

Board Environmental Expertise and Carbon Disclosure Quality: A Sample of 28 Australian Securities Exchange Listed Firms

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Abstract. This study uses 28 listed firms on the Australian Stock Exchange (ASX) as a sample to examine the relationship between board environmental expertise and carbon disclosure quality (CDQ). The CDQ index is hand-collected based on Scope 1, 2, and 3 greenhouse gas (GHG) emissions disclosures in annual reports, employing a Tobit regression model to analyse 140 firm-year observations over the period 2019 to 2023. The results show that board environmental expertise has a significant positive association with CDQ. The robustness tests indicate that across alternative model specifications, this positive relationship is consistent in direction and is still significant when an alternative measurement method is employed. The heterogeneity analysis reveals that the positive relationship is concentrated in low-pollution industries, while a negative relationship is observed in high-pollution industries, indicating that the relationship between board environmental expertise and CDQ differs across industry contexts. These findings contribute to the Upper Echelons Theory literature and provide an empirical basis for the role of board environmental expertise in shaping the quality of firms' carbon disclosure.

Keywords: Board environmental expertise, carbon disclosure, greenhouse gas emissions, Tobit regression, ASX-listed firms

1. Introduction

The increasing impacts of climate change have made firm environmental transparency an increasingly important issue for regulators, investors and other stakeholders. Since GHG emissions are closely related to climate risks, compliance requirements and the long-term sustainable development of firms, carbon disclosure has received wide attention in various firm sustainability research. High-quality carbon disclosure enables stakeholders to assess the environmental performance and climate-related risks of firms, thus supporting them in making more informed investment and governance decisions.

Australia provides a particularly relevant context for examining carbon disclosure practices. As one of the world's largest resource-exporting economies, Australia faces substantial pressure to address climate change and improve corporate environmental accountability. The growing regulatory and stakeholder pressure has highlighted the importance of climate-related disclosure in

the capital market [1]. Following the adoption of the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD) and introducing mandatory climate reporting standards, Australian listed firms have faced higher requirements for more comprehensive carbon disclosure. Although substantial variation remains across firms, international studies also show that following TCFD recommendations is closely related to higher-quality climate-related disclosure [2]. Therefore, understanding the factors affecting the quality of carbon disclosure has become an important research topic.

Previous studies have identified various corporate governance mechanisms that affect carbon disclosure [3-5]. However, most existing studies focus on structural governance characteristics rather than the particular skills and knowledge of directors.

Researchers have increasingly recognised the important role of board environmental expertise in corporate sustainability outcomes. Previous studies suggest that board environmental expertise contributes to corporate sustainability outcomes [6, 7]. However, particularly in the Australian context, there is still limited evidence on whether directors' environmental expertise improves CDQ.

This study examines the relationship between board environmental expertise and CDQ using a CDQ index constructed from Scope 1, 2, and 3 GHG emissions disclosures in annual reports and makes three main contributions to the literature. First, it expands the research field of corporate governance and carbon disclosure by focussing on board environmental expertise rather than traditional board characteristics. Second, it provides recent evidence from the Australian capital market. Third, it introduces an objective and replicable CDQ measurement method based on GHG emissions disclosures, thereby reducing the subjectivity commonly associated with content-analysis-based disclosure indices.

2. Literature review and hypothesis development

2.1. Theoretical foundation

Upper Echelons Theory, proposed by Hambrick and Mason, suggests that organisational outcomes can be explained to some extent by the characteristics, experiences and values of senior executives [8]. As executives and directors face a complex and uncertain business environment, their backgrounds influence how they interpret information and how they formulate strategic decisions.

In the context of environmental governance, directors with environmental expertise may deeply understand climate risks, emissions management, sustainable development regulations and environmental reporting standards. These directors can identify various environmental challenges and encourage firms to adopt more transparent carbon disclosure practices. Building on this theoretical foundation, the following sections review the empirical literature on corporate governance, board environmental expertise and carbon disclosure.

2.2. Corporate governance and carbon disclosure

Corporate governance mechanisms are widely recognised as important factors affecting firm carbon disclosure. Specifically, studies in different countries reach relatively consistent conclusions. For example, Liao et al. find that gender diversity, board independence, and environmental committees can promote GHG emissions disclosure based on British listed firms [3]. Similarly, Ben-Amar et al. find that Canadian listed firms with a high proportion of female directors are more inclined to disclose information about climate change [4]. In addition, cross-country research shows that the board-level sustainability committee can improve the quality of climate-related disclosure,

indicating that the specialised governance structure helps to strengthen the disclosure of climate-related information in firms [9].

Evidence from Australia further supports these findings. Elsayih et al. find that both board independence and board diversity can improve the transparency of carbon disclosure in Australian listed firms [5].

Taken together, these findings show that there is a close relationship between board governance mechanisms and carbon disclosure. However, these studies mainly focus on the characteristics of traditional boards while paying less attention to directors' environmental expertise.

2.3. Board expertise and sustainability outcomes

The research focus is gradually shifting from the traditional board characteristics to the directors' expertise, as an important governance resource. The board environmental expertise reflects the knowledge, skills, and experience in environmental management, sustainability and strategic decision-making, which may more directly influence the environmental governance and oversight of firms. Empirically, board environmental expertise can further improve the environmental performance of firms beyond the traditional governance structure [10].

International research further supports this view. Iliev and Roth find that directors with expertise in sustainable development can significantly improve the firms' environmental and social performance. They argue that this expertise helps directors identify environmental risks and support firms in developing sustainability-oriented strategies [6]. Similarly, della Corte et al. find that board industry expertise can promote the development of ESG strategies, thus improving the overall ESG performance of firms [7]. In addition, other studies find that board expertise in sustainability can enhance stakeholders' confidence in the long-term environmental commitment of firms [11].

In addition to these sustainability outcomes, board expertise may further influence firms' carbon disclosure practices. For example, a study of Japanese listed firms finds that the diversity of board expertise moderates the relationship between board gender diversity and carbon disclosure, indicating that the characteristics of the board related to the expertise influence the carbon disclosure practices of firms, not just serving as general governance characteristics [12].

Taken together, these findings indicate that board expertise is an important governance resource that influences the environmental decision-making of firms. However, the existing literature mainly focuses on the impact of the board expertise on environmental performance, ESG strategies and sustainability performance, while the direct evidence of whether board environmental expertise can improve the CDQ is still limited.

2.4. Hypothesis development

Based on Upper Echelons Theory, board environmental expertise may directly affect CDQ through the following mechanisms. Directors with environmental expertise are more likely to identify incomplete carbon disclosure and encourage management to provide more comprehensive Scope 1, 2, and 3 emissions data. In addition, such directors are more familiar with greenhouse gas accounting standards (e.g., the GHG Protocol) and regulatory requirements, which can improve the board's oversight effectiveness on CDQ.

From the perspective of stakeholders, firms face increasing pressure from investors, regulators, customers and society to provide high-quality climate-related disclosure. Directors with environmental expertise may be more responsive to these expectations and advocate greater carbon disclosure transparency.

H1: Board environmental expertise is positively associated with CDQ.

While H1 examines the average effect across the full sample, the relationship between board environmental expertise and CDQ may vary depending on the industry contexts. In high-pollution industries, firms face greater regulatory scrutiny and are more exposed to climate-related litigation and reputational risks. Therefore, firms may adopt more cautious disclosure strategies to avoid excessive attention from regulators or stakeholders to their environmental impact. In contrast, in low-pollution industries, due to the relatively low environmental risks and regulatory pressure, environmental expertise is more likely to be used to promote voluntary transparent disclosure, thus improving corporate reputation and winning the trust of stakeholders.

H2: The relationship between board environmental expertise and CDQ differs between high-pollution and low-pollution industries.

3. Research methodology

3.1. Sample and data

Sample selection follows three criteria. First, firms must have publicly available annual reports in all sample years; second, firms must disclose sufficient information in the directors' biographies to identify board environmental expertise; third, firms must disclose sufficient financial information to calculate the control variables. After applying these criteria, the final sample contains 28 firms, with a total of 140 firm-year observations. The sample covers a broad range of industries, including high-pollution industries (e.g., mining, energy, steel and chemical industry) and low-pollution industries, so as to facilitate heterogeneity analysis.

3.2. Variable measurement

The dependent variable is CDQ, which measures the completeness of emissions disclosure in annual reports. Unlike conventional disclosure indices that rely on subjective content analysis, this study adopts an objective scoring approach based on Scope 1, Scope 2, and Scope 3 emissions disclosures following the GHG Protocol. The scoring criteria are presented below (Table 1):

Table 1. Disclosure criteria

Score	Disclosure Criteria
0	No Scope emissions information disclosed in the annual report
1	Scope 1 and Scope 2 disclosed only in combined form, or only one scope disclosed separately
2	Scope 1 and Scope 2 disclosed separately with absolute emission values
3	Scope 1, Scope 2, and Scope 3 all disclosed separately with absolute emission values

The CDQ index is adapted from the Carbon Integrity Index (CIX) framework. Scope 3 reporting remains systematically weaker than Scope 1 and Scope 2 reporting, which provides both methodological and empirical support for treating scope integrity as an effective indicator of CDQ [13]. Accordingly, this study develops a simplified scoring scheme ranging from 0 to 3 suitable for the annual report disclosures, in which the disclosure of Scope 1 and 2 represents the basic level of transparency, while the inclusion of Scope 3 reflects a more advanced and comprehensive level of carbon disclosure.

Standalone sustainability reports and ESG reports are excluded to ensure consistency across firms. Only absolute emission data (e.g., MtCO₂-e) are included, while emission intensity measures are excluded from the scoring scheme. The measure directly reflects the integrity of the firm's GHG emissions reporting and can be independently verified. Accordingly, the indicator measures substantive carbon disclosure, not just the existence of statements related to sustainable development. Higher CDQ scores indicate more comprehensive carbon emissions disclosure.

The key independent variable is Board Environmental Expertise (ENV_EXP). Following the expertise-based governance literature, environmental expertise is identified based on directors' professional backgrounds and qualifications disclosed in annual report biographies. If a director has relevant experience or qualifications in environmental science, environmental engineering, sustainable management, climate change policy, renewable energy, environmental regulations or ESG governance, the director is classified as having environmental expertise. ENV_EXP is measured as the ratio of the number of directors with environmental expertise to the total number of directors.

This study controls for firm size (SIZE), leverage (LEV), profitability (ROA), revenue growth (GROWTH), and board size (BOARD_SIZE). Detailed variable definitions are provided in the notes. Year fixed effects (Year FE) are included to control for changes in the regulatory environment and macroeconomic conditions over time. Financial data are obtained from the Osiris database, while CDQ data and board characteristics are manually collected from firms' annual reports.

3.3. Model specification

Because CDQ is a left-censored dependent variable and bounded between 0 and 3, ordinary least squares (OLS) estimation may produce biased estimates. Therefore, Tobit regression is employed as the primary estimation method. The empirical model is specified as follows:

$$CDQ_{it} = \beta_0 + \beta_1 ENV_EXP_{it} + \beta_2 SIZE_{it} + \beta_3 LEV_{it} + \beta_4 ROA_{it} + \beta_5 GROWTH_{it} + \beta_6 BOARD_SIZE_{it} + YearFE + \varepsilon_{it} \quad (1)$$

To assess robustness, a random-effects (RE) panel model and an alternative measure, $\ln(ENV_EXP)$, are also employed. To test H2, subsample analyses are conducted by dividing the sample into high-pollution and low-pollution industries based on industry pollution intensity.

4. Empirical results

4.1. Descriptive statistics

Table 2 reports the descriptive statistics for all variables used in the analysis. The average value of CDQ is 1.064, indicating that most firms provide limited carbon disclosure in their annual reports. On average, firms disclose either partial Scope emissions or combined Scope 1 and 2 emissions, but do not provide complete Scope 3 data.

Table 2. Descriptive statistics

Variable	N	Mean	Std. Dev.	Min	Max
CDQ	140	1.064	1.167	0	3

Table 2. (continued)

ENV_EXP	140	0.423	0.124	0.130	0.818
SIZE	140	23.748	0.808	22.157	25.761
LEV	140	0.547	0.167	0.220	1.010
ROA	140	0.058	0.075	-0.161	0.363
GROWTH	140	0.085	0.281	-0.584	1.647
BOARD_SIZE	140	9.117	1.420	7	14

Notes: CDQ is a carbon disclosure quality index (0–3). ENV_EXP is the proportion of directors with environmental expertise. SIZE is the natural logarithm of total assets. LEV is total liabilities divided by total assets. ROA is net income divided by total assets. GROWTH is the annual growth rate of total revenue. BOARD_SIZE is the total number of directors.

4.2. Main regression results

ENV_EXP has a significant positive association with CDQ, which provides strong support for H1 (Table 3). The weakening of the significance in the linear RE model is consistent with the methodological recommendation for corner-solution dependent variables: when nearly half of the observations are truncated at zero, the linear panel estimator may produce biased and inefficient coefficients, and the Tobit regression model clearly considers this truncated problem [14, 15]. This further confirms the rationality of using the Tobit regression model as the main analysis model in this study.

Among the control variables, only SIZE is positively associated with CDQ, consistent with previous research results suggesting that large firms face greater public scrutiny. The coefficients of LEV, ROA, GROWTH, and BOARD_SIZE are not statistically significant. One possible explanation is that ENV_EXP directly influences disclosure decision-making through the oversight mechanism of the board, rather than acting through the characteristics of the firm. Although variables such as ROA and LEV describe the economic characteristics of firms, environmental expertise affects the evaluation, monitoring and disclosure of climate-related information, so it is more closely related to CDQ.

Table 3. Regression results

Variables	(1) Tobit Main	(2) RE Robustness	(3) Tobit ln_ENV
ENV_EXP	6.387*** (2.372)	1.351 (1.311)	
ln_ENV_EXP			2.944*** (1.039)
SIZE	1.920*** (0.432)	0.554*** (0.192)	1.888*** (0.433)
LEV	-1.668 (1.660)	0.178 (0.880)	-1.733 (1.653)
ROA	3.140	0.623	3.799

Table 3. (continued)

	(3.968)	(1.253)	(4.011)
GROWTH	-0.701	-0.398*	-0.646
	(0.896)	(0.221)	(0.895)
BOARD_SIZE	-0.223	-0.060	-0.238
	(0.225)	(0.087)	(0.226)
Year FE	Yes	Yes	Yes
Observations	140	140	140
R ² / Pseudo R ²	0.122	0.267	0.122

Notes: Standard errors are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. All Tobit models use Year FE (lower limit = 0, upper limit = 3). Hausman test: $\chi^2(10) = 12.88$ ($p = 0.231$), supporting the use of RE over FE.

4.3. Heterogeneity analysis

To test H2, Table 4 presents the results of the subsample analysis by industry pollution intensity. For low-pollution industries, ENV_EXP and CDQ have a significant positive association ($\beta = 18.610$, $p < 0.01$); while for high-pollution industries, the two are negatively and significantly associated ($\beta = -7.638$, $p < 0.01$), indicating that the impact of ENV_EXP on CDQ varies substantially in the context of different industries.

In addition to the risk-based explanation proposed in H2, the regulatory crowding-out may also help explain the negative association observed in high-pollution industries. Studies have shown that mandatory disclosure may crowd out voluntary incremental disclosure by reducing the marginal informational value of additional disclosure efforts [16]. Because during the sample period, large emitters in high-pollution industries have been required to report emission data of Scope 1 and 2 according to Australia's National Greenhouse and Energy Reporting (NGER) scheme, ENV_EXP has limited room for further improving CDQ, and strategic caution is only one of several plausible mechanisms. Overall, these findings provide empirical support for H2, indicating that the intensity of industry pollution substantially shapes the relationship between ENV_EXP and CDQ.

Table 4. Heterogeneity analysis by industry pollution intensity

Variables	High-pollution Industries	Low-pollution Industries
ENV_EXP	-7.638*** (2.362)	18.610*** (4.755)
SIZE	0.728* (0.416)	1.438** (0.717)
LEV	5.095** (2.230)	0.009 (2.532)
ROA	6.333** (2.586)	12.926 (8.925)
GROWTH	-2.279***	-0.060

Table 4. (continued)

	(0.759)	(1.682)
BOARD_SIZE	0.125	-0.720*
	(0.217)	(0.387)
Year FE	Yes	Yes
Observations	50	90
Log Likelihood	(54.120)	(93.035)
Pseudo R ²	0.305	0.161

5. Discussion

The positive association between board environmental expertise and CDQ shows that the environmental expertise of directors plays an important role in shaping the carbon disclosure practices of firms. These findings extend the existing literature and show that board environmental expertise is a distinct governance resource beyond traditional board characteristics, and the intensity of industry pollution is a key boundary condition that affects its relationship with CDQ.

From a theoretical perspective, this study demonstrates that board environmental expertise not only influences the sustainability performance reported in prior studies, but also directly influences CDQ, thus extending Upper Echelons Theory and showing that board environmental expertise has a more direct impact on carbon disclosure than firms' underlying economic characteristics.

Heterogeneity analysis further shows that the effect of board environmental expertise varies in the context of different industries. This context-dependent pattern highlights the important limitation of treating board environmental expertise as universally beneficial: in high-emission industries, directors who understand the regulatory and reputational consequences of extensive disclosure may be more cautious. Whether this cautious approach is strategic disclosure management or prudent risk avoidance remains an open question.

There are several limitations in this study. First, the sample is limited to 28 companies listed on ASX and may not represent the broader Australian market. Second, the CDQ measure is only based on the disclosure content in the annual report and does not cover the information in the standalone sustainability reports, which may lead to an underestimation of the quality of actual disclosure. Third, since the environmental expertise is identified from directors' biographies disclosed by the firm, this indicator may partially reflect the motivation of the firm to emphasise the environmental credentials of the director, rather than fully capturing directors' actual expertise. If companies with strong ESG orientation are also more inclined to highlight the environmental background of the directors, the observed relationship may partly reflect reverse causality, rather than a unidirectional effect of board environmental expertise on CDQ [17, 18].

6. Conclusion

Overall, this study finds that there is a positive association between board environmental expertise and CDQ, and the results remain robust across alternative model specifications. Heterogeneity analysis further shows that there are differences in this relationship in the context of different industries: in low-pollution industries, board environmental expertise is positively associated with CDQ; while in high-pollution industries, a negative association is observed.

As Australia continues to strengthen regulatory requirements for climate-related disclosures, the appointment of directors with environmental expertise may help improve the board's ability to oversee climate-related disclosure and better respond to stakeholders' expectations for transparency. Regulators and institutional investors may also regard board environmental expertise as an indicator of the quality of corporate governance when evaluating firms' climate disclosure commitments. On this basis, future research could use larger samples, longer study periods, and additional disclosure sources such as standalone sustainability reports to more comprehensively understand how board environmental expertise shapes CDQ.

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