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The impact of carbon awareness, country-governance, and innovation on the cost of equity: Evidence from oil and gas firms

Nohade Nasrallah [a], Rim El Khoury [b], Osama F. Atayah [c], Hazem Marashdeh [d,*], Khakan Najaf [e]

[a] Excelia Business school France – CERIIM, France
[b] Lebanese American University, Byblos, Lebanon
[c] College of Business, Canadian University Dubai, United Arab Emirates
[d] College of Business, Abu Dhabi University, Abu Dhabi, United Arab Emirates
[e] College of Business, Liwa College, United Arab Emirates

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ABSTRACT

The present paper explores the impact of carbon awareness on the cost of equity (COE) with a keen focus on the influence of country governance and innovation factors. Drawing on Bloomberg data spanning from 2011 to 2022, our analysis encompasses 263 firms within the Oil and Gas sector across 50 countries, culminating in 2122 annual observations. Through the employment of a comprehensive suite of regression analyses—including median regression, M-estimator regression, and MM-estimator regression, alongside Firm-Fixed Effect and Reverse Causality Models—we uncover a consistently negative association between carbon awareness and COE. Our investigation further assesses the effect of country-level governance on COE, revealing a universally negative correlation. Among governance indicators, regulatory quality emerges as a particularly significant factor. Similarly, we observe a consistent negative relationship between country-level innovation and COE, reinforcing the significance of national innovation capabilities in financial performance metrics. These findings remain robust across a range of tests, underscoring their reliability and relevance. The study is important for policymakers, investors, managers, and strategic environmentalists.

1. Introduction

The need for firms to raise carbon awareness is paramount (Subramaniam et al., 2015). Managing climate change risk becomes a strategic factor for corporate success, competitiveness, and economic resilience (Sharfman and Fernando, 2008). Nowadays, businesses increasingly focus on reducing carbon emissions due to global concerns. Shareholders and creditors evaluate a firm's sustainability and make investment decisions based on disclosed carbon information (Siddique et al., 2021). In parallel, regulators stakeholders are also concerned about corporate impact on carbon emissions, pressuring companies to disclose more carbon-related information. In response, companies often set goals like carbon neutrality and peak carbon emissions to signal their awareness and commitment to sustainability. Carbon awareness is the firm's capability to proactively identify key risks arising from carbon-related

* Corresponding author.
E-mail addresses: nohade.kassis@gmail.com (N. Nasrallah), rim.elkhoury01@lau.edu.lb (R. El Khoury), Dr.osamaatayah@gmail.com (O.F. Atayah), hazem.marashdeh@adu.ac.ae (H. Marashdeh), khakan.nj@gmail.com (K. Najaf).

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issues and seriously consider potential consequences (Zsóka, 2008; Hunjra et al., 2024).

From another viewpoint, considering corporate heterogeneous environmental strategies is crucial in the context of the industry's standards (Li and Ramanathan, 2018). Industry significantly affects debt financing costs and carbon disclosure (Fernández-Cuesta et al., 2019) and inherent constraints require sustainable practices. This is particularly relevant for heavy and high-polluting industries like Oil and Gas, characterized by heavy dependence on carbon-intensive operations and high exposure to environmental and geopolitical risks. Mandatory reporting, as per the Companies Act 2006 Regulations, has a mitigating effect on reducing Greenhouse Gas emissions (Downar et al., 2021). Previous studies have explored carbon emissions' impact on firm performance (Caragnano et al., 2020; Maaloul, 2018). A nuanced stream contributes to weighing the dynamic effect of carbon awareness on firms' cost of capital as an appropriation to understand better companies' vigilance and strategies to monitor their polluting levels. Yet, it is important to highlight that a limited number of studies specifically address this issue within the oil and gas industry context. Shad et al. (2020) find a negative relationship between sustainability reporting and the cost of capital in Malaysian oil and gas companies.

As prior studies were not conclusive in exploring the impact of carbon performance, the issue appears highly entangled in how debt and equity markets assess companies' carbon risk, particularly in conjunction with country governance quality and mechanisms. This latter factor is pivotal in facilitating firms' access to external funds. On another echelon, it is widely acknowledged that firms operating in high-innovation environments experience a lower cost of equity capital, influencing thereby many channels such as economic growth, global competitiveness, financial systems, quality of life, infrastructure development, employment, trade openness, and ultimately giving rise to robust economic expansion (Corrado et al., 2013; Dachs and Peters, 2014; Petrakis et al., 2015).

Accordingly, the present study contributes to exploring the impact of carbon awareness on the cost of capital in the oil and gas industry. We rely on a representative sample of 2122 firm-years and control for unobserved variations or macroeconomic factors that might influence the cost of equity (COE) and carbon awareness across countries or over time. We account for country-level governance settings using the World Bank Worldwide Governance Indicators. We utilize an aggregate index (efficiency), representing the dummies average of the six country-level governance characteristics, namely, control of corruption, government effectiveness, political stability, regulatory quality, rule of law, and voice and accountability as these indicators are inherently interconnected, exhibiting strong positive correlations. We also consider the impact of country-level innovation on COE utilizing four indicators: government expenditures on education, journal articles, R&D expenditure, and patent applications by including an aggregate measure of innovation and then incorporating each dimension separately.

This paper makes several key contributions to the existing literature on carbon awareness and the cost of equity (COE), particularly within the oil and gas industry. While a growing body of research explores the effects of carbon emissions on firm performance, the relationship between carbon awareness and COE remains underexplored, particularly in carbon-intensive sectors like oil and gas, which are heavily reliant on fossil fuels and face significant environmental risks. This study addresses this gap by focusing specifically on the oil and gas industry, offering insights that are distinct from broader industry studies and addressing the industry's unique environmental and financial challenges. First, the study contributes to the literature by focusing on a carbon-intensive industry that has been relatively underexplored in terms of how carbon awareness affects COE. Although previous studies, such as Caragnano et al. (2020), Lee et al. (2019), and Maaloul (2018), have examined the impact of carbon emissions and sustainability efforts on firm performance and the cost of debt, they have not provided a focused analysis on the cost of equity specifically within the oil and gas sector. This paper advances the field by providing new insights into how carbon awareness influences equity costs, offering a nuanced perspective on how carbon mitigation strategies affect financial outcomes in an industry with high environmental and regulatory exposure. Second, the paper extends the existing literature by incorporating country-level governance as a direct factor affecting COE. Using the World Bank's Global Governance Indicators, this study examines how governance quality directly influences the cost of equity. Unlike previous research, which often overlooks the role of governance in shaping firm-level financial outcomes, this study underscores the importance of strong institutional environments. This is a key distinction from prior work such as Lee et al. (2019), which did not account for governance as a significant factor in financial performance. Third, the study integrates country-level innovation into the analysis, exploring how national innovation capabilities can mitigate financial risks. This contribution addresses a gap in the literature by linking innovation—through indicators such as R&D expenditure, patent applications, and education spending—with lower COE for firms. It also expands on previous studies by showing how national innovation efforts can enhance firms' financial resilience in the face of environmental risks, an aspect that was not covered in Caragnano et al. (2020) and Maaloul (2018). Fourth, the research makes a methodological contribution by employing a robust analytical approach that includes median regression, M-estimator regression, MM-estimator regression, as well as Firm-Fixed Effect and Reverse Causality Models. These advanced statistical techniques ensure the reliability of the findings and address potential endogeneity and unobserved heterogeneity, issues that are prevalent in financial studies involving environmental variables. By incorporating these methods, the study contributes novel empirical evidence to the literature and demonstrates the effectiveness of robust regression techniques in analyzing complex relationships between carbon awareness, governance, innovation, and financial performance—an approach that goes beyond the more conventional methods used in prior studies like Lee et al. (2019) and Caragnano et al. (2020). Finally, this study offers practical implications for policymakers, investors, and managers in the oil and gas industry. It suggests that increasing carbon awareness can lead to lower equity costs, particularly in countries with strong governance and high levels of innovation. These findings provide actionable insights for firms aiming to reduce their cost of capital by improving their environmental practices and aligning more closely with national innovation strategies. This focus on actionable insights for firms and policymakers differentiates this paper from previous studies, as it not only explores theoretical implications but also offers concrete steps for industry practitioners to enhance financial and environmental performance.

The findings indicate a negative association between carbon awareness and the cost of equity, across all models. Firms with less carbon mitigation are penalized with greater equity costs, suggesting that commitment to climate change mitigation corresponds to

lower costs of equity. Our result reinforces that investors find carbon mitigation commitment valuable, eliciting a favorable response, and aligning with the broader trend of environmental responsibility and sustainability in corporate practices. When incorporating country-level governance, we find a negative correlation with the cost of equity. Notably, regulatory quality stands out as the most pronounced impactful component. When considering the impact of country-level innovation, our results reveal a negative correlation between all country-level innovation and the cost of equity, consistent across all models. Higher levels of innovation can lead to improved efficiency in the economy, as new technologies and processes are developed and implemented. The results remain the same after a battery of robustness tests.

The remainder of the paper continues as follows. In Section 2, we provide the theoretical backgrounds by relying on information asymmetry and signaling theory. Section 3 provides a full explanation of the methodology, sample, and variables description. We discuss our main findings in Section 4 and conclude with Section 5.

2. Theoretical background and hypotheses

Recently, there has been a notable increase in carbon awareness and disclosure debates. Carbon awareness is crucial for businesses as it uncovers the extent of harmful environmental consequences such as climate change and global warming (Al-Fakir Al Rabab'a et al., 2023). Adopting carbon awareness policies can give businesses a competitive edge and more sustainable practices can prevent businesses from becoming obsolete (Garzón-Jiménez and Zorio-Grima, 2021). Carbon awareness debate motivates businesses to disclose their sustainability efforts and proactive initiatives that might reduce the level of their carbon emissions (Kalu et al., 2016; Bagh et al., 2024). In this regard, carbon disclosure is influenced by several factors such as information transfer factor, cost factor, regulatory requirement factor, market pressure, and stakeholder expectations (Li et al., 2018). Those factors are grounded by many theoretical perspectives.

Stakeholder theory posits that organizations must consider the interests of all stakeholders, including investors, customers, employees, and the community (Freeman and Reed, 1983). Green innovation improves stakeholder relationships, reduces perceived risks, and enhances financial performance by attracting socially conscious investors and increasing trust, thereby lowering the cost of equity (Jones, 1995). This theory emphasizes the importance of transparency in environmental practices and how it can influence investor behavior and firm valuation. The Resource-Based View (RBV) suggests that firms with valuable, rare, inimitable, and non-substitutable (VRIN) resources—such as advanced technologies, brand reputation, or strong managerial capabilities—can achieve a competitive advantage (Barney, 2001). Building on this, the Natural Resource-Based View (NRBV) suggests that a firm's resources and capabilities, particularly in managing environmental issues, can provide a competitive advantage (Hart, 1995). Firms that innovate in green technologies and demonstrate strong governance in their environmental practices can differentiate themselves in the market, leading to improved financial performance and lower costs of equity, as they are perceived as lower risk by investors (Alkebsee et al., 2023). In addition, the shareholder risk perspective highlights that green innovation mitigates environmental risk, lowering the equity risk premiums demanded by investors. As firms improve their sustainability practices, they reduce litigation, reputation, and regulatory risks, leading to lower perceived risk and reduced COE (Miles and Covin, 2000). This aligns with Agency Theory (Meckling and Jensen, 1976), which emphasizes aligning management and shareholder interests to enhance firm value through sustainable practices. When management prioritizes green innovation and transparency in carbon emissions, it can enhance shareholder value and lower the cost of equity by reducing perceived risks associated with environmental liabilities (Eisenhardt, 1989). The investor base perspective complements this by showing how green innovation expands a firm's investor base. Non-green firms face higher capital costs due to a shrinking pool of ethical investors, while firms engaging in eco-friendly practices attract a broader range of investors, enhancing risk-sharing and lowering the COE (Elmawazini et al., 2022). This perspective aligns with Signaling Theory where transparent disclosures of sustainability efforts reduce information asymmetry and attract investors, further lowering the COE (Connelly et al., 2011). Information asymmetry might lead to misguided investment choices while a higher level of carbon information disclosure is associated with a lower level of information asymmetry, leading to a direct reduction of the cost of equity. Institutional Theory also plays a critical role in understanding how firms respond to external pressures and regulatory frameworks (Scott, 2008). Firms operating in countries with strong environmental governance are more likely to adopt green innovations, improving their carbon performance and reducing their COE. Resource Dependence Theory (Pfeffer and Salancik, 2015) suggests that firms engaging in sustainability attract the necessary resources—such as funding and partnerships—by being perceived as stable and responsible, further reducing their COE. Finally, Targeted Disclosure Cycle (TDC) Theory (Verrecchia, 1983) explains how firms manage the timing of their disclosures to optimize investor perceptions, reduce information asymmetry, and lower perceived risk, contributing to a lower COE.

Studies on carbon emissions disclosure and its impact on the cost of equity yield mixed results, showing positive, negative, and U-shaped associations. Some research highlights the role of controlling factors, environmental dimensions, and investors' perceptions of risk and stock liquidity in shaping this relationship. A higher extent of information disclosure positively affects stock liquidity, reducing thereby the risk level which in turn leads to a decreasing cost of equity (Li et al., 2019). Du et al. (2017) find that lenders take into account and reward or penalize firms based on environmental performance. Kumar and Firoz (2018) and Maaloul (2018) find that carbon emissions are positively and significantly associated with the cost of debt financing. Kim et al. (2015) conclude to a positive relationship between carbon risk and the cost of equity. They also argue that this relationship is greater for companies belonging to industries with lower environmental sensitivity. Balachandran and Nguyen (2018) report that carbon risk hurts the stability of earnings, affecting dividend payments. Maaloul (2018) finds that the cost of debt is positively associated with total carbon emissions and carbon intensity while Hamm et al. (2021) find a positive association between the cost of debt and carbon risk but they also show that this relationship was negated for firms with high carbon risk awareness. By examining a diverse dataset of 1897 firms spanning over 50 different countries throughout the period 2008–2016, Trinks et al. (2022) find a positive association between carbon emission

on the cost of equity capital. Another research stream indicates a negative association between carbon disclosure and the cost of capital (He et al., 2013). Drawing on a dataset of companies listed on NASDAQ, Albarrak et al. (2019) find that firms opting to voluntarily disclose carbon-related information via Twitter generally experience a decrease in their cost of equity. Moreover, Zhou et al. (2018) find a significant U-shaped relationship between carbon disclosure and cost of capital. Based on the previous theories and empirical studies, we propose the following hypothesis:

Hypothesis 1. (H1): carbon awareness affects negatively the cost of equity.

According to Kaufmann et al. (2011), country governance refers to the authorized exercise of power, guided by established traditions, laws, and institutions, for the public administration of a nation's social and economic resources. It is specifically defined as "the traditions and institutions by which authority in a country is exercised" (Kaufmann et al., 2011). Governance is evaluated using six indicators related to three domains: government selection, monitoring, replacement, policy formulation and implementation, and citizen and state adherence to institutions. Key indicators include voice and accountability, political stability, effectiveness, regulatory quality, rule of law, and corruption control. The governance quality of a country helps firms to access external funds on favorable terms by mitigating agency conflicts. Strong corporate governance reduces agency costs, restricts managerial discretion, protects investors, and lowers risk premiums on long-term funds. Robust governance mechanisms increase expropriation costs for dominant shareholders, limit their control over firms, enhance financial market monitoring, and reduce the likelihood of firms taking excessive risks or engaging in asset substitution. Secondly, following the law and finance literature, a country's institutional environment can directly contribute to mitigating agency problems. For instance, Demirgüç-Kunt and Maksimovic (1999) argue that the institutional environment of a country, which facilitates monitoring and enforcement of appropriate financial contracts, can control agency costs. Conversely, rational investors limit their funding to poorly governed countries, where the risk of significant expropriation and corruption is higher. Legal protections at the country level may also influence firms' choices in adopting their governance provisions (Doidge et al., 2007). As a result, they differ in the limitations they place on managerial and large shareholder discretion (Aslan and Kumar, 2014), shaping the national institutional environment and the strength of firms' external monitoring forces (Judge et al., 2008). La Porta et al. (1998) argue that the differences in legal protections of investors might help explain the variations in how firms are financed and owned in different countries. Hail and Leuz (2006) demonstrate that firms from countries with more extensive disclosure requirements, stronger securities regulation, and stricter enforcement mechanisms experience a significantly lower cost of capital, enhancing their ability to raise external funds and capitalize on growth opportunities. Daniel et al. (2012) empirically demonstrate that firm-level governance practices are related to the country's institutional environment. Country-level governance quality significantly influences investments, with good quality reinforcing economic growth. Additionally, poor governance mechanisms can create ambiguity and heightened policy uncertainty (Pástor and Veronesi, 2012), leading to more volatile markets, especially during turbulent periods. Greater uncertainty is a challenge for both individuals and firms in making forward-looking decisions; it substantially increases the cost of equity. In line with these arguments, we posit that in poorly governed countries, external equity holders demand higher risk premiums on equity capital due to the elevated risk of expropriation by managers or public officials (Alves and Ferreira, 2011). In contrast, in better-governed countries, equity capital becomes less costly. Thus, all else being equal, we hypothesize that better country governance corresponds to a lower cost of equity.

Hypothesis 2. (H2): Country-level governance is inversely related to the cost of equity.

Other influential country-level variables can affect firms' cost of equity. For example, certain studies suggest that country-policy uncertainty commands a premium on equity risk due to inherent undiversifiable political risk (Pástor and Veronesi, 2012). The escalation of economic policy uncertainty diminishes financial stability, leading to an augmented cost of equity and reduced innovation (Phan et al., 2021). The study suggests that firms in high-innovation environments experience a lower cost of equity capital due to three pathways. Firstly, country-level innovation helps firms project a positive image, attracting investors and broadening their investor base. However, there is limited research on the impact of country-level innovation on equity cost. A diverse investor base, with heterogeneous risk preferences and trading motives, is crucial for optimal funding. Existing literature indicates that effective risk-sharing among a broader set of capital providers results in a reduced cost of capital (Dhaliwal et al., 2011). Secondly, from the shareholders' perceived risk exposure viewpoint, country-level innovation may influence firm performance and value, reducing uncertainty and leading to a lower cost of equity financing. Bena and Garlappi (2020) propose a theoretical model illustrating the causality from patented innovation to expected returns, measured by the cost of equity in asset pricing models. Their study suggests that patented innovation decreases the Capital Asset Pricing Model (CAPM) beta, leading to a reduction in expected returns. Country-level innovation, similar to firm-level innovation, can impact the cost of equity by affecting economic policy uncertainty and growth. Policymakers widely recognize innovation as a catalyst for economic advancement, highlighting its potential to influence equity costs.

In the realm of economic drivers, innovation is widely acknowledged as a pivotal force (Andergassen et al., 2009), influencing channels such as economic growth, global competitiveness, financial systems, quality of life, infrastructure development, employment, trade openness, and ultimately giving rise to robust economic expansion (Petrakis et al., 2015). Additionally, other studies differentiate between innovation input and output. Innovation input, such as research and development expenditure (R&D), can significantly increase analysts' estimates of the cost of equity, reflecting the uncertainty arising from the risky nature of R&D investment (Shi, 2003). Innovation output, such as patents in the technology sector, can negatively impact analysts' estimates of the cost of equity. Innovation output generates lower variance in future cash flow distribution, reducing a company's R&D risk. Research suggests that innovation input increases uncertainty, while innovation output decreases it. However, some studies suggest that more innovation input and output raise investors' expected excess return. This paper posits that as the level of innovation at the country level increases, the cost of

equity for firms operating within that innovative environment will decrease. This hypothesis is based on the potential positive effects of country-level innovation on investor perceptions, risk reduction, and economic growth.

Hypothesis 3. (H3): Country-level innovation is inversely related to the cost of equity.

3. Data and methodology

3.1. Data

The analysis leverages data from Bloomberg, covering the period from 2011 to 2022, encompassing 263 firms across 50 countries, resulting in 2122 annual observations (firm-year) after filtering out entries with missing data. To mitigate the influence of outliers, we applied a winsorization process to all variables at the 1 % and 99 % levels. Additionally, to maintain rigor in our analysis, we ensured that the Variance Inflation Factor (VIF) values post-regression did not exceed 5.

3.2. Variables

3.2.1. Dependent variable

There are various terms for the Cost of Equity. In this study, we use the firm-level weighted average cost of equity defined by Bloomberg ($Equity_{it}$).

3.2.2. Independent variables

For H1, we focus on the association between carbon awareness ($Carbon_{it}$) at the firm level and the cost of equity. $Carbon_{it}$ is considered as a dummy variable, taking the value of "1" if there is high carbon awareness in the firm and "0" otherwise. Meanwhile, H2 investigates the relationship between $Efficiency_{jt}$ at the country level and the Cost of Equity. $Efficiency_{jt}$ is proxied by the average of the dummies, representing the six components of country governance which are country-level corruption, government effectiveness, political stability, regulatory quality, rule of law, and voice and accountability. Each component dummy is calculated as 1 if the component's score is above the average, and 0 otherwise. In this paper, we separately regress each of the proxied variables on the Cost of Equity. For H3, we examine the relationship between $Innovation_{jt}$ at the country level and the Cost of Equity. Similarly, $Innovation_{jt}$ is proxied as the average of the dummies of four components which are country-level governance expenditure on education, journal articles, R&D expenditure, and patent applications. Each component dummy is calculated as 1 if the component's score is above the average, and 0 otherwise. In this paper, we separately regress each of the proxied variables on the Cost of Equity.

3.2.3. Control variables

In this research, we used firm-level control variables such as board size (number of board members), ROA (profit before tax and interest/total assets), Firm Size (Log of total assets), audit committee (audit committee members), leverage, Tobin's Q Ratio, Altman Z-score, and profit margin (profit after tax/ sales) of the firm based on prior studies (Najaf et al., 2022). Following prior studies of carbon risk awareness and the cost of equity (Jung, et.al, 2018), we account for unobserved time-variant effects. Appendix A defines all variables.

3.3. Methodology

Previous research has illuminated how increased carbon emissions can elevate a firm's cost of capital. This study seeks to delve into the nuanced association between carbon risk awareness and the cost of equity, while also examining the effects of governance and innovation on both a country and micro/macro level. Our hypotheses probe into three distinct relationships: between carbon risk awareness and COE (Eq. 1), the influence of country-level efficiency (Eq. 2), and the impact of country-level innovation on the cost of equity (Eq. 3).

$$Equity_{it} = \alpha + \beta_i Carbon_{it} + \sum_{i=1}^{n=8} Controls_{it} + \varepsilon_{it} \tag{1}$$

$$Equity_{it} = \alpha + \beta_i efficiency_{jt} + \sum_{i=1}^{n=8} Controls_{it} + \varepsilon_{it} \tag{2}$$

$$Equity_{it} = \alpha + \beta_i Innovation_{jt} + \sum_{i=1}^{n=8} Controls_{it} + \varepsilon_{it} \tag{3}$$

Where i denotes the firm, t refers to the year; j refers to the country, and εit is the error term at year t for each model.

In our regression analysis, we adopt several methods to explore the relationships among our test variables. Initially, the Ordinary Least Squares (OLS) regression model was used as our foundational approach, adjusting for both country-specific factors and year-fixed effects. Additionally, we cluster the regression analysis at the country level to further refine our understanding. Second, median regression was used to minimize the sum of absolute deviations, making it less sensitive to outliers compared to ordinary least squares

(OLS) regression. Third, M-estimator regression reduces the influence of outliers by applying a weighting function to the residuals, improving robustness in the presence of non-normal error distributions. Third, the MM-estimator regression combines the robustness of M-estimators with a high breakdown point, providing efficient and reliable estimates even with contaminated data. The MM-estimator regression was chosen due to its robustness against outliers and its high breakdown point, which makes it particularly suitable for financial data that may contain extreme values or non-normal distributions. The efficiency level of 70 % was selected to balance robustness and statistical power, providing robust estimates while maintaining a reasonable degree of efficiency. This decision was validated through sensitivity analyses conducted at various efficiency levels (95 %), which consistently demonstrated the robustness of our findings. Additionally, MM-regression outlier test scatterplot was employed to identify potential outliers that could skew the regression results, with most data points clustering near the model's center, indicating alignment with the expected model, while isolated points were flagged as potential anomalies.

To address the potential endogeneity between carbon awareness and the cost of equity, we employed several methodological approaches. First, we included firm-fixed effects in our regression models to control for unobserved heterogeneity that could be driving the relationship. Second, we conducted a reverse causality test to ensure that our findings reflect the effect of carbon awareness on the cost of equity, rather than the reverse. These approaches help mitigate endogeneity concerns and strengthen the validity of our conclusions.

The strategic selection of robust regression techniques underscores our commitment to preserving the integrity of our study's results. This comprehensive approach not only addresses the complexities inherent in the data but also grounds the study's conclusion on a robust analytical foundation.

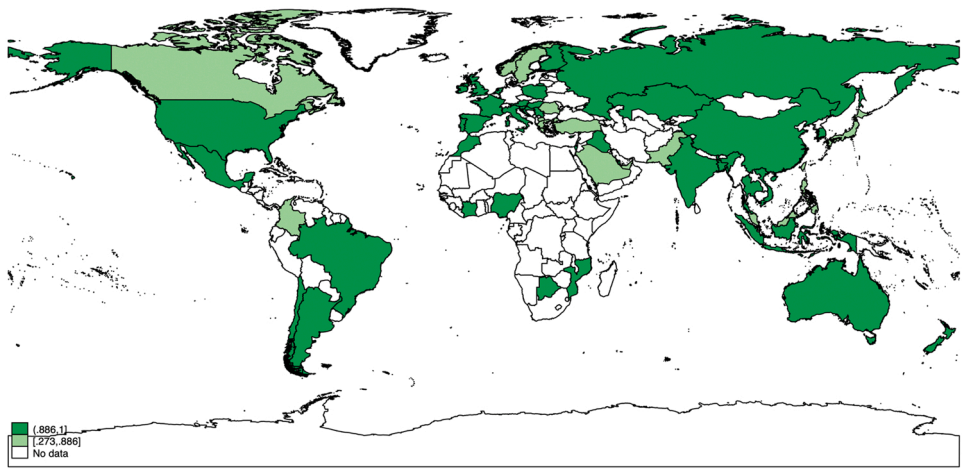
4. Findings and empirical analyses

4.1. Descriptive statistics

Fig. 1 map illustrates global carbon awareness using data from Bloomberg, with darker shades of green indicating higher awareness levels. It reveals a stark contrast in environmental consciousness among nations, as indicated by firm-level data aggregated on a country basis. The shading implies that some countries are significantly more engaged with carbon-related issues—potentially reflecting stronger environmental policies or greater corporate responsibility. The absence of data in certain regions underscores the uneven distribution of carbon awareness and highlights gaps that may need addressing. This map serves not only as an analytical tool for understanding global carbon awareness but also as a call to action for nations lagging to step up their environmental efforts.

Fig. 2 contrasts carbon awareness with the cost of equity across various countries, utilizing a dual-axis histogram generated from Bloomberg data. The visual correlation depicted suggests an inverse relationship between carbon awareness and the cost of equity at the firm level. As carbon awareness increases, indicated by the length of the blue bars, there is a general trend towards a reduction in the cost of equity, represented by the red bars. This implies that in countries where there is a higher consciousness about carbon emissions, firms might be benefiting from lower costs of equity, potentially due to investors' favorable perception of sustainable practices leading to reduced financial risks. This figure serves to reinforce the notion that environmentally conscious strategies can have tangible financial benefits for firms, signaling to markets that responsible environmental stewardship is not only ethically sound but also economically advantageous.Fig. 3

Table 1 presents the descriptive statistics for both the independent variables and dependent variables utilized in this study, including the means, standard deviations, minimums, 1st percentiles, 99th percentiles, and maximum values for the full sample, which includes 2122 firm-year observations. For the cost of equity, the mean is 2.42 %, ranging from a minimum of −0.09 % to a maximum of



Source: This graph is produced by authors using Bloomberg Batabase

Fig. 1. World map of carbon awareness.

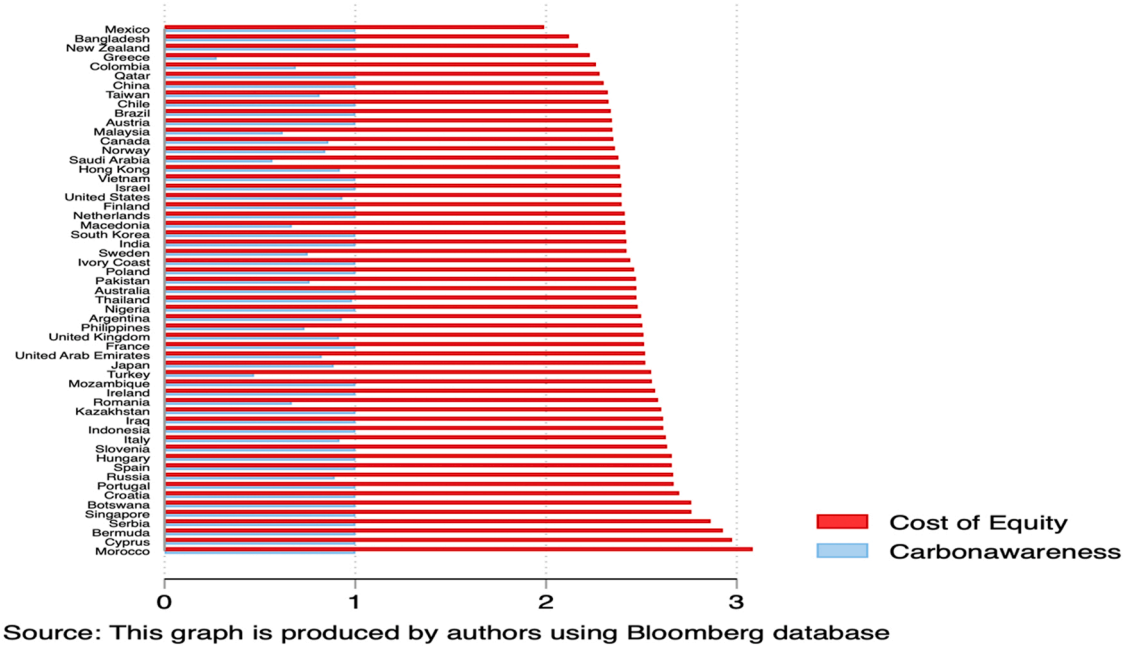


Fig. 2. Carbon awareness and cost of equity over countries.

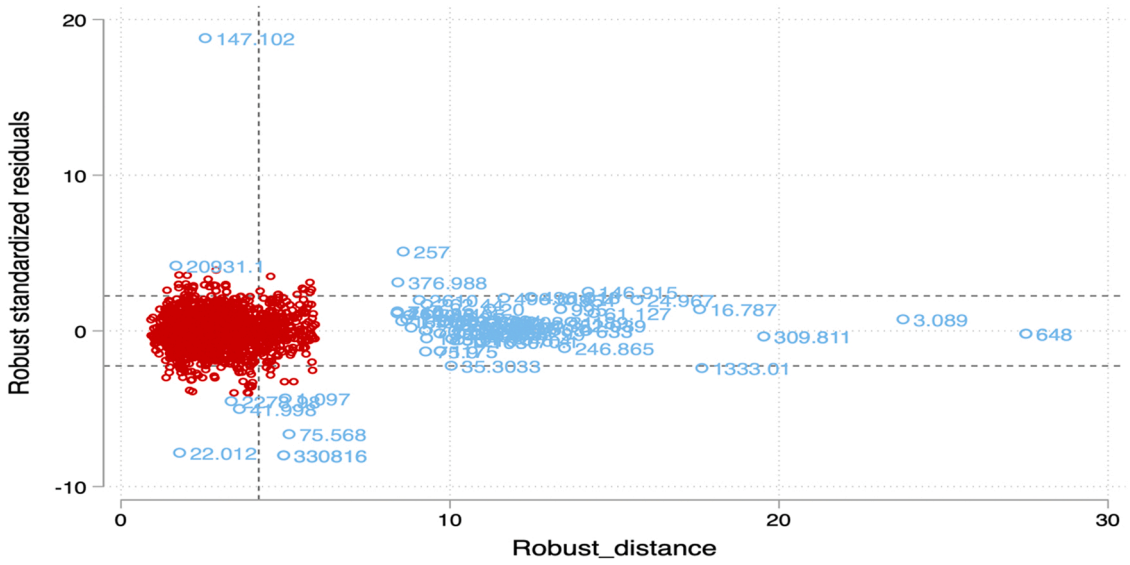


Fig. 3. MM-regression Outlier Test **For H5:** Fig. IV presents two margin plots that explore the relationship between country-level innovation and efficiency and the predicted cost of equity. Both plots display a downward trend, indicating that as innovation and efficiency increase within a country, the average predicted cost of equity for firms decreases. On the left, the plot titled "Predicted Cost of Equity by Innovation" shows that higher levels of country-level innovation are associated with a lower predicted cost of equity. This suggests that innovative environments may be perceived as less risky by investors, possibly due to a more dynamic economy and the potential for higher returns, thus reducing the cost of equity. Similarly, the right plot, "Predicted Cost of Equity by Efficiency," demonstrates that countries with greater efficiency, which could be a reflection of effective operations, regulatory environments, or market dynamics, also tend to have a lower predicted cost of equity. This could be interpreted as efficient markets offering more stable investment opportunities, again perceived as less risky.The error bars in both plots indicate the variability or confidence in the mean predicted values, and they appear to be relatively consistent across different levels of innovation and efficiency.In summary, these margin plots provide evidence that country-level innovation and efficiency are inversely related to the cost of equity, suggesting that firms in more innovative and efficient countries could benefit from lower equity financing costs.

Table 1
Variable descriptive statistics (N= 2122).

Variables	Mean	Std. Dev.	Min	Max	p1	p99	Skew.	Kurt.
Equity	2.42	0.37	−0.09	7.93	1.42	3.24	1.02	29.23
Carbon	0.91	0.29	0.00	1.00	0.00	1.00	−2.83	8.98
Efficiency	0.56	0.47	0.00	1.00	0.00	1.00	−0.30	1.17
Innovation	0.40	0.38	0.00	1.00	0.00	1.00	0.48	1.80
Board Size	9.73	2.96	2.00	21.00	4.00	17.00	0.34	2.87
Firm Size	10.58	2.99	−0.45	19.31	3.79	18.34	0.11	2.95
Audit comm.	3.43	1.41	0.00	9.00	0.00	7.00	−0.40	4.66
Leverage	0.92	0.64	0.00	7.27	0.13	3.47	2.98	19.20
Tobin	0.26	0.42	−1.25	3.64	−0.62	1.42	1.20	8.64
ROA	1.52	1.07	−5.22	8.97	−1.47	3.72	−0.57	7.74
Profit margin	1.90	1.42	−4.64	11.44	−1.55	4.80	−0.05	5.34
Z score	0.95	0.73	−2.41	5.79	−1.08	2.70	0.24	6.63

7.93 %. The mean value of the carbon is 0.91, indicating that the majority of firms in the sample have an above average score of commitment to climate change mitigation. Efficiency and Innovation have lower means of 0.56 and 0.40, respectively, indicating that firms score lower on innovation than on efficiency. Moving to control variables, the average board size is 9.73 ranging from 2 members to 21 members, while the average audit committee is 3.43 ranging from 0 to 9. The mean of leverage is 0.92, signifying that these firms are not highly leveraged. The average value of ROA is 1.52, ranging from −5.22 (minimum) to 8.97 (maximum), indicating that several firms reported negative income during the sample period, a conclusion like the results of profit margin. The natural logarithm of firm size (SIZE) has a mean of 10.58, equivalent to an unreported mean firm value of $39,340. The results, presented in the last two columns, include the skewness and kurtosis. All variables, except efficiency, innovation, board size, and firm size, exhibit excess kurtosis, suggesting that the distribution has fatter tails, indicating a higher likelihood of extreme values or outliers. Several variables have skewness between −0.5 and +0.5, indicating a fairly symmetrical distribution. However, while the cost of equity, leverage, and Tobin are positively skewed, Carbon is negatively skewed. Fig. 4

4.2. *Correlation test*

The correlations among the control variables were estimated to detect multicollinearity issues. Table 2 presents Pearson's and Spearman-rank (in Italic) correlation. It indicates a lack of significant correlation coefficients among the firm-level control variables. The highest and most significant correlation was noted between ROA and Profit Margin, being 0.728, which is still below the multicollinearity benchmark limit (0.80).

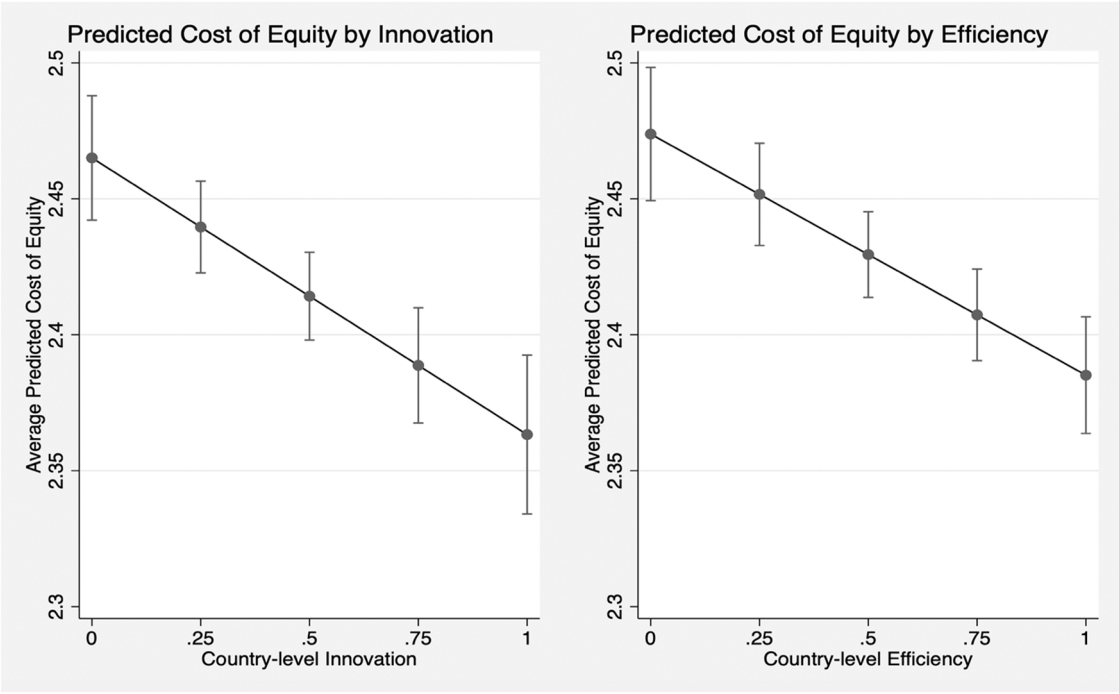


Fig. 4. Margin plots.

Table 2
Correlation Coefficients (Pearson and Spearman-rank (italicised) correlations are presented).

Variables	Code	1	2	3	4	5	6	7	8
Board Size	1		*0.55*	*0.262*	*0.137*	*−0.131*	*−0.1*	*−0.164*	*−0.136*
Firm Size	2	0.512*		*0.014*	*0.085*	*−0.291*	*−0.076*	*−0.219*	*−0.063*
Audit comm.	3	0.203*	−0.007		*0.07*	*0.163*	*0.036*	*0.106*	*−0.126*
Leverage	4	0.043*	0.034	0.035		*−0.043*	*−0.4*	*−0.51*	*−0.4*
Tobin	5	−0.170*	−0.287*	0.111*	−0.036		*0.309*	*0.245*	*0.367*
Roa	6	−0.120*	−0.113*	0.032	−0.316*	0.317*		*0.657*	*0.444*
Profit margin	7	−0.171*	−0.224*	0.130*	−0.343*	0.238*	0.728*		*−0.026*
Z score	8	−0.133*	−0.087*	−0.136*	−0.401*	0.454*	0.396*	−0.002	

Note: * shows significance at the 0.01, 0.05, and 0.10 level

4.3. Multivariate regression analysis

In this section, we empirically investigate the impact of carbon awareness on COE within a multivariate framework while accounting for the factors likely to affect COE. All models incorporate year and country-fixed dummies, along with clustering of error terms at the firm level. This helps control for unobserved variations or macroeconomic factors that might influence COE and/carbon across countries or over time.

Table 3 presents the results of regressions for the entire sample of 2122 firm-years using seven models. The findings indicate a negative association between Carbon and COE, across all models, with statistical significance at the 1 % level. Firms with less carbon mitigation are penalized with greater equity cost, in line with several studies (Albarrak et al., 2019; Bui et al., 2020; Guo et al., 2024; Kim et al., 2015). The coefficient of Carbon ranges from −0.087 (Model 6) to −1.928 (Model 7). This suggests that commitment to climate change mitigation corresponds to lower costs of equity. Consequently, the decision by firms to be committed to climate change yields benefits for both firm management and investors, as it enables investors to receive timely and efficient information, ultimately reducing uncertainty in evaluating a firm's future cash flows and improving risk assessment.

The estimated coefficients for the Carbon imply that a one standard deviation increase in Carbon leads to a COE decrease of 14, 10, 10,10, 11, 8.7, and 193 basis points in Models 1–7, respectively. These estimates also hold economic significance. The findings presented in Table 3 indicate an overall positive reaction from investors towards carbon commitment, resulting in a lower cost of equity.

Table 3
Regression analysis of carbon awareness on the cost of equity- first hypothesis.

$Equity_{it} = \alpha + \beta_i Carbon_{it} + \sum_{i=1}^{n=8} Controls_{it} + \varepsilon_{it}$ $Equity_{it}$ is a continuous variable as a proxy for cost of equity of a firm(i) in year (t). $Carbon_{it}$ is a dummy variable, where firms with above average of score by Bloomberg company commitment to climate change mitigation, otherwise "0". The $Controls_{it}$ is a list of control variables. Also, we take into account unknown country & year fixed effects. The full sample includes 2122 observations from the year 2010 until 2021. We allow for the clustering of error terms at the firm level. The variance inflation factors (VIF) are well below the tolerance level (VIF<5) and the superscript asterisks ***, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

Variables	***Cost of Equity***						
	Model 1 *OLS Reg.*	Model 2 *Median Reg.*	Model 3 *M-estimator*	Model 4 *MM-estimator (70 %)*	Model 5 *MM-estimator (95 %)*	Model 6 *Firm-Fixed Effect*	Model 7 *Reverse Causality*
Carbon	**−0.141*** **	**−0.104*** **	**−0.103*** **	**−0.103*** **	**−0.107*** **	**−0.087** **	**−1.928*** **
	[−3.545]	**[−3.330]**	**[−4.319]**	**[−3.883]**	**[−4.611]**	**[−2.237]**	**[−2.732]**
Board Size	−0.001	−0.006	−0.003	0.001	0.001	0.007	0.044**
	[−0.210]	[−1.568]	[−1.194]	[0.158]	[0.397]	[0.901]	[2.260]
Firm Size	0.006	0.008**	0.007**	−0.000	0.005	0.113***	−0.004
	[0.707]	[2.048]	[2.363]	[−0.057]	[1.391]	[2.810]	[−0.330]
Audit comm.	−0.015	−0.010	−0.005	−0.002	−0.003	−0.021*	−0.054**
	[−1.518]	[−1.503]	[−1.013]	[−0.284]	[−0.528]	[−1.708]	[−2.469]
Leverage	−0.033	−0.043**	−0.028**	−0.031**	−0.021	0.111***	0.027
	[−1.358]	[−2.403]	[−2.049]	[−2.041]	[−1.409]	[2.825]	[0.607]
Tobin	−0.120***	−0.071**	−0.097***	−0.112***	−0.126***	−0.035	−0.496***
	[−2.804]	[−2.487]	[−4.425]	[−3.724]	[−5.171]	[−0.741]	[−3.093]
Roa	−0.002	0.012	−0.001	0.008	0.002	−0.020	0.050
	[−0.104]	[0.765]	[−0.097]	[0.521]	[0.168]	[−0.699]	[1.132]
Profit margin	0.017	0.006	0.019**	0.012	0.022**	0.014	−0.051
	[1.039]	[0.501]	[2.013]	[1.062]	[2.272]	[0.490]	[−1.085]
Z score	−0.051**	−0.062***	−0.041***	−0.033	−0.028*	−0.000	0.023
	[−2.186]	[−3.130]	[−2.666]	[−1.592]	[−1.661]	[−0.009]	[0.380]
Constant	2.631***	2.458***	2.503***	2.573***	2.498***	2.323***	4.030***
	[18.505]	[15.916]	[21.114]	[40.376]	[45.561]	[10.973]	[6.886]
SE cluster	Firm	Firm	Firm	Firm	Firm	Firm	Firm
Country and Year Fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2122	2122	2122	2122	2122	2122	2122
R^2 Squared/ Pseudo R2/ Scale Parameter	0.17	0.12	0.17	0.27	0.28	0.63	0.18

Such behavior improves legitimacy and investor recognition. Investors perceive carbon-related information as valuable for assessing risks and informing their investment decisions. These results align with similar studies conducted on US firms (Plumlee et al., 2015). Moreover, these outcomes are in line with the theoretical principles of information theory, as proposed by (Diamond and Verrecchia, 1991). Our result reinforces the idea that investors do not disregard pollution-related disclosures, as suggested by (Moser and Martin, 2012). Investors value carbon mitigation commitments as they signal environmental responsibility and proactive emissions reduction. These commitments help evaluate future performance, anticipate penalty costs, and assess litigation costs, enhancing decision-making and aligning with the trend of environmental responsibility and sustainability in corporate practices.

This finding is in line with the principles of agency theory, signaling theory, and legitimacy theory, indicating that more commitment to climate diminishes information asymmetry, reflects a commitment to social responsibility and legitimacy within the broader community, encompassing customers, competitors, and society at large (Bui et al., 2020). Such practices also assist businesses in alleviating pressure from the government and other stakeholders regarding current climate change and global warming issues (Caruana and Chatzidakis, 2014). Our findings reinforce the positive impact of climate commitment, contributing to lower risk and improved financial outcomes. Consequently, investors are more inclined to trade the securities and portfolios of firms engaging in credible and comprehensive carbon mitigation. This aligns with existing literature, which asserts that when companies adhere to ethical investing standards, they gain appeal to specific investors who subsequently offer more cost-effective capital to these companies (Dhaliwal et al., 2011).

The outcomes related to the control variables presented in Table 3 indicate noteworthy patterns. In models 1–5 and 7, the coefficients of Tobin exhibit a negative and statistically significant association. This suggests that undervalued firms with a lower market-to-book ratio tend to experience an increase in COE, consistent with (Albarrak et al., 2019). Similarly, the coefficients for Z-score are negative in Models 1–3 and 5. Therefore, companies with a lower likelihood of default are less prone to financial constraints, resulting in a reduced default risk and, consequently, a lower cost of capital. This negatively significant correlation aligns with previous studies, suggesting that firms with higher profitability tend to have lower default risk, leading to a lower cost of capital (Lemma et al., 2019). Table 6

Table 4
Regression analysis of country-level efficiency on the cost of equity- second hypothesis.

$Equity_{it} = \alpha + \beta_i efficiency_{it} + \sum_{i=1}^{n=8} Controls_{it} + \varepsilon_{it}$ $Equity_{it}$ is a continuous variable as a proxy for cost of equity of a firm(i) in year (t). $Efficiency_{it}$ is the sum of control of corruption, government effectiveness, political stability, regulatory quality, rule of law and voice and accountability. The rest of variables are same as Table 2. The superscript asterisks ***, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

Variables	***Cost of Equity***						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Efficiency Index	**−0.061****						
	[−2.168]						
Corruption		**−0.059****					
		[−2.197]					
Govt. efficiency			**−0.063****				
			[−2.346]				
Political Stability				**−0.015*****			
				[−3.956]			
Regulatory quality					**−0.065****		
					[−2.439]		
Rule of Law						**−0.062****	
						[−2.309]	
Voice and Accountability							**−0.058****
							[−2.216]
Board Size	0.005	0.005	0.004	0.006**	0.004	0.005	0.005
	[0.697]	[0.687]	[0.643]	[1.971]	[0.649]	[0.670]	[0.728]
Firm Size	−0.004	−0.004	−0.004	−0.006	−0.004	−0.004	−0.004
	[−0.455]	[−0.449]	[−0.436]	[−1.004]	[−0.424]	[−0.430]	[−0.443]
Audit comm.	−0.024	−0.023	−0.023	−0.024	−0.025	−0.024	−0.025
	[−1.105]	[−1.079]	[−1.086]	[−1.508]	[−1.156]	[−1.092]	[−1.165]
Leverage	−0.135***	−0.135***	−0.135***	−0.142***	−0.135***	−0.135***	−0.131***
	[−3.234]	[−3.245]	[−3.247]	[−5.769]	[−3.246]	[−3.245]	[−3.114]
Tobin	−0.007	−0.007	−0.008	−0.004	−0.007	−0.008	−0.006
	[−0.375]	[−0.400]	[−0.402]	[−0.327]	[−0.363]	[−0.407]	[−0.315]
Roa	0.029*	0.029*	0.029*	0.029***	0.028*	0.029*	0.028*
	[1.922]	[1.950]	[1.931]	[2.733]	[1.897]	[1.940]	[1.859]
Profit margin	−0.039	−0.038	−0.038	−0.040**	−0.039	−0.038	−0.041*
	[−1.585]	[−1.573]	[−1.574]	[−2.326]	[−1.587]	[−1.575]	[−1.689]
Z score	0.002	0.002	0.002	0.001	0.002	0.002	0.002
	[0.346]	[0.332]	[0.359]	[0.388]	[0.367]	[0.337]	[0.372]
Constant	2.448***	2.448***	2.452***	2.416***	2.454***	2.451***	2.445***
	[25.829]	[25.749]	[25.859]	[46.529]	[25.762]	[25.725]	[25.982]
SE cluster	Firm	Firm	Firm	Firm	Firm	Firm	Firm
Country and Year Fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2122	2122	2122	2122	2122	2122	2122
R^2 Squared	0.06	0.06	0.06	0.05	0.05	0.06	0.06

Table 5
Regression analysis of country-level innovation on the cost of equity- third hypothesis.

$Equity_{it} = \alpha + \beta_i Innovation_{it} + \sum_{i=1}^{n=8} Controls_{it} + \varepsilon_{it}$ $Equity_{it}$ is a continuous variable as a proxy for cost of equity of a firm(i) in year (*t*). $Innovation_{it}$ is the sum of govt. exp. on education, journal articles, R&D expenditure, and patent applications. The rest of variables are same as Table 2. The superscript asterisks ***, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

Variables	***Cost of Equity***				
	Model 1	Model 2	Model 3	Model 4	Model 5
Innovation Index	**−0.071****				
	[−2.432]				
Education		**−0.044****			
		[−2.061]			
Journal			**−0.011*****		
			[−3.411]		
R&D				**−0.059*****	
				[−3.701]	
Patent					**−0.042****
					[−2.114]
Board Size	0.002	0.001	0.002	0.002	0.002
	[0.357]	[0.211]	[0.318]	[0.568]	[0.342]
Firm Size	0.006	0.007	0.006	0.005*	0.006
	[0.846]	[0.959]	[0.928]	[1.667]	[0.897]
Audit comm.	−0.005	−0.007	−0.006	−0.005	−0.005
	[−0.572]	[−0.737]	[−0.570]	[−0.859]	[−0.547]
Leverage	−0.023	−0.023	−0.024	−0.024	−0.024
	[−1.070]	[−1.041]	[−1.093]	[−1.553]	[−1.091]
Tobin	−0.134***	−0.135***	−0.139***	−0.135***	−0.138***
	[−3.168]	[−3.241]	[−3.286]	[−5.491]	[−3.259]
Roa	−0.004	−0.005	−0.003	−0.004	−0.003
	[−0.232]	[−0.292]	[−0.177]	[−0.290]	[−0.188]
Profit margin	0.028*	0.029*	0.028*	0.027**	0.028*
	[1.832]	[1.933]	[1.829]	[2.555]	[1.835]
Z score	−0.041*	−0.039	−0.042*	−0.041**	−0.042*
	[−1.667]	[−1.602]	[−1.720]	[−2.379]	[−1.721]
Constant	2.435***	2.435***	2.413***	2.442***	2.417***
	[26.779]	[26.429]	[27.051]	[47.009]	[27.037]
SE cluster	Firm	Firm	Firm	Firm	Firm
Country and Year Fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	2122	2122	2122	2122	2122
R^2 Squared	0.06	0.06	0.06	0.05	0.05

Firm size is positive and significant in models 2, 3, and 6, contradicting the expectation that bigger firms should have reduced cost of equity attributed to a better information environment (Gebhardt et al., 2001). While it is inconsistent with (Albarrak et al., 2019; Sharfman and Fernando, 2008), the results imply that the market views larger-sized firms as high-risk entities, demanding a higher required rate of return. The negative sign of leverage in models 2, 3, and 4 is not consistent with previous studies highlighting that a high leverage indicates a high risk, which should be translated into a higher cost of equity. However, ROA is not significant in any model, inconsistent with (El Ghoul et al., 2018). Board size has no significant impact, while the presence of an audit committee enhances a firm's information environment, resulting in a lower cost of equity, only in Models 6 and 7. It may contribute to monitoring decisions, enhancing disclosure policy and transparency, and reporting reliable information. Firms with a low Z-score are anticipated to have a higher COE due to the increased uncertainty surrounding future earnings profitability.

The regression models have an R^2 ranging from 0.12 (Model 2) to 0.63 (Model 6), signifying that the models explain between 12 % and 63 % of the variance in COE. These results underscore the role of Carbon in reducing equity financing. This finding suggests that managers could strategically use Carbon to enhance legitimacy among stakeholders, improve recognition, lower acquisition costs, and enhance investors' risk estimation.

In Table 4, the variation in COE across different country-level governance settings using the World Bank Worldwide Governance Indicators. The indicators include voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, and control of corruption. Voice and accountability measure citizen participation in elections and decision-making, political stability assesses the likelihood of illegal destabilization, regulatory quality evaluates the government's ability to promote private sector development, government effectiveness measures the quality of public and civil services, rule of law evaluates confidence in societal rules, and control of corruption assesses public power for private gain. These indicators range from approximately −2.5–2.5, with higher values indicating stronger governance (Kaufmann et al., 2011). These indicators are inherently interconnected, exhibiting strong positive correlations. Consequently, we decide not to include them simultaneously as independent variables in a regression. Instead, we utilize an aggregate index (efficiency), representing the average of dummies in Model 1 while we separately include each individual dummy variable in Models 2–6, respectively. We can confirm the support for our second null hypothesis, indicating a negative correlation between all country-level governance and the cost of capital, statistically significant at the 5 % level or better. This negative and significant relationship is evident in all models. In the first specification, a one-unit increase in Efficiency is associated with a 61-basis-point reduction in the cost of capital. This relationship remains robust even when efficiency is measured by its

Table 6
Equality of coefficients test for micro versus macro factors- *Fourth Hypothesis*.

In this analysis we test the impact of carbon awareness on cost of equity versus efficiency and cost of equity relationship, innovation and cost of equity relationship. Afterwards, we compare the equality of coefficients of each panel regression models. The z-tests of the coefficients are one- tailed test of significance: The Chi-square is a test that the corresponding coefficient across the two models are equal; two-tailed tests are reported. ***< 0.01, **< 0.05 and *< 0.1.

Variables	**Cost of Equity**					
	Carbon (Firm level)	Efficiency (Country-level)	Chi-square	Carbon (firm level)	Innovation (country-level)	Chi-square
Independent Variables	**−0.141*****	**−0.061****	**3.86*****	**−0.141*****	**−0.071****	**5.94*****
	[−3.545]	**[−2.168]**		**[−3.545]**	**[−2.432]**	
Board Size	−0.001	0.005		−0.001	0.002	
	[−0.210]	[0.697]		[−0.210]	[0.357]	
Firm Size	0.006	−0.004		0.006	0.006	
	[0.707]	[−0.455]		[0.707]	[0.846]	
Audit comm.	−0.015	−0.024		−0.015	−0.005	
	[−1.518]	[−1.105]		[−1.518]	[−0.572]	
Leverage	−0.033	−0.135***		−0.033	−0.023	
	[−1.358]	[−3.234]		[−1.358]	[−1.070]	
Tobin	−0.120***	−0.007		−0.120***	−0.134***	
	[−2.804]	[−0.375]		[−2.804]	[−3.168]	
Roa	−0.002	0.029*		−0.002	−0.004	
	[−0.104]	[1.922]		[−0.104]	[−0.232]	
Profit margin	0.017	−0.039		0.017	0.028*	
	[1.039]	[−1.585]		[1.039]	[1.832]	
Z score	−0.051**	0.002		−0.051**	−0.041*	
	[−2.186]	[0.346]		[−2.186]	[−1.667]	
Constant	2.631***	3.435***	-	2.631***	2.435***	
	[18.505]	[6.779]		[18.505]	[26.779]	
SE cluster	Firm	Firm		Firm	Firm	
Country and Year Fixed effect SE cluster	Yes	Yes		Yes	Yes	
N	2122	2122		2122	2122	
R^2 Squared	0.06	0.07		0.06	0.07	

dimensions. The coefficients on individual governance dimension range between −0.015 and −0.065 indicating that higher levels of governance indicators are associated with a lower cost of equity. Notably, regulatory quality stands out as the component with the most pronounced impact on COE, with a coefficient of −0.065 (Model 5), leading to a decrease in the leverage ratio by about 65 basis points, while political stability has the least impact, with a coefficient of −0.015 (Model 4).

The study indicates that COE is higher in countries with weak governance quality and weak country-level governance compared to those with strong government effectiveness, highlighting the mechanisms through which governance influences corporate financing decisions. Firstly, the institutional environment of a country significantly shapes the landscape for firms and other economic entities, determining their obligations, rules of engagement, and opportunities within society (North, 1990). This environment also plays a crucial role in defining transaction and production costs, thereby influencing the profitability and viability of economic activities. Consequently, robust governance, encompassing fundamental concepts such as freedom, accountability, stability, rule of law, and a lack of corruption, inherently reduces transaction costs by mitigating the repercussions of trust violations in markets (Goodell and Goyal, 2018). Secondly, country governance boosts investor confidence in funding markets by providing robust protection against expropriation by shareholders (Awartani et al., 2016) through effective monitoring and control mechanisms under legal frameworks (Öztekin, 2015). These mechanisms contribute to lowering the cost of capital, as supported by existing evidence (Álvarez-Botas and González, 2021; Hail and Leuz, 2006). Consequently, stronger country governance facilitates firms' access to external finance and enhances their financial flexibility by reducing the costs associated with both debt and equity financing.

Third, country governance plays a direct role in mitigating agency conflicts within firms and indirectly contributes to their reduction by fostering corporate governance practices(Demirgüç-Kunt and Maksimovic, 1999; Doidge et al., 2007; La Porta et al., 1998). Specifically, countries with robust governance enable more effective and cost-efficient firm-level governance mechanisms. The significant interplay between firm-level governance mechanisms and the broader governance framework at the country level is exemplified in various cross-country studies, such as those conducted by (Klapper and Love, 2004), among others. These investigations suggest that the extent of firm-level corporate governance is, to some extent, shaped by the overall quality of a country's governance framework. (Klapper and Love, 2004) provide compelling evidence indicating that advancements in the efficiency of a country's legal infrastructure contribute significantly to enhancing the overall governance rankings at the firm level. Thus, the quality of governance explicitly shapes a firm's corporate governance practices, impacting the cost of equity through agency costs and transaction regulation. Previous research also highlights that strong institutional environments alleviate issues related to information asymmetry by fostering higher disclosure levels, corporate governance standards, and investor protection rights (Alves and Ferreira, 2011). The governance structure of a nation significantly influences the institutional mechanisms that govern financial markets. The effectiveness of these institutions, including legal processes, political stability, corruption levels, and accountability, determines their oversight quality and effectiveness. Firm-level characteristics have no significant impact on the cost of equity (COE), with leverage and ROA having a negative and positive effect, respectively.

Table 5 investigates the impact of country-level innovation on the cost of equity (COE), utilizing four indicators: government expenditures on education, journal articles, R&D expenditure, and patent applications. Given the positive correlation among these indicators (i.e., high R&D will lead to more patents), Model 1 includes an aggregate measure of innovation by averaging up these four indicators, while Models 2–5 incorporate each dimension separately. Our analysis supports the third null hypothesis, revealing a negative correlation between all country-level innovation and the cost of equity, statistically significant at the 5 % level or better. This negative and significant relationship is consistent across all models. More specifically, a one-unit increase in innovation is associated with a 71-basis-point reduction in the cost of equity, a robust relationship even when innovation is measured by its dimensions. Thus, higher levels of innovation can lead to improved efficiency in the economy, as new technologies and processes are developed and implemented. It can result in lower costs of production and higher profits for companies, ultimately leading to a lower cost of equity. Moreover, innovation can help companies reduce risks by developing new products or services that address existing market needs or create new opportunities. This can lead to a lower cost of equity.

The coefficients on individual innovation range between −0.011 and −0.059, indicating that higher levels of innovation are associated with a lower cost of equity. Notably, R&D stands out as the component with the most pronounced impact on COE, with a coefficient of −0.059 (Model 4), while the journal articles dimension has the least impact, with a coefficient of −0.011 (Model 3). R&D expenditure is directly related to the development of new technologies, products, and processes, which can have a significant impact on a firm's future cash flows and risk. As a result, higher R&D expenditure is associated with a lower cost of equity, as investors perceive the firm to have greater growth opportunities and reduced risk (Zhang et al., 2024). On the other hand, government expenditure on journal articles may not have a direct impact on firm-level innovation and growth. While it may contribute to the dissemination of knowledge and information, its impact on the development of new technologies and products may be less direct compared to R&D expenditure. As a result, it is not surprising that it has the least impact on the cost of equity compared to other innovation indicators. Moving to control variables, leverage becomes insignificant, while Tobin's Q and Z-score exhibit a negative impact versus a positive impact on profit margin.

4.4. Discussion

The observed negative association between carbon awareness and the cost of equity (COE) can be attributed to several key mechanisms. Carbon awareness signifies a firm's proactive approach to managing environmental risks, which is increasingly valued by investors. By committing to carbon mitigation, firms reduce information asymmetry, offering investors clearer insights into their long-term sustainability and risk profiles. This reduction in perceived financial risks leads investors to demand lower returns, thereby decreasing the COE.

Country-level governance is a critical factor in shaping this relationship. Strong governance structures create a stable and predictable environment for firms. This stability enhances investor confidence, as the risks of government intervention or sudden regulatory changes are minimized. Consequently, firms operating in well-governed countries benefit from a lower COE, as investors are more willing to accept lower returns in exchange for reduced uncertainty. Similarly, country-level innovation is closely linked to the cost of equity. National innovation, reflected in metrics such as R&D expenditure, patent applications, and government support for education, fosters an environment conducive to technological advancement and economic growth. Firms in highly innovative countries gain from improved operational efficiencies, access to cutting-edge technologies, and the ability to differentiate themselves in the marketplace. These advantages not only enhance a firm's competitiveness but also reduce risks associated with future cash flows, leading to a lower COE.

While the direct relationships between carbon awareness, governance, innovation, and COE are clear, potential mediators could influence these dynamics. For example, firm-level governance mechanisms—such as board structure and transparency in financial reporting—might mediate the impact of carbon awareness on COE. Firms with strong internal governance could be better positioned to capitalize on their carbon mitigation strategies, thus amplifying the reduction in COE. Market liquidity could also serve as a mediator. Firms that are more carbon-aware and operate in well-governed and innovative environments might experience higher market liquidity, as they attract a broader base of investors. Increased liquidity can, in turn, lead to a lower COE, as the ease of trading shares reduces the risk premium demanded by investors.

While our analysis strongly supports the relationships between carbon awareness, governance, innovation, and COE, alternative explanations should be considered. Unobserved macroeconomic variables, such as fluctuations in global oil prices or changes in international trade policies, might independently affect COE. Additionally, industry-specific factors—like the level of competition or regulatory burdens in the oil and gas sector—could influence the cost of equity, irrespective of the variables examined in this study. A potential limitation is the issue of endogeneity, where reverse causality might occur. For instance, firms with a lower COE could have more resources to invest in carbon mitigation and innovation, rather than these investments leading to a lower COE. Although robust regression models and reverse causality considerations were employed, the possibility of endogeneity remains a factor for future research to explore. Lastly, while potential mediators and alternative explanations were acknowledged, this study does not directly test these factors. Future research could benefit from a more detailed exploration of these mediating and moderating variables to provide a comprehensive understanding of the mechanisms driving the observed effects. Such exploration could include testing for firm-level governance influences, market liquidity impacts, and other macroeconomic factors that might play a role in the relationship between carbon awareness and the cost of equity.

5. Conclusion

The present study contributes to a better understanding of how environmental consciousness can align with firms' capital structure and more precisely the cost of equity by potentially driving a shift towards more sustainable practices in Oil and Gas industries with significant environmental footprints. We explore the impact of carbon awareness on the cost of equity (COE) while accounting for the influential role of country governance and innovation factors. Drawing on Bloomberg data spanning from 2011 to 2022, our analysis encompasses 263 firms within the Oil and Gas sector across 50 countries, culminating in 2122 annual observations. We perform a comprehensive suite of regression analyses and a battery of robustness tests. All models incorporate year and country-fixed dummies, along with clustering of error terms at the firm level.

The findings indicate a negative association between carbon awareness and COE, across all models. Firms with less carbon mitigation are penalized with greater equity costs. This suggests that commitment to climate change mitigation corresponds to lower costs of equity. Consequently, the decision by firms to be committed to climate change yields benefits for both firm management and investors, as it enables investors to receive timely and efficient information, ultimately reducing uncertainty in evaluating a firm's future cash flows and improving risk assessment. This finding is in line with the principles of agency theory, signaling theory, and legitimacy theory, indicating that more commitment to climate diminishes information asymmetry, and reflects a commitment to social responsibility and legitimacy within the broader community, encompassing customers, competitors, and society.

Upon incorporating the impact of country-level governance (first, we incorporate an aggregate measure of governance by averaging up its six indicators, and then reconduct the analysis by incorporating each dimension separately), we find a negative association between all country-level governance and COE, significant at the 5 % level or better. This negative and significant relationship is evident in all models. These findings suggest that holding other factors constant, COE is higher in countries characterized by weak governance quality country-level governance compared to those with strong government effectiveness. The institutional environment of a country significantly shapes the landscape for firms and other economic entities, determining their obligations, rules of engagement, and opportunities within society.

When we investigate the impact of country-level innovation on COE. We first perform the analysis based on an aggregate measure of innovation by averaging up its four indicators and then reconduct the analysis by incorporating each dimension separately. Findings reveal a negative correlation between all country-level innovation and COE, statistically significant at the 5 % level or better. This negative and significant relationship is consistent across all models. This indicates that higher levels of innovation can lead to improved efficiency in the economy, as new technologies and processes are developed and implemented. Moving to the analysis of the 4 individual innovation components, we find that R&D stands out as the component with the most pronounced impact on COE while the journal articles dimension has the least impact.

For policymakers, the study emphasizes the critical importance of strengthening environmental regulations and fostering innovation within the oil and gas industry. By enhancing environmental standards and investing in national innovation infrastructure—such as research and development (R&D) and education—governments can create a business environment that rewards sustainable practices with financial benefits. Additionally, improving governance structures, particularly in areas like regulatory quality and government effectiveness, can further mitigate the financial risks associated with carbon-intensive industries, thereby supporting sustainable economic development. From an economic perspective, policymakers should consider these findings when crafting regulations and incentives aimed at fostering carbon awareness and sustainability within the oil and gas industry. Such policies could enhance economic efficiency while simultaneously supporting environmental goals.

Managers in the oil and gas industry should prioritize carbon awareness in their strategic planning, recognizing its potential to significantly reduce the cost of equity and enhance financial sustainability. The study suggests that firms actively engage with and respond to country-level governance structures, particularly regulatory quality, as a means of optimizing financial outcomes and mitigating equity costs. Additionally, the study underscores the importance of investing in innovative practices and technologies. These investments not only contribute to environmental sustainability but also offer financial benefits, enhancing a firm's attractiveness to investors.

Investors are encouraged to incorporate sustainability considerations into their investment strategies. Firms that proactively manage their carbon footprint and operate within strong governance and innovation frameworks tend to present lower financial risks and offer higher potential returns. Investors should use the study's findings as a criterion to assess the long-term viability and financial health of firms in the oil and gas industry, guiding more sustainable investment strategies.

Strategic environmentalists can leverage the findings of this study to advocate for stronger environmental policies at the national level. The demonstrated financial benefits of carbon awareness, robust governance, and innovation provide a compelling case for policy changes that align environmental sustainability with economic growth. By promoting these changes, strategic environmentalists can help ensure that environmental responsibility is not only ethically sound but also economically beneficial.

However, the study has some limitations. As its main focus is on the oil and gas industry, the findings may not be entirely generalizable to other sectors. The specific environmental and regulatory challenges faced by this industry may limit the applicability of the results to broader economic contexts. Additionally, the study may have omitted certain control variables that could influence the cost of equity, which could affect the robustness of the findings.

For future research, it is recommended to extend the analysis beyond the oil and gas industry to include other sectors with significant environmental footprints, such as manufacturing, transportation, and utilities. This would help determine whether the observed effects are industry-specific or more universally applicable. Moreover, incorporating a broader set of Environmental, Social, and Governance (ESG) factors could provide a more holistic view of how sustainability practices influence financial performance, offering deeper insights into the broader implications of sustainable business practices across various industries. While this study

investigates the direct effects of carbon awareness, country-level governance, and innovation on the cost of equity, we acknowledge that more complex relationships may exist. Specifically, carbon awareness could influence COE indirectly through country-level innovation, particularly as firms' sustainability efforts drive broader national advancements in green technology. Although we do not explicitly test this mediation effect, future research could explore whether innovation mediates the relationship between carbon awareness and COE, providing a deeper understanding of how firm-level environmental strategies impact financial outcomes via national innovation.

Authors Statement

We the undersigned declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere. We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us. We understand that the Corresponding Author is the sole contact for the Editorial process.

Dr. Hazem Marashdeh is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs

CRediT authorship contribution statement

Khakan Najaf: Methodology. **Rim El Khoury:** Validation, Conceptualization. **Hazem Marashdeh:** Investigation, Conceptualization. **Nohade Nasrallah:** Writing – original draft, Conceptualization. **Osama Atayah:** Investigation, Data curation, Conceptualization.

Appendix A. Variables Definition

Dependent Variables

Variable	Definition	Relevant Studies
Equity	A continuous variable as a proxy for cost of equity of a firm(i) in year (t) as defined by Bloomberg.	Karim et al. (2021)

Independent variables

Variable	Definition	Relevant Studies
Carbon	$Carbon_{it}$ is a dummy variable, where firms with above average of score by Bloomberg company commitment to climate change mitigation, otherwise "0".	Subramaniam et al. (2015)
Efficiency	It is the average of the binary dummies of 6 components (control of corruption, government effectiveness, political stability, regulatory quality, rule of law and voice and accountability), each taking a value of 1 if the corresponding value is above the average, 0 otherwise.	Li and Ramanathan (2018)
Innovation	It is the average of the binary dummies of 4 components (govt. exp. on education, journal articles, R&D expenditure, and patent applications), each taking a value of 1 if the corresponding value is above the average, 0 otherwise.	Andergassen et al. (2009)

Firm-level control variables

Variable	Definition	Relevant Studies
Board Size	Total Number of Board members.	Najaf et al. (2021)
Firm Size	Log (Total Assets)	Gebhardt et al., (2001)
Audit Committee	Number of the Audit Committee.	Najaf et al. (2021)
Tobin	A continuous variable proxied by the Tobin's Q ratio as defined by Bloomberg.	Albarrak et al., (2019)
ROA	Log (Profit before tax and interest)/ Total Assets	El Ghoul et al., (2018)
Profit Margin	$\frac{Profit\ after\ tax}{Sales}$	Najaf et al. (2021)Fk
Z Score	A continuous variable proxied by default risk of the firm.	Lemma et al., (2019)

Fixed effect controls

Variable	Definition	Relevant Studies
Year	Year ranged from 2011 to 2022.	Najaf et al. (2022)
Country	1 (0) if during year *t*, firm *i* is operating in Country *j* and 0 otherwise.	Demirgüç-Kunt and Maksimovic (1999)

Data availability

Data will be made available on request.

References

Albarrak, M.S., Elnahass, M., Salama, A., 2019. The effect of carbon dissemination on cost of equity. Bus. Strategy Environ. 28 (6), 1179–1198. https://doi.org/10.1002/bse.2310.

Al-Fakir Al Rabab'a, E., Rashid, A., Shams, S., 2023. Corporate carbon performance and cost of debt: Evidence from Asia-Pacific countries. Int. Rev. Financ. Anal. 88 (March), 102641. https://doi.org/10.1016/j.irfa.2023.102641.

Alkebsee, R., Habib, A., Li, J., 2023. Green innovation and the cost of equity: evidence from China. China Account. Financ. Rev. 25 (3), 368–395. https://doi.org/10.1108/CAFR-06-2022-0075.

Álvarez-Botas, C., González, V.M., 2021. Institutions, banking structure and the cost of debt: new international evidence. Account. Financ. 61 (1), 265–303. https://doi.org/10.1111/acfi.12567.

Alves, P.F.P., Ferreira, M.A., 2011. Capital structure and law around the world. J. Multinatl. Financ. Manag. 21 (3), 119–150. https://doi.org/10.1016/j.mulfin.2011.02.001.

Andergassen, R., Nardini, F., Ricottilli, M., 2009. Innovation and growth through local and global interaction. J. Econ. Dyn. Control 33 (10), 1779–1795. https://doi.org/10.1016/j.jedc.2009.04.003.

Aslan, H., Kumar, P., 2014. National governance bundles and corporate agency costs: A cross-country analysis. Corp. Gov.: Int. Rev. 22 (3), 230–251. https://doi.org/10.1111/corg.12055.

Awartani, B., Belkhir, M., Boubaker, S., Maghyereh, A., 2016. Corporate debt maturity in the MENA region: Does institutional quality matter? Int. Rev. Financ. Anal. 46, 309–325. https://doi.org/10.1016/j.irfa.2015.10.002.

Bagh, T., Zhou, B., Alawi, S.M., Azam, R.I., 2024. ESG resilience: Exploring the non-linear effects of ESG performance on firms sustainable growth. Res. Int. Bus. Financ. 70, 102305.

Balachandran, B., Nguyen, J.H., 2018. Does carbon risk matter in firm dividend policy? Evidence from a quasi-natural experiment in an imputation environment. J. Bank. \ Financ. 96, 249–267.

Barney, J.B., 2001. Is the resource-based "view" a useful perspective for strategic management research? Yes. Acad. Manag. Rev. 26 (1), 41–56.

Bena, J., Garlappi, L., 2020. Corporate innovation and returns. *The Review of Corporate Finance*. Studies 9 (2), 340–383.

Bui, B., Moses, O., Houqe, M.N., 2020. Carbon disclosure, emission intensity and cost of equity capital: multi-country evidence. Account. Financ. 60 (1), 47–71. https://doi.org/10.1111/acfi.12492.

Caragnano, A., Mariani, M., Pizzutilo, F., Zito, M., 2020. Is it worth reducing GHG emissions? Exploring the effect on the cost of debt financing. J. Environ. Manag. 270, 110860.

Caruana, R., Chatzidakis, A., 2014. Consumer Social Responsibility (CnSR): Toward a Multi-Level, Multi-Agent Conceptualization of the "Other CSR. J. Bus. Ethics 121 (4), 577–592. https://doi.org/10.1007/s10551-013-1739-6.

Connelly, B.L., Certo, S.T., Ireland, R.D., Reutzel, C.R., 2011. Signaling theory: A review and assessment. J. Manag. 37 (1), 39–67.

Corrado, C., Haskel, J., Jona-Lasinio, C., Iommi, M., 2013. Innovation and intangible investment in europe, japan, and the united States. Oxf. Rev. Econ. Policy 29 (2), 261–286. https://doi.org/10.1093/oxrep/grt017.

Dachs, B., Peters, B., 2014. Innovation, employment growth, and foreign ownership of firms: A European perspective. Res. Policy 43 (1), 214–232. https://doi.org/10.1016/j.respol.2013.08.001.

Daniel, S.J., Cieslewicz, J.K., Pourjalali, H., 2012. The Impact of National Economic Culture and Country-Level Institutional Environment on Corporate Governance Practices: Theory and Empirical Evidence. Manag. Int. Rev. 52 (3), 365–394. https://doi.org/10.1007/s11575-011-0108-x.

Demirgüç-Kunt, A., Maksimovic, V., 1999. Institutions, financial markets, and firm debt maturity*. J. Financ. Econ. 54 (3), 295–336. https://doi.org/10.1016/S0304-405X(99)00039-2.

Dhaliwal, D.S., Li, O.Z., Tsang, A., Yang, Y.G., 2011. Voluntary nonfinancial disclosure and the cost of equity capital: The initiation of corporate social responsibility reporting. Account. Rev. 86 (1), 59–100. https://doi.org/10.2308/accr.00000005.

Diamond, D.W., Verrecchia, R.E., 1991. Disclosure, liquidity, and the cost of capital. J. Financ. 46 (4), 1325–1359.

Doidge, C., Andrew Karolyi, G., Stulz, R.M., 2007. Why do countries matter so much for corporate governance? J. Financ. Econ. 86 (1), 1–39. https://doi.org/10.1016/j.jfineco.2006.09.002.

Downar, B., Ernstberger, J., Reichelstein, S., Schwenen, S., Zaklan, A., 2021. The impact of carbon disclosure mandates on emissions and financial operating performance. Rev. Account. Stud. 26 (3), 1137–1175. https://doi.org/10.1007/s11142-021-09611-x.

Du, X., Weng, J., Zeng, Q., Chang, Y., Pei, H., 2017. Do lenders applaud corporate environmental performance? Evidence from Chinese private-owned firms. J. Bus. Ethics 143, 179–207.

Eisenhardt, K.M., 1989. Agency Theory: An Assessment and Review. Acad. Manag. Rev. 14 (1), 57–74. https://doi.org/10.5465/amr.1989.4279003.

El Ghoul, S., Guedhami, O., Kim, H., Park, K., 2018. Corporate Environmental Responsibility and the Cost of Capital: International Evidence. J. Bus. Ethics 149 (2), 335–361. https://doi.org/10.1007/s10551-015-3005-6.

Elmawazini, K., Chkir, I., Mrad, F., Rjiba, H., 2022. Does green technology innovation matter to the cost of equity capital? Res. Int. Bus. Financ. 62, 101735. https://doi.org/10.1016/j.ribaf.2022.101735.

Fernández-Cuesta, C., Castro, P., Tascón, M.T., Castaño, F.J., 2019. The effect of environmental performance on financial debt. European evidence. J. Clean. Prod. 207, 379–390.

Freeman, R.E., Reed, D.L., 1983. Stockholders and Stakeholders: A New Perspective on Corporate Governance. Calif. Manag. Rev. 25 (3), 88–106. https://doi.org/10.2307/41165018.

Garzón Jiménez, R., Zorio-Grima, A., 2021. Sustainability engagement in Latin America firms and cost of equity. Acad. Rev. Latinoam. Adm. 34 (2), 224–243.

Gebhardt, W.R., Lee, C.M.C., Swaminathan, B., 2001. Toward an implied cost of capital. J. Account. Res. 39 (1), 135–176.

Goodell, J.W., Goyal, A., 2018. What determines debt structure in emerging markets: Transaction costs or public monitoring? Int. Rev. Financ. Anal. 55, 184–195. https://doi.org/10.1016/j.irfa.2017.07.004.

Guo, X., Wei, T., Wang, A., Hu, H., 2024. Corporate governance effects of digital finance: Evidence from corporate tax avoidance in China. Res. Int. Bus. Financ., 102526

Hail, L., Leuz, C., 2006. International differences in the cost of equity capital: Do legal institutions and securities regulation matter? J. Account. Res. 44 (3), 485–531. https://doi.org/10.1111/j.1475-679X.2006.00209.x.

Hamm, S.J.W., Jung, M.J., Park, M., 2021. Corporate venture capital, disclosure, and financial reporting. Corp. Gov.: Int. Rev. https://doi.org/10.1111/corg.12379.

Hart, S.L., 1995. A Natural-Resource-Based View of the Firm. Acad. Manag. Rev. 20 (4), 986–1014. https://doi.org/10.5465/amr.1995.9512280033.

He, Y., Tang, Q., Wang, K., 2013. Carbon disclosure, carbon performance, and cost of capital. China J. Account. Stud. 1 (3–4), 190–220. https://doi.org/10.1080/21697221.2014.855976.

Hunjra, A.I., Bouri, E., Azam, M., Azam, R.I., Dai, J., 2024. Economic growth and environmental sustainability in developing economies. Res. Int. Bus. Financ. 70, 102341.

Jones, T.M., 1995. Insrumental Stakeholder Theory: A synthesis of Ethics and Economics. Acad. Manag. Rev. 20 (2), 404–437. https://doi.org/10.5465/amr.1995.9507312924.

Judge, W.Q., Douglas, T.J., Kutan, A.M., 2008. Institutional antecedents of corporate governance legitimacy. J. Manag. 34 (4), 765–785. https://doi.org/10.1177/0149206308318615.

Kalu, J.U., Buang, A., Aliagha, G.U., 2016. Determinants of voluntary carbon disclosure in the corporate real estate sector of Malaysia. J. Environ. Manag. 182, 519–524. https://doi.org/10.1016/j.jenvman.2016.08.011.

Kaufmann, D., Kraay, A., Mastruzzi, M., 2011. The worldwide governance indicators: Methodology and analytical issues. Hague J. Rule Law 3 (2), 220–246. https://doi.org/10.1017/S1876404511200046.

Kim, Y.-B., An, H.T., Kim, J.D., 2015. The effect of carbon risk on the cost of equity capital. J. Clean. Prod. 93, 279–287. https://doi.org/10.1016/j.jclepro.2015.01.006.
Klapper, L.F., Love, I., 2004. Corporate governance, investor protection, and performance in emerging markets. J. Corp. Financ. 10 (5), 703–728. https://doi.org/10.1016/S0929-1199(03)00046-4.
Kumar, P., Firoz, M., 2018. Impact of carbon emissions on cost of debt-evidence from India. Manag. Financ. 44 (12), 1401–1417.
La Porta, R., Lopez-de-Silanes, F., Shleifer, A., Vishny, R.W., 1998. Law and finance. J. Political Econ. 106 (6), 1113–1155. https://doi.org/10.1086/250042.
Lee, Y.-Y., Choi, H., Cho, K.-S., 2019. Effects of carbon source, C/N ratio, nitrate. Temp., pH N2O Emiss. Funct. denitrifying Genes heterotrophic denitrification. *J. Environ. Sci. Health, Part A* 54 (1), 16–29.
Lemma, T.T., Feedman, M., Mlilo, M., Park, J.D., 2019. Corporate carbon risk, voluntary disclosure, and cost of capital: South African evidence. Bus. Strategy Environ. 28 (1), 111–126. https://doi.org/10.1002/bse.2242.
Li, D., Huang, M., Ren, S., Chen, X., Ning, L., 2018. Environmental Legitimacy, Green Innovation, and Corporate Carbon Disclosure: Evidence from CDP China 100. J. Bus. Ethics 150 (4), 1089–1104. https://doi.org/10.1007/s10551-016-3187-6.
Li, L., Liu, Q., Wang, J., Hong, X., 2019. Carbon information disclosure, marketization, and cost of equity financing. Int. J. Environ. Res. Public Health 16 (1). https://doi.org/10.3390/ijerph16010150.
Li, R., Ramanathan, R., 2018. Exploring the relationships between different types of environmental regulations and environmental performance: Evidence from China. J. Clean. Prod. 196, 1329–1340.
Maaloul, A., 2018. The effect of greenhouse gas emissions on cost of debt: Evidence from Canadian firms. Corp. Soc. Responsib. Environ. Manag. 25 (6), 1407–1415.
Meckling, W.H., & Jensen, M.C. (1976). Theory of the Firm. *Managerial Behavior, Agency Costs and Ownership Structure*.
Miles, M.P., Covin, J.G., 2000. Environmental Marketing: A Source of Reputational, Competitive, and Financial Advantage. J. Bus. Ethics 23 (3), 299–311. https://doi.org/10.1023/A:1006214509281.
Moser, D.V., Martin, P.R., 2012. A broader perspective on corporate social responsibility research in accounting. Account. Rev. 87 (3), 797–806.
North, D.C., 1990. Institutions, Institutional Change and Economic Performance. Cambridge University Press.
Öztekin, Ö., 2015. Capital Structure Decisions around the World: Which Factors Are Reliably Important? J. Financ. Quant. Anal. 50 (3), 301–323. https://doi.org/10.1017/S0022109014000660.
Pástor, L., Veronesi, P., 2012. Uncertainty about Government Policy and Stock Prices. J. Financ. 67 (4), 1219–1264. https://doi.org/10.1111/j.1540-6261.2012.01746.x.
Petrakis, P.E., Kostis, P.C., Valsamis, D.G., 2015. Innovation and competitiveness: Culture as a long-term strategic instrument during the European Great Recession. J. Bus. Res. 68 (7), 1436–1438. https://doi.org/10.1016/j.jbusres.2015.01.029.
Pfeffer, J., Salancik, G., 2015. External control of organizations—Resource dependence perspective. In: In *Organizational behavior*, 2. Routledge, pp. 355–370.
Phan, D.H.B., Iyke, B.N., Sharma, S.S., Affandi, Y., 2021. Economic policy uncertainty and financial stability–Is there a relation? Econ. Model. 94, 1018–1029. https://doi.org/10.1016/j.econmod.2020.02.042.
Plumlee, M., Brown, D., Hayes, R.M., Marshall, R.S., 2015. Voluntary environmental disclosure quality and firm value: Further evidence. J. Account. Public Policy 34 (4), 336–361. https://doi.org/10.1016/j.jaccpubpol.2015.04.004.
Scott, W.R., 2008. Institutions and organizations: Ideas and interests. Sage Publications.
Shad, M.K., Lai, F.W., Shamim, A., McShane, M., 2020. The efficacy of sustainability reporting towards cost of debt and equity reduction. Environ. Sci. Pollut. Res. 27 (18), 22511–22522. https://doi.org/10.1007/s11356-020-08398-9.
Sharfman, M.P., Fernando, C.S., 2008. Environmental risk management and the cost of capital. Strateg. Manag. J. 29 (6), 569–592. https://doi.org/10.1002/smj.678.
Shi, C., 2003. On the trade-off between the future benefits and riskiness of R\&D: A bondholders' perspective. J. Account. Econ. 35 (2), 227–254.
Siddique, M.A., Akhtaruzzaman, M., Rashid, A., Hammami, H., 2021. Carbon disclosure, carbon performance and financial performance: International evidence. Int. Rev. Financ. Anal. 75, 101734.
Subramaniam, N., Wahyuni, D., Cooper, B.J., Leung, P., Wines, G., 2015. Integration of carbon risks and opportunities in enterprise risk management systems: evidence from Australian firms. J. Clean. Prod. 96, 407–417.
Trinks, A., Ibikunle, G., Mulder, M., Scholtens, B., 2022. Carbon Intensity and the Cost of Equity Capital. Energy J. 43 (2), 181–214. https://doi.org/10.5547/01956574.43.2.atri.
Verrecchia, R.E., 1983. Discretionary disclosure. J. Account. Econ. 5, 179–194. https://doi.org/10.1016/0165-4101(83)90011-3.
Zhang, Y., Peng, H., Liu, T., Xie, K., 2024. Corporate innovation and analysts' estimates of the cost of equity: Evidence from China. Int. Rev. Econ. \ Financ. 89, 83–101.
Zhou, Z., Tang, Y., Dong, J., Chi, Y., Ni, M., Li, N., Zhang, Y., 2018. Environmental performance evolution of municipal solid waste management by life cycle assessment in Hangzhou, China. J. Environ. Manag. 227, 23–33.
Zsóka, Á.N., 2008. Consistency and "awareness gaps" in the environmental behaviour of Hungarian companies. J. Clean. Prod. 16 (3), 322–329.