters' DataStream [TRDS]*
Fixed/Assets	A firm's fixed assets, also known as tangibility, that represents the firm's net value of property, plant and equipment (PPE) less the firm's accumulated reserves for its amortization, depletion, and depreciation [WC02501] then scaled by its total assets [WC02999].	*Thompson Reuters' DataStream [TRDS]*
Operating income growth	The growth rate of a firm's operating income [WC01250]. Where: *Operating income = Interest Income-Total (01016) + Non-Interest Income (01021) – Interest Expense-Total (01075) – Non- Interest Expense (01245) – Provision for Loan Losses (01271).*	*Thompson Reuters' DataStream [TRDS] and Authors' calculation.*
Operating net cash flow/Assets	A firm's net cash flow earned from its operating activities [WC04860] scaled by its total assets [WC02999]. The net operating cash flow exhibits the firm's net cash receipts and disbursements resulting from its operations. This	*Thompson Reuters' DataStream [TRDS]*

	item is calculated as the total of the firm's funds from operations, funds used or for its other operating activities, and extraordinary items.	
GDP Capita Growth	The annual growth rate of a country's GDP per capita to which a firm belongs [NY.GDP.PCAP.KD.ZG].	*World Development Indicators of World Bank [WDIs-WB]*
Inflation	A country's inflation, GDP deflator (annual %).	*World Development Indicators of World Bank [WDIs-WB]*
R&D/GDP	A country's research and development expenditure as % of GDP [GB.XPD.RSDV.GD.ZS].	*World Development Indicators of World Bank [WDIs-WB]*
Trade/GDP	Trade (% of GDP), which is the ratio of trade measured by the sum of exports and imports of goods and services and GDP	*World Development Indicators of World Bank [WDIs-WB]*
Urban population growth	A country's Urban population growth (annual %) for capturing its urbanization [SP.URB.GROW].	*World Development Indicators of World Bank [WDIs-WB]*
Country governance quality	A country's aggregate governance quality index, which captures the aggregate likelihood value of the following sub-categories of the country: 1- Control of Corruption, 2- Government Effectiveness, 3- Political Stability and Absence of Violence/Terrorism, 4- Regulatory Quality, 5- Rule of Law, and 6- Voice and Accountability. Each of the sub-categories is ranging approximately from -2.5 to 2.5.	*World Governance Indicators of World Bank [WGIs-WB]*
Additional variables		
Eco_age	The number of years a firm has positive eco-innovation scores	*Thompson Reuters' DataStream [TRDS] and Authors' calculation*
CliGovInx	A composite climate governance index with three components: board-level environmental committee (i.e., Env_committee: taking the value of one if the firm has a board-level environmental committee, and zero otherwise); sustainability reporting (i.e., Sus_report: taking the value of one if the firm publishes a sustainability report and zero otherwise); climate incentives (i.e., Climate_incentive: taking the value of one if the firm provides incentives for individual management of issues and matters relevant to climate change, and zero otherwise). The composite index, therefore, reflects the climate governance strength of a firm, with a range of (0-3).	*Thompson Reuters' DataStream [TRDS] and Authors' calculation*
ESG	The overall score of a firm's environment, social, and governance performance by Refinitiv Eikon [TRESGS]. The ESG scores range from 0 to 100.	*Thompson Reuters' Refinitiv Eikon [formerly ASSET4]*
Interest_5years	5-year estimated average interest rate, estimated as the arithmetic average of a firm's interest rates within the last five years on average [WC08360].	*Thompson Reuters' DataStream [TRDS]*

Appendix B:
A Brief of Related literature

Eco-innovation			
Citation	**Main variable**	**Variables**	**Sign**
Zaman *et al.* (2021)	Eco-innovation score	*Independent*	-
Nadeem *et al.* (2020)	Process and product eco-innovation	*Dependent*	+
Arena *et al.* (2018)	Product eco-innovation	*Dependent*	+
Cost of Debt			
Regenburg and Seitz (2021)	Interest rate	*Dependent*	+
Eliwa *et al.* (2021)	Interest expense to the average debt	*Dependent*	+
Altieri (2021)	Yield spread	*Dependent*	+
Mansi *et al.* (2021)	Yield spread	*Dependent*	+
Arifin, Hasan, and Kabir (2020)	Interest rate	*Dependent*	-
Gao *et al.* (2020)	Yield Spreads	*Dependent*	-
Palea and Drogo (2020)	Interest expense on the average debt	*Dependent*	+
Li *et al.* (2019)	Average interest rate	*Dependent*	-
Tee (2018)	Interest expense to average debt	*Dependent*	+/-
Zhou *et al.* (2018)	Interest expense to interest-bearing debt average	*Dependent*	+/- U-shaped
Isin (2018)	All-in-Spread-Drawn	*Dependent*	+
Ni and Yin (2018)	Cost of bank loans	*Dependent*	+
La Rosa *et al.* (2018)	Interest rate and credit rating	*Dependent*	-/+
Jung *et al.* (2018)	Interest expense	*Dependent*	+
Chakravarty and Rutherford (2017)	All-in-Spread-Drawn	*Dependent*	-
Huang *et al.* (2016)	Credit ratings and yield spreads	*Dependent*	-
Borisova *et al.* (2015)	Credit spreads	*Dependent*	+
Chen and King (2014)	Yield spread	*Dependent*	-
Byun *et al.* (2013)	*Credit spread*	*Dependent*	-
Bradley and Chen (2011)	Credit rating and yield spread	*Dependent*	+/-
Qi *et al.* (2010)	Yield spread	*Dependent*	-
Qiu and Yu (2009)	Credit spread	*Dependent*	+

Appendix C:

The tabulation of the G7 countries including financial firms [Panel A] and excluding financial firms [Panel B] for the period 2000-2020

COUNTRY NAME	**Freq.**	**Percent**	**Cum.**	**COUNTRY NAME**	**Freq.**	**Percent**	**Cum.**
Panel A: Financial firms				Panel B: Non-financial firms			
Canada	5,040	8.93	8.93	Canada	4,800	8.94	8.94
France	840	1.49	10.42	France	780	1.45	10.39
Germany	840	1.49	11.9	Germany	800	1.49	11.88
Italy	840	1.49	13.39	Italy	800	1.49	13.37
Japan	4,725	8.37	21.76	Japan	4,500	8.38	21.74
United Kingdom	12,558	22.25	44.01	United Kingdom	11,960	22.26	44.01
United States	31,605	55.99	100	United States	30,080	55.99	100
Total	56,448	100		Total	53,720	100	

Appendix D:
Classification of polluting sectors and innovative sectors

Polluting sectors			Innovative sectors		
Industry group code	**SIC 1**	**Industry group name**	**Industry group code**	**SIC 1**	**Industry group name**
2510	2821	Diversified Chemical Manufacturers	1310	4581	Engines, Components & Parts Manufacturers
2520	2671	Household Chemicals	1320	3721	Military & Commercial Aircraft Manufacturers
2530	2813	Industrial Chemicals & Gases Manufacturers	1350	3721	Miscellaneous Aerospace
2540	2851	Paint & Resin Manufacturers	1610	5651	Apparel Manufacturers
2550	3842	Rubber & Tire Manufacturers	1620	3149	Diversified Apparel Manufacturers
2570	2821	Synthetic Fibers	1640	3021	Shoe Manufacturers
2580	2879	Miscellaneous Chemicals	1900	3711	Automotive
2810	7359	Diversified Construction Companies	1910	3711	Diversified Automotive Manufacturers
2820	NA	Brick, Clay & Refractory Products	1920	2396	Original Parts & Accessories Manufacturers
2830	NA	Builders' Metal Products	1930	3714	Replacement Parts & Accessories Manufacturers
2840	NA	Cement Products	1940	3711	Truck & Trailer Manufacturers
2850	NA	Construction Aggregates	2510	2821	Diversified Chemical Manufacturers
2870	NA	Engineering & Contracting Services	2520	2671	Household Chemicals
2880	NA	Home Builders	2530	2813	Industrial Chemicals & Gases Manufacturers
2890	NA	Gypsum, Lumber & Building Supplies	2540	2851	Paint & Resin Manufacturers
2892	NA	Prefabricated & Mobile Home Builders	2550	3842	Rubber & Tire Manufacturers
2893	NA	Miscellaneous Construction	2570	2821	Synthetic Fibers
5200	NA	Metal Producers	2580	2879	Miscellaneous Chemicals
5210	NA	Diversified	2810	7359	Diversified Construction Companies
5220	NA	Aluminum Producers	3410	2834	Diversified
5230	NA	Copper Producers	3420	2844	Cosmetics & Toiletries
5240	NA	Gold Producers	3430	2834	Ethical Drug Manufacturers
5250	NA	Iron Ore Producers	3440	3841	Medical, Surgical & Dental Suppliers
5260	NA	Lead & Zinc Producers	4010	8249	Diversified
5270	NA	Silver Producers	4020	3823	Automatic Controls
5280	NA	Steel Producers - Integrated	4030	3571	Electronic Data Processing Equipment
5290	NA	Steel Producers - Non-Integrated	4040	3483	Government & Defense Electronic Systems
5291	NA	Steel Producers - Specialty	4050	3825	Instruments, Gauges & Meters
5292	NA	Miscellaneous Metal Producers	4060	3674	Parts & Components

5510	NA	Diversified	4070	3651	Radio, T.V. & Phonograph Manufacturers
5520	3562	Bearing Manufacturers	4080	7372	Systems & Subsystems
5530	NA	Metal Containers	4090	7372	Miscellaneous Electronics
5550	NA	Supplies & Distributors	4310	6022	Commercial Banks - Multi-Bank Holding Companies
5560	NA	Wire, Chain & Spring	4320	6029	Commercial Banks - One Bank Holding Companies
5570	3491	Miscellaneous Metal Products Manufacturers	4370	6331	Insurance Companies
5810	NA	Coal Producers	4394	7372	Securities Brokerage Firms
5820	NA	Crude Oil & Natural Gas Producers	4395	7359	Miscellaneous Financial
5830	7371	Holding Companies	4960	3826	Gauges & Meters Manufacturers
5850	NA	Integrated International Oil Producers	4992	7359	Miscellaneous Machinery & Equipment
5860	NA	Liquefied Petroleum Gas Distributors	5520	3562	Bearing Manufacturers
5870	NA	Exploration, Drilling Service & Equipment	5570	3491	Miscellaneous Metal Products Manufacturers
5880	2911	Oil Refiners & Distributors	5830	7371	Holding Companies
5890	NA	Miscellaneous Oil, Gas & Coal	5880	2911	Oil Refiners & Distributors
6110	NA	Diversified	6450	7371	Miscellaneous Printing & Publishing
6120	NA	Packaging Products	6710	7372	Games & Toys
6130	NA	Printing & Writing Paper	7091	5045	Miscellaneous Retailers
6140	NA	Miscellaneous Paper	7970	7359	Miscellaneous Transportation
8210	4813	Communications	8210	4813	Communications
8220	NA	Electric Power Companies	8550	8093	Medical Services
8230	NA	Electric Power Holding Companies	8570	2835	Scientific Equipment & Supplies
8240	NA	Electric Power & Gas Companies	8580	7372	Service Organizations
8250	NA	Natural Gas Distributors	8591	5045	Wholesalers
8260	NA	Natural Gas Holding Companies	8592	7372	Miscellaneous Companies
8270	NA	Natural Gas Pipelines			
8280	NA	Water Companies			

Note: Following the literature (Görgen et al, 2020; Nguyen, 2017), we classify our sample firms that belong to polluting sectors in which those firms are determined with a high level of carbon emission intensity. Based on the ten major Global Industry Classification Standard (GICS), the three sectors recognised as having the highest carbon intensity are Energy, Utilities, and Materials. Given this cross-country evidence for G7 countries, we employ Industry group code [WC06011] in addition to the use of 4-digit Standard Industrial Classification [SIC 1] provided by Thompson Reuters' DataStream (TRDS) for the two-step classification. Since SIC codes are available only for the US markets; hence, they are labelled as "Not Applicable" (NA) in this Appendix. Employing the two-step classification for polluting sectors, we classify innovative sectors following the classification by the report of Science, Technology and Industry Scoreboard by OECD (2021)

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