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Climate risk disclosures and auditor expertise

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ABSTRACT

Many jurisdictions are establishing requirements for corporations to disclose climate-related risks, and for those disclosures to be audited. One of the first jurisdictions to do so is Australia, where the Australian Accounting Standards Board (AASB) and Auditing and Assurance Standards Board (AUASB) issued a Joint Bulletin in 2018 stating that both preparers and auditors should consider the impact of climate risks on the company's financials. Utilising the Australian setting, this paper introduces a new measure of audit partner expertise, namely *expertise in climate-related issues*, and examines whether it is associated with the client company's climate risk reporting. We define audit partner expertise in climate-related issues based on their client portfolio composition in terms of greenhouse gas emissions. We find that the likelihood and quality of climate risk disclosures is higher when the audit partner has climate risk expertise, and this finding is driven by clients in industries with material climate risks.

1. Introduction

According to the *Task Force on Climate Related Financial Disclosures* (TCFD), "warming of the planet caused by greenhouse gas emissions poses serious risks to the global economy and will have an impact across many economic sectors" (TCFD, 2017). To provide investors with useful information about the risks from climate change and to direct the investments to sustainable businesses, regulators around the world are now developing new rules that would connect climate risks more clearly to the company's financial statements and require this information to be audited. In the EU, for example, the Corporate Sustainability Reporting Directive (CSRD) requires the consideration of financial implication of climate-related financial risks and requires companies to disclose climate-related information in the management report (Directive 2022/2464, 2022). The SEC also proposed rules to enhance and standardize climate-related disclosures for investors (SEC, 2022). In Australia, the *Joint Bulletin on Climate-related and other emerging risks disclosures* (AASB & AUASB, 2018), in effect since 2019, requires that Australian listed companies and their auditors should consider the impact of climate risks on the company's financial reporting. This recent shift of emphasis on climate risk reporting regulations requires the auditors of the financial reports to consider and understand the climate risks related to the client company's operations.

In this paper, we examine the extent to which auditors make a difference to client disclosure, by investigating whether an audit partner's climate risk expertise is associated with a greater likelihood and higher quality of client climate risk disclosures. We utilize

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the recent regulatory change regarding climate risk reporting in Australia. Australia is a global leader in climate reporting (Zhou, 2022), and a setting where carbon emissions are documented to have an impact on stock market valuations (Choi et al., 2021). With the Joint Bulletin requiring companies to consider climate risks in their financial reports, Australia has been one of the forerunners in climate risk disclosure requirements (Anderson, 2019; EFRAG, 2019; Grayston, 2019; Müller et al., 2024; TCFD, 2019). This requirement has shifted the company's disclosures of climate-related risks under the scope of financial statement audit and thereby increased auditors' responsibility in assessing those disclosures. When climate-related disclosures are made in the financial statements, including the notes, they are required to be audited (AASB & AUASB, 2018). When the disclosures are presented elsewhere in the annual reports but outside of the financial statements, they are not audited, but the auditor should consider whether these disclosures are materially inconsistent with the financial report or the auditor's knowledge (AASB & AUASB, 2018).[1]

We hypothesize that audit partners with specialized knowledge in climate-related issues could help their clients in translating information on climate risks into high-quality disclosures. Literature shows that auditors can improve client company disclosure quality through discussing issues with management (Dunn & Mayhew, 2004; Han et al., 2012; Legoria et al., 2017; Liu et al., 2023), and that high quality auditors have ability and incentives to do so (DeAngelo, 1981; DeFond & Zhang, 2014; C.-Y. Lim & Tan, 2008; Palmrose, 1988). In addition, we expect that the association between expertise and climate risk disclosure quality is most evident in industries where such disclosures add the most value, that is, industries with material climate risks. Stakeholder monitoring and information asymmetry regarding climate risks are expected to be greater in these industries, and the potential benefits from better disclosures could outweigh the costs of reporting and providing proprietary information.

To capture audit partner expertise in climate-related issues, we introduce a new measure of specialization based on the audit partner's portfolio of clients' Greenhouse Gas Emissions (GHG Emissions). For a robustness check of climate-related expertise, we create alternative measures based on: 1) portfolio of clients' GHG Emissions in previous years (2016 and 2017), with the assumption that the expertise accumulated before the Joint Bulletin could be useful in helping clients develop their climate risk disclosures, and 2) portfolio of clients in the industries with material climate risks.

In addition to climate-related expertise, a client's climate risk disclosure is likely affected by auditors' industry expertise, capturing greater understanding of client business. Auditors with both industry and climate-related expertise may have better capabilities to influence client climate risk disclosure. Moreover, industry expertise and climate-related expertise are likely to overlap to some extent, and hence, it is important that the measurement of emissions is at firm level instead of industry level. To disentangle the effects of climate-related expertise from industry expertise, and to examine the influence of the combination of the two, we create three variables which refer to 1) audit partners with both industry and climate-related expertise, 2) partners with only industry expertise, and 3) partners with only climate-related expertise.

Our proxies for climate-related risk disclosures include 1) an indicator for the occurrence of climate risk disclosure and 2) a composite measure for disclosure quality, considering length, originality, and the number of categories disclosed per the TCFD framework. In accordance with the AASB & AUASB (2018) requirements, we consider climate-related risk disclosure in any part of the annual report, including the financial statements, the directors' report, the governance report, and the sustainability report. [2] Following the literature on risk disclosures (Dobler et al., 2011; Lang & Lundholm, 1993; Linsley & Shrives, 2006; Miihkinen, 2012; Singhvi & Desai, 1971) and environmental reporting (Ben-Amar & McIlkenny, 2015Ben-Amar & McIlkenny, 2015; Clarkson et al., 2018), we control for factors such as audit firm size, whether financial statement auditor and sustainability assurer are from the same audit firm, the client's environmental performance (GHG Emissions deflated by revenues and adjusted for industry), the client's level of risks and reporting incentives, board characteristics, sustainability reporting practices and other relevant factors influencing disclosure decisions.

We find that the auditor's climate-related expertise is positively associated with the likelihood and quality of clients' climate-related risk disclosures in the annual reports, and that this result is driven by clients in industries with material climate risks (according to the TCFD classification). These results demonstrate that the audit partner's climate expertise is an important factor in explaining the climate risk disclosures of her/his clients.

Our study contributes to the literature in two ways. First, to the best of our knowledge, no prior study considers the role of audit partners in client's climate risk reporting – an area which has not traditionally been in the scope of auditing, but which is currently a major topic in practice. In a very recent study, Liu et al. (2023) finds that audit firm sustainability focus (captured from tweets) is positively associated with client sustainability disclosure. We add to this scarcely researched area of auditor involvement in sustainability reporting. In general, our findings provide new insights into prior literature regarding the influence of competent audit partners on client disclosures (e.g., Bozzolan & Miihkinen, 2021; Campbell et al., 2014; Dunn & Mayhew, 2004; Oliveira et al., 2011).

Second, we introduce a new dimension of audit partner expertise, namely climate-related expertise. While prior research about auditor expertise has focused mainly on the auditor's industry specialization (DeFond & Zhang, 2014), we provide evidence on how climate-related expertise is positively related to client climate risk disclosures. In this respect, we also contribute to the literature on auditor expertise as input to audit quality (DeFond & Zhang, 2014; Knechel et al., 2013). Our findings suggest that auditing of companies exposed to climate issues increases the climate-related expertise of the audit partner. We hence add to the prior literature examining other types of expertise such as those related to listed firm specialization (Ittonen et al., 2015; Zerni, 2012), governmental entity specialization (Elder et al., 2015; Lowensohn et al., 2007), specialization in specific SEC regulation (Legoria et al., 2017), and auditor's special knowledge about litigation (Chen et al., 2018).

[1] AASB & AUASB (2018) referred to ASA 720 - *The Auditor's Responsibilities Relating to Other Information*, the Australian equivalent of ISA 720.

[2] Table 4, Panel A shows the position in the annual report that companies in our data use to disclose climate risks.

Regarding practical implications, our findings are important for the audit profession itself. As sustainability reporting or sustainability impacts are gradually coming closer to (or will even be integrated into) financial reporting, auditors need to have sufficient knowledge on assessing such information. Consequently, our results should be of interest to regulators and legislators in understanding not only the effect of the climate risk disclosure standards and recommendations, but also more broadly speaking, ESG standards and recommendations. Regulators could for example consider whether sustainability aspects should be included in the education and training requirements for statutory auditors.[3] Furthermore, investors have now specifically identified climate-related risks as being used in their decision-making, but not being adequately addressed in annual reports (AASB & AUASB, 2018). As firms are increasingly being incentivized to apply for green financing and pressurized by their stakeholders to show their sustainability effort, our study helps management in choosing auditor profiles that are likely to better assess climate related risk disclosures to meet investor expectations.

In the next section we start by discussing the change in reporting landscape for environmental disclosures and then develop the hypotheses. The third section describes our research design, including variable definitions, empirical models, and data. The fourth section presents the empirical results, and the last section concludes our study.

2. Background and hypotheses development

2.1. Development of the reporting landscape for environmental disclosures

Over the past decades, the reporting landscape for environmental disclosures including climate risks has been widened with many new regulations, standards, guidelines, and frameworks.[4] In recent years, regulators and investors have particularly emphasised the need for more information on the effects of climate change and related risks on companies' financial performance. Investors use climate risk information in their investment decisions (Ilhan et al., 2023), and a lack of information about climate risk implications to the company's future performance can be assumed to have an adverse impact on the company's share price.

Consequently, recent developments in the corporate reporting landscape emphasize the disclosure of the financial implications of climate change. The major proponent of this development is the Task Force on Climate-related Financial Disclosures (TCFD) which provides guidance on how to effectively disclose climate-related risks and opportunities in four core elements: governance, strategy, risk management, and metrics and targets.[5] The TCFD focuses primarily on the users of the financial statements and recommends providing information about the financial impacts of climate-related risks on firms' financial reports.

In the spirit of the TCFD, jurisdictions worldwide are establishing rules and regulations to enhance climate disclosures, and to increase firms' awareness of their climate risks. In this context, in 2018, Australia is one of the first countries in the world to issue guidance – the Joint Bulletin (AASB & AUASB, 2018) – on how to disclose climate risks in the financial reports (Anderson, 2019; EFRAG, 2019; Grayston, 2019; Müller et al., 2024; TCFD, 2019). This guidance also emphasizes the role of auditors in assessing the impact of climate-related risks, considering not only qualitative aspects such as the client's internal controls and risk management system but also bias in accounting estimates. In addition, auditors are required to approach climate risk issues with the same rigor as they do for financial items. As the auditors' responsibilities over clients' climate risks and the related disclosure increase, it is important to consider auditors' climate risk related competencies.

2.2. Audit partner expertise in climate-related risks

Auditor knowledge and expertise are important direct inputs to the audit process, thereby influencing the quality of an audit (Francis, 2011; Knechel et al., 2013). An auditor with greater expertise is expected to make higher-quality judgments in the audit process, for example which tests and procedures should be used, and how to evaluate audit evidence. Prior literature emphasizes the role of domain-specific knowledge — knowledge related to certain kinds of clients to develop expertise (Bonner & Lewis, 1990). Specialization enables auditors to acquire such knowledge through education, training, and direct experience in auditing companies within specific domains (Bonner & Lewis, 1990). Auditors who work exclusively in a certain domain will have deeper experience and in turn, better knowledge about the domain characteristics and trends (Krishnan, 2003; Solomon et al., 1999). Related to this, Christensen et al. (2016) show that both investors and auditors consider individual auditors with appropriate experience and expertise to be an indicator of higher audit quality.

[3] Education requirements related to sustainability are being considered, for example by the International Accounting Education Standards Board (IFAC, 2024). Furthermore, the IFRS Foundation (2023) has published educational material on the effect of climate-related matters on financial statements.

[4] E.g., GRI (The Global Reporting Initiative); CDP (formerly Carbon Disclosure Project); CDSB (Climate Disclosure Standards Board); Value Reporting Foundation; International Sustainability Standards Board (ISSB).

[5] TCFD describes two types of climate-related risks: (1) the physical impacts caused by, for example, acute weather events or chronic heat waves, and (2) transition risks when we move towards a lower-carbon economy. The latter component includes risks related to policy changes and litigation, technology, markets, and reputation.

Literature on auditor specialization has focused mostly on industry-level specialization, providing ample evidence that, compared to non-specialists, industry specialist auditors are associated with higher audit quality.[6] In general, industry specialist auditors are expected to possess a greater understanding of the client's business and its environment. Auditors acquire industry knowledge from specialized indirect experience (e.g., training) and focused direct experience (working on engagements in a specific industry) (Solomon et al., 1999). Some prior studies have explored other domains in which auditors may develop their knowledge and expertise, for example, clients with a certain ownership type (Zerni, 2012), or public sector and non-profit organizations (Elder et al., 2015; Lowensohn et al., 2007).[7]

In this paper, we suggest that auditors can develop their expertise in climate-related issues. Increased competence of the auditor in climate-related matters could stem from the experience in auditing businesses that are more affected by climate risks. Through this experience, the auditor could have more information about, for example, relevant changes in regulation or standards regarding climate risks and their impact on clients, or about stakeholder concerns regarding climate issues.[8] Knowledge about environmental matters can partly overlap with industry-specific knowledge, and therefore industry specialists may have knowledge of the industry-specific environmental issues of the client. However, knowledge on climate-related matters is not limited to a specific industry but can be obtained from clients' climate risk exposure across different industries.

There are several reasons why auditor expertise on climate-related issues may matter. Auditors need to understand climate risks and their impact, to assess whether the risk is material to the client's business and what implications it may have (AASB & AUASB, 2018). Auditors use their knowledge to assess accounting estimates and management bias regarding climate risks and to judge whether climate risks should be disclosed in the financial statements. Moreover, even when these disclosures are presented in the annual reports but outside of the financial statements, such as the directors' report or corporate governance report, auditors are expected to read the disclosures and if necessary, disclose that there is an uncorrected material misstatement (ASA 720, 2015). Therefore, auditors must understand climate-related risks even if the risks do not affect accounting estimates and are not reported in the financial statements.

2.3. *Hypotheses development*

In this study, we examine whether auditor expertise on climate-related issues makes a difference for client climate risk disclosure. Previous literature on various corporate disclosures suggests that auditors considered "higher quality" can assist the client and influence disclosure quality (Dunn & Mayhew, 2004; Han et al., 2012; Legoria et al., 2017).[9] This applies not only to the disclosures in audited financial statements but also to the unaudited sections of an annual report. For example, Legoria et al. (2017) found that companies with specialist auditors are more likely to disclose information about major customers in the unaudited sections of annual reports. Moreover, Liu et al. (2023) found that audit firm sustainability focus (measured by sustainability focus in tweets) is positively associated with client sustainability reporting. In general, discussions between client management and their auditor create the opportunity for information flow and knowledge can be transferred to the clients regarding best practices and other recommendations.[10] Auditors with appropriate expertise can act as an information intermediary, who provide necessary information for client reporting decisions through discussions within audit engagement (Liu et al., 2023). This, in turn, can reduce client reporting costs (Liu et al., 2023). Consequently, auditors with greater climate-related knowledge could be able to act as an intermediary of information regarding climate risks.

Furthermore, auditors could be expected to have incentives to influence clients' climate risk disclosures. First, pressure to provide high quality information on climate risks emerges from increasing awareness of climate change.[11] The pressure can be particularly strong in the Australian setting, where the standard setters have issued the Joint Bulletin on climate risk disclosure. Further, auditors have the incentive to encourage their clients to disclose more comprehensively, for example by informing the client about new requirements on climate risk disclosure, since they are exposed to reputation and litigation risk if their clients' reporting practices are perceived as low quality (DeAngelo, 1981; DeFond & Zhang, 2014; C.-Y. Lim & Tan, 2008; Palmrose, 1988).

[6] These studies have utilized various measures of audit quality, such as violations of reporting standards (O Keefe et al., 1994), error detecting (Owhoso et al., 2002), accrual-based earnings managements (Balsam et al., 2003; Krishnan, 2003; Reichelt & Wang, 2010), earnings response coefficients (Balsam et al., 2003; C.-Y Lim & Tan, 2008), financial fraud (Carcello & Nagy, 2004), going-concern opinions (C.-Y Lim & Tan, 2008; Reichelt & Wang, 2010), and disclosures of internal control weaknesses (Rose-Green et al., 2011).

[7] In addition, Chen et al. (2018) found that industry knowledge and litigation knowledge interact to enhance the timeliness of a client's disclosure. Legoria et al. (2017) provide evidence that firms with auditors specializing in specific SEC regulation are more likely to disclose information about major customers.

[8] While some of this experience will be developed by the audit team, the partner has ultimate responsibility and is required to understand the engagement very well (PCAOB, 2010; Reid & Youngman, 2017).

[9] For example, in the US setting, Legoria et al. (2017) provide discussion and examples on how auditors may be involved in advising companies in their SEC filing requirements. They provide evidence that firms with specialist auditors are more likely to disclose information about major customers. Dunn and Mayhew (2004) documented that in unregulated industries industry-specialist auditors are positively associated with disclosure quality. Moreover, Chen et al. (2018) find that industry specialist auditors enhance the timeliness of loss contingency disclosures. Finally, Han et al. (2012) report that auditor size is positively associated with disclosure transparency.

[10] For example, based on their archival evidence, supported by an interview with a Big 4 partner, Legoria et al. (2017) suggest that higher-quality auditors would go beyond the minimum requirement by the SEC, and meet and discuss with the client regarding their disclosure.

[11] Hartlieb and Eierle (2022) provide evidence that climate change awareness has increased in recent years and that auditors do consider clients' climate risks in their pricing. Truong et al. (2020) also find that audit fees are higher for clients with higher climate risk.

However, the climate disclosure setting involves a great deal of discretion and uncertainty in reporting practices (e.g., in determining material risks), and hence is not entirely mandatory. This might signify that the reputation and litigation risks usually incentivizing auditors are less prevalent for climate risk disclosures. Moreover, climate-related issues have traditionally not been within the scope of auditing, and the extent to which auditors can influence such disclosures could be limited. It should also be noted that, to influence client disclosure, auditors' climate-related expertise alone may not be sufficient. A greater understanding of the client's business and industry environment, traditionally captured by industry expertise, may also be required. Whether climate-related expertise influences client climate risk disclosure beyond, or in combination with, industry expertise is an open empirical question. Finally, the auditor's influence on disclosures is also limited due to independence rules. While these rules allow the auditor to give advice and recommendations to assist management in reporting decisions, the auditor cannot assume any responsibility for judgments or decisions regarding the company's reporting (including climate risks) to avoid threats to independence. All judgments and decisions regarding the company's reporting are the responsibility of management (see, for example, the Code of Ethics (IESBA, 2023) subsections 400.18 A4 and 400.19).

In balance, considering the increasing pressure for climate-risk disclosures, combined with prior studies on the importance of auditor specialization on audit quality, we predict that client firms audited by audit partners who have expertise in climate-related issues are more likely to disclose and to provide higher quality disclosures on climate risks than those clients whose auditor lacks expertise in climate risks. Consequently, our first hypothesis is the following.

H1. There is a positive association between audit partner expertise in climate-related issues and clients' climate risk disclosure.

Some industries are more likely to have material environmental issues than others. Cho and Patten (2007) study environmental disclosures and categorize firms based on their industries as environmentally sensitive and non-environmentally sensitive.[12] Environmentally sensitive firms are expected to be more exposed to environmental legislation than non-environmentally sensitive firms and to have more environmental disclosures. Similar results are found in other studies although the classification of industries varies (De Villiers & Van Staden, 2011; Gallego-Álvarez et al., 2018; Patten, 2002). The TCFD also classifies industries based on their exposure to climate risks and provides further guidance for industries that are significantly affected by climate risks.[13] Finally, Schiemann and Sakhel (2019) find that not all climate-related risk disclosures have the same consequences of reducing information asymmetry, since the association depends on materiality.

Overall, stakeholder monitoring and information asymmetry regarding climate risks are expected to be greater in industries with material climate risks, which could lead to the benefits from better disclosures outweighing the costs of reporting and providing proprietary information. Therefore, we expect that climate risk expertise of the auditors enhances the likelihood and quality of climate risk disclosure only in industries that are most affected by these risks. We use the TCFD categorization to define these industries and refer to them as "industries with material climate risks". Consequently, our second hypothesis is as follow.

H2. The positive association between audit partner expertise in climate-related issues and client's climate risk disclosure is stronger in industries with material climate risks than in industries without material climate risks.

3. Research design

3.1. Measuring audit partner climate risk expertise

Following the idea that auditor expertise emerges from the experience of conducting similar tasks in auditing (Bonner & Lewis, 1990), our first measure of climate risk expertise (*CLIMATE_SPEC*) captures auditors' knowledge when working with firms producing a high level of emissions. Heavy emitters attract more scrutiny from the government and society and are subjected to more environmental regulations.[14] Therefore, we argue that audit partners who engage with heavy emitters are more knowledgeable about environmental-related matters and climate-related issues.[15] We operationalize *CLIMATE_SPEC* by computing the total annual GHG Emissions (Scope 1 and Scope 2) of companies in our sample and then calculating each audit partner's share of the annual emissions based on her client portfolio. We set *CLIMATE_SPEC* equal to one if the partner's share of emissions is higher than the cut-off value and zero otherwise. The cut-off value in the main analyses is calculated as (1/number of audit partners) *1.2, indicating that specialist auditors are those who have a market share that is 20 percent greater than the calculated average (Audousset-Coulier et al., 2015).

We create the following alternative measures for audit partner climate-related expertise. First, we create *CLIMATE_SPEC* using alternative cut-off values of 30% and 50% to test whether the results are sensitive to a specific cut-off value. Second, since the regulation about disclosing climate risks is new, audit partners with experience engaging with heavy emitters in previous years could be in a better position to assess clients' climate risk disclosures than auditors who began working with heavy emitters only in 2018.

[12] In their categorization, the environmentally sensitive firms are in the following industries: oil exploration, paper, chemical and allied products, petroleum refining, metals, mining, and utilities.

[13] Those industries are energy, transportation, materials and building, agriculture, food, and forest products, banks, insurance companies, asset owners, and asset managers (TCFD, 2017).

[14] Heavy emitters in Australia must measure and report emissions under the National Greenhouse and Energy Reporting Act (NGER, 2007).

[15] While partners can delegate tasks, the audit partner is "the most important determinant of audit quality" (PCAOB, 2010; Reid & Youngman, 2017). Audit partners need to understand the engagement very well so that they can make important decisions regarding choosing the team members, whether to use experts, the audit process, the audit report, and communicating with clients (Chang et al., 2016; Lee & Levine, 2020).

Therefore, we create an alternative measure for climate-related expertise based on audit partners' portfolios in the years 2016 and 2017. Specifically, we calculate the partner's share of GHG Emissions in the two years 2016 and 2017 and compare that to the cut-off value (as above) to define the expert auditors. Finally, we calculate the partner's share of audited assets of clients in the industries with material climate risks and compare that to the cut-off value (as above) to define climate expert auditors. We argue that auditors who are involved in these clients will have more knowledge about climate issues and related regulations.

3.2. The measurement of climate risk disclosures

Prior studies have used a variety of measures to assess disclosures, including a binary variable (Schiemann & Sakhel, 2019), the number of words (Campbell et al., 2014; Elshandidy & Neri, 2015; Miihkinen, 2012), the number of sentences (Abraham & Cox, 2007; Dobler et al., 2011; Elshandidy & Neri, 2015; Linsley & Shrives, 2006), and a scale or index developed based on a certain disclosing criterion (Clarkson et al., 2008). In this study, we define a set of measures to capture the occurrence and quality of climate risk disclosures.

The *occurrence* of climate risk disclosures is measured with the binary variable *DISCLOSURE* which takes the value of one if the client has climate-related risk disclosure in any part of the annual report, including the financial statements, the directors' report, the governance report, and the sustainability report, and zero otherwise.

The *quality* of disclosures is measured by continuous variables to capture climate risk disclosures from different dimensions. A composite measure is created to summarize all the dimensions into one measure. The first dimension, *LENGTH,* measures the length of the climate-risk disclosure. Following prior studies (Elshandidy & Neri, 2015; Elzahar & Hussainey, 2012; Oliveira et al., 2011), we measure disclosure length by counting the number of sentences that contain certain keywords related to climate risk disclosures by using natural language processing. Illustrative examples of climate risk disclosures by sample companies can be found in Appendix 2 while more information about the automated content analysis can be found in Appendix 3. The second dimension of climate risk disclosure is *CAT_NUM* which is a count variable for the number of TCFD categories that are discussed in the disclosures. TCFD recommends firms disclose climate-related information in four dimensions: governance, strategy, risk management, and metrics and target. Two graduate assistants with extensive accounting backgrounds read the disclosures and counted the number of dimensions each disclosure covers.[16] After giving each disclosure a score from 0 (no disclosure) to 4, we calculated the inter-rater reliability (Krippendorff's alpha) between the two assistants to check for their rating consistency. Our inter-reliability rate is 0.786, which is higher than the satisfactory threshold of 0.75 (Milne & Adler, 1999). We then re-checked the inconsistencies between the two coders and agreed on the final scores.

The third dimension of climate risk disclosure, *ORIGINALITY,* measures the percentage of words in the disclosures that are not considered as boilerplate. Clarkson et al. (2008) point out that both good and bad environmental performers report environmental issues, but the quality of disclosures can be different. While good performers report "hard information" that reveals their true performance and is hard to mimic, poor performers report "soft information" that can be stated by any other firms and have low information content. We utilize the method developed by Dyer et al. (2017) to identify the phrases that are considered as boilerplate disclosures, that is, being extremely common and having low information value (see Appendix 3). We then define *ORIGINALITY* as an inverse measure of boilerplate content as follows:

$$ORIGINALITY = 100 * \left(1 - \frac{\text{The number of words in boilerplate phrases}}{\text{The number of words in the original disclosures}}\right) \quad (1)$$

Thus, a higher score for *ORIGINALITY* means that there is less boilerplate disclosure.

A composite measure summarizes different dimensions of complex theoretical constructs and is widely used in accounting literature (Bozzolan & Miihkinen, 2021; Cahan et al., 2016; Van Tendeloo & Vanstraelen, 2008). We create a composite measure for the quality of climate risk disclosure from *LENGTH*, *CAT_NUM*, and *ORIGINALITY*. Following Cahan et al. (2016), we rank *LENGTH*, *CAT_NUM*, and *ORIGINALITY* from high to low for each year and then take a natural log of the average ranking of each firm to produce the composite measure *COMPOSITE.*[17]

3.3. Econometric model

We test our hypotheses using a regression model as follows:

$$f(Y_{i,t}) = \alpha_0 + \alpha_1 CLIMATE\_SPEC_{i,t} + \sum_{j=1}^{k} \alpha_{j+1} CONTROL_{j,i,t} + \varepsilon_{i,t} \quad (2)$$

where $f()$ is the logit link function if the dependent variable (Y) is the occurrence of the disclosure (*DISCLOSURE*) or linear function if Y is the quality of disclosure (*COMPOSITE*). *CLIMATE_SPEC,* is a binary variable based on the total emissions of the audit partner's

[16] Before going through all the disclosures independently, we conducted a trial run with ten chosen annual reports with and without climate risk disclosures and resolved any potential misunderstandings or inconsistencies in understanding the TCFD framework and grading criteria.

[17] As an alternative to average ranking, we use the principal component analysis to reduce the three quality dimensions into one variable *COMPOSITE_PCA*. The results are not materially different.

portfolio. Subscripts *i* and *t* refer to firm and year, respectively. All estimations include year and industry fixed effects. The industry effects are based on four-digit Global Industry Classification Standard (GICS) codes. The z- and t-statistics are computed from the robust standard errors clustered by firm.

We also include in the model the partner industry specialization, *IND_SPEC*, which is a binary variable for industry specialist auditors. The variable *IND_SPEC* equals one if the audit partner's industry market share, calculated by total audited assets, is higher than a cut-off value ((1/number of audit partners in an industry) *1.2) and zero otherwise. The industry categorization is based on four-digit GICS codes. Since climate-related expertise and industry expertise can overlap, we follow Francis, Khurana, and Pereira (2005) and replace the two indicators of auditor expertise (*CLIMATE_SPEC, IND_SPEC)* with binary variables for the three different categories to differentiate between each type of expertise or their combination. The categories are: partners who are both climate specialists and industry specialists (*CLIMATE_AND_IND*); partners who are climate specialists but not industry specialists (*CLIMATE_NOT_IND*) and partners who are industry specialists but not climate specialists (*IND_NOT_CLIMATE*).

We follow prior studies in the disclosure literature to establish the set of control variables. We control for firm size (*SIZE*) as the log of total assets, and profitability (*ROA*) as income before tax and extraordinary items scaled by total assets. Size has been proved to be associated with more disclosure, as bigger firms are more visible, under more scrutiny and pressure from the public, and have lower disclosure costs (Cowen et al., 1987; Darrell & Schwartz, 1997; Deegan & Gordon, 1996; Patten, 1991). Profitability is usually included as one important determinant of disclosures but there is no consensus about its effect (Lang & Lundholm, 1993; Raffournier, 1995). More profitable firms might want to disclose more information under the signaling theory and thus have positive coefficients (Singhvi & Desai, 1971). However, some papers find no relationship (Patten, 1991; Raffournier, 1995) or a negative relationship (Miihkinen, 2012; Wallace & Naser, 1995) between profitability and disclosures.

We control for environmental performance (*EP*) as the ratio of GHG Emissions scaled by total revenues and adjusted for the industry. A negative value for *EP* means that a firm has less GHG Emissions, that is, a better environmental performance than its industry peers. We follow Griffin et al. (2017) to estimate the GHG emissions for non-disclosing firms (see Appendix 4 for details). The relationship between environmental performance and disclosure has been extensively investigated in the literature and is explained by two competing theories. Legitimacy theory predicts a negative relationship between performance and disclosure as poor environmental performers self-disclose information under pressure from society, and signaling theory predicts a positive relationship between performance and disclosure, as good environmental performers want to signal the market of their good performance by disclosing more information.

We control for the level of firm risk by several measures following prior studies. We use stock beta (*BETA*) as a proxy for systematic risk, and leverage (*LVG*) and current ratio (*CURRENT*) as proxies for financial risk (Dobler et al., 2011; Linsley & Shrives, 2006). Leverage is calculated as total liabilities divided by total assets, and the current ratio is current assets deflated by current liabilities. Higher systematic risk (*BETA*) is expected to be associated with more risk disclosures (Dobler et al., 2011; Linsley & Shrives, 2006; Miihkinen, 2012), while the results on the association between leverage and disclosure are mixed (Dobler et al., 2011).

Regarding the sample firms' incentives for disclosing risks, we control for the market-to-book ratio (*MB*) because a firm with a high market-to-book ratio has high growth prospects and thus has more incentive to disclose (Gul & Leung, 2004; S. Lim et al., 2007; Miihkinen, 2012). In addition, we control the need for external financing (*FINANCE*) as it increases the firm's incentives to disclose more information (Francis, Khurana, & Pereira, 2005; Lang & Lundholm, 1993). *FINANCE* is defined as the total debt and equity issuance over three consecutive years scaled by total assets.

Board characteristics have been shown to affect the disclosure of sustainability information (Ben-Amar & McIlkenny, 2015Ben-Amar & McIlkenny, 2015; Jizi, 2017; Pucheta-Martínez & Gallego-Álvarez, 2019). Therefore, we control for the number of directors on the board (*BOARD_SIZE*) and the existence of a sustainability committee (*SUS_COM*). We also control for the existence of a sustainability report (*SUS_REPORT*) and whether this report is assured by a third party (*SUS_AUDIT*), as these two factors can affect the likelihood of reporting climate risk on the annual reports.

Prior studies have found that the joint provision of audit and sustainability assurance increases both the quality of financial statement audits and sustainability assurance (Ruiz-Barbadillo & Martínez-Ferrero, 2020). This is due to the spillover of knowledge from the sustainability assurance team to the financial statement audit team (Maso et al., 2020). Therefore, we control for this spillover effect with an indicator variable *SPILLOVER*, which equals one if the audit partner of the financial statements and the sustainability assurer are from the same audit firm and zero otherwise. We expect that information flow within the audit firm will help the auditor in charge to have a better understanding of the client's environmental situation and hence better assess the related risks. We take into account both the effect of sustainability assurance (*SUS_AUDIT*) and the effect of that assurance being provided by the same auditor (*SPILLOVER*).

The length of the annual report positively affects the likelihood of any term, including those related to climate risks. Thus, we follow Loughran et al. (2007) and control for the length of the annual report (*R_LENGTH*), measured as the natural logarithm of total words in the annual report.

In the test of hypothesis H2, where we compare the effects of audit partner expertise in the industries with and without material climate risks, we split the sample into two subgroups. Specifically, the group of industries with material climate risks include energy, transportation, materials and building, agriculture, food, and forest products, banks, insurance companies, asset owners, and asset managers (TCFD, 2017). The variables used in the study are defined in Appendix 1.

3.4. Sample selection, summary statistics, and univariate results

3.4.1. Sample selection

Our sample comprises a balanced panel of 1000 firm-year observations for the fiscal years 2018 and 2019, corresponding to periods ending in June 2019 and June 2020, respectively. This period is particularly pertinent as it captures the period immediately following the issuance of the Joint Bulletin in December 2018, allowing for an analysis of its impact on climate risk disclosures. The firms included in our sample are drawn from the S&P All Ordinaries stock index as of December 2018. This selection is driven by three key considerations. First, the S&P All Ordinaries index encompasses the 500 largest companies in the Australian equities market, accounting for over 95 percent of the total market value of shares listed on the Australian Securities Exchange (ASX). This comprehensive coverage ensures that our sample is representative of the majority of the Australian stock market. Companies beyond the top 500, typically much smaller in size and often including numerous small mining exploration companies, are excluded to maintain focus and relevance.

Second, empirical evidence from corporate reporting and voluntary disclosure literature suggests that larger firms are more likely to exhibit higher quantity and quality in their disclosures. This trend makes larger companies particularly relevant for studying the effects of the Joint Bulletin's guidance on disclosures. It is reasonable to hypothesize that these larger listed companies would be more responsive to the new guidelines compared to their smaller counterparts.[18] Third, our measure of disclosure quality requires manual collection of data from annual reports, so that studying all listed companies is not possible nor efficient. Focusing on the top 500 companies in Australia, or a smaller subset, balances the need for comprehensive coverage with the practical constraints of manual data collection and is commonly used in research as a dataset for these reasons (e.g., Bachmann & Spiropoulos, 2023; Buckby et al., 2015; Subramaniam et al., 2009).

Financial and auditor data are collected from Thomson Reuters and Orbis databases, and missing observations are hand-collected from companies' annual reports. Data on GHG emissions are collected from Thomson Reuters and the National Greenhouse and Energy Reporting database maintained by the government of Australia. Appendix 1 provides a detailed description of the data sources.

3.4.2. Summary statistics and correlation

Table 1 presents a detailed breakdown of the number of observations and disclosure activity of each industry, categorized based on the Global Industry Classification Standard (GICS) as recommended by the Task Force on Climate-related Financial Disclosures (TCFD, 2017). The Materials sector (GICS code 1510) has the most observations (25%), followed by the Financial sector (GICS codes 4010, 4020, 4030) (12.6%). We further distinguish between industries with and without material climate risks, respectively, presenting data on reported emissions and the number of firms disclosing climate risks for fiscal years 2018 and 2019. Industries with material climate risks account for 61.8% of the sample. Sectors such as Energy, Materials, and Financial Services (including Banks and Insurance), which TCFD categorizes as highly susceptible to climate risks, exhibit a progressive increase in climate risk disclosures over the two-year sample period. Conversely, sectors considered to have lower material climate risks display comparatively limited activity in climate risk reporting, underscoring the heterogeneity in climate risk disclosure practices across different industry sectors.

Table 2 Panel A presents descriptive statistics of our variables. The mean value of *DISCLOSURE* is 0.181, indicating that 18.1% of the sample (181 observations) includes climate risk disclosures in their annual reports.[19] Among 181 observations with climate risk disclosures, the average length was 31 sentences (untabulated). There are 819 observations without climate risk disclosure; the average length for the entire sample is five sentences. The number of categories discussed in the climate risk disclosure according to TCFD (*CAT_NUM*) is 0.38 on average for the whole sample and 2.69 among those that disclose climate risks (untabulated). The maximum percentage of boilerplate words in the disclosures was 18%, and the mean was 3% (untabulated).

The percentage of observations with climate-related specialist auditors (*CLIMATE_SPEC*) is 14.9% and with industry specialist auditors (*IND_SPEC*) is 30.1%. Audit partners with both types of expertise (*CLIMATE_AND_IND*) account for 10.9%, audit partners with only climate-related expertise (*CLIMATE_NOT_IND*) 4%, and audit partners with only industry expertise (*IND_NOT_CLIMATE*) 19.2% of the sample.

The mean and median values of *SIZE* are close to each other, suggesting that the sample includes an even distribution of firms of different sizes. *ROA* has a mean of −3.986 and a median of 3.014, which suggests that some sample firms suffered heavy losses. The statistics for *EP* show that there are some heavy and light emitters in the sample, as can be seen from the negative and low minimum values and positive and high maximum values of the ratio. Statistics for the *MB* ratio show that, on average, the sample firms are growth firms, as can be seen from the average *MB* ratio of 4.034. Moreover, the values of *BETA*, *LVG*, *CURRENT*, and *FINANCE* provide evidence of variation in these control variables.

The size of the board (*BOARD_SIZE*) varied from 1 to 15 members, and the average size of the board was 6. Only 20.9% of the sample referred to the existence of a sustainability committee *(SUS_COMM)*. 26.8% of observations indicate the issuance of a sustainability report (*SUS_REPORT*), either stand-alone or as part of the annual report. However, only 8.2% of the sample firms indicate

[18] This is consistent with the AASB-AUASB research report on climate-related disclosures (AASB & AUASB, 2022). Figure 3 in this joint research report shows that, while 85% of top 100 companies (ASX100) disclose climate risks in 2018, only 12% of companies outside of top 500 disclose.

[19] There are 27 observations (2.7% of the sample) disclosing climate risks in the notes of the financial statements. We add an indicator for disclosing climate risks in the notes of the financial statement as a fourth element of the disclosure quality measure (*COMPOSITE*) because including this information in the financial statements could be indicative of higher disclosure quality. The results remain qualitatively the same as in the main analysis.

Table 1
Sample composition across industries.

GICS industry group		Number of observations	Number of observations with reported emissions	No. Of firms disclosing climate risks per year	
				2018	2019
Industries with material climate risks		**618**	**357**	**62**	**88**
1010	Energy	68	42	9	15
1510	Materials	250	121	20	32
2010	Capital Goods	44	27	2	3
2030	Transportation	20	16	2	2
2550	Retailing	50	36	1	1
3010	Food & Staples Retailing	6	6	2	1
3020	Food, Beverage & Tobacco	42	25	7	9
4010	Banks	24	19	5	7
4020	Diversified Financials	84	41	8	11
4030	Insurance	18	14	3	4
5510	Utilities	12	10	3	3
Industries with no material climate risks		**382**	**227**	**7**	**24**
2020	Commercial & Professional Services	40	26	2	4
2510	Automobiles & Components	10	4	0	1
2520	Consumer Durables & Apparel	14	4	0	0
2530	Consumer Services	50	44	1	4
3030	Household & Personal Products	8	8	1	2
3510	Health Care Equipment & Services	56	35	0	4
3520	Pharmaceuticals, Biotechnology & Life Sciences	44	17	1	2
4510	Software & Services	80	45	0	2
4520	Technology Hardware & Equipment	16	4	0	0
4530	Semiconductors & Semiconductor Equipment	2	0	0	0
5010	Telecommunication Services	16	7	0	2
5020	Media & Entertainment	30	26	2	2
6010	Real Estate	16	7	0	1

Notes: Industries are grouped based on Global Industry Classification Standard (GICS), as suggested by TCFD (2017). The division of material climate risks is based on TCFD (2017). According to TCFD (2017), industry groups that are most affected by climate risks are: Energy; Materials and Buildings; Transportation; Agriculture, Food, and Forest Products; Banks, Insurance companies, Asset managers, and Asset owners.

that the sustainability report is audited by external auditors (*SUS_AUDIT*). Moreover, for 5.6% of the sample the financial statement auditor and sustainability report assurer are from the same audit firm (*SPILLOVER*). Most firms (71.4%) have Big4 as external auditors (*BIG4*).

3.4.3. *Univariate tests*

Table 2 Panel B presents the univariate tests between the two groups with and without specialists by showing the results of the *t*-test. Firms with specialist auditors are more likely to disclose climate risks in their annual reports (*DISCLOSURE*) and have a higher quality of disclosure (*COMPOSITE)*, represented as longer disclosures (*LENGTH)*, more categories that are discussed in the disclosure (*CAT_NUM)*, and less information identified as boilerplate (*ORIGINALITY)* (results for the components of *COMPOSITE* untabulated). The test results for *CLIMATE_AND_IND*, *CLIMATE_NOT_IND*, and *IND_NOT_CLIMATE* are significant and the direction of the relationship is as expected.

In addition, firms with specialist auditors are larger (*SIZE*) and have higher profitability (*ROA*). They also have a larger board *(BOARD_SIZE)* and are more likely to have a sustainability committee and report *(SUS_COMM; SUS_REPORT)*. They are more likely to have Big4 as auditors and external assurance for sustainability reports *(BIG4; SUS_AUDIT)*. In addition, they have longer annual reports *(R_LENGTH)*. Firms with climate expert auditors (*CLIMATE_SPEC*) do not differ significantly from those without expert auditors in terms of risk (*BETA, CURRENT)* and new financing aspects *(FINANCE)*. Regarding environmental performance (*EP*), firms with climate expert auditors have a worse performance as can be seen from the more negative value of the ratio (−4.459 vs. −5.239).

The correlation between *IND_SPEC* and *CLIMATE_SPEC* is 0.39 (the correlation matrix is not tabulated).[20] Both measures of expertise are highly correlated with *DISCLOSURE* (0.40 and 0.37, *p*-value <0.01, respectively) and *COMPOSITE* (0.40 and 0.38, *p*-value <0.01, respectively). In addition, the expertise measures have the strongest correlation with *SIZE* (0.61 and 0.40, *p*-value <0.01, respectively).

[20] The coefficient of determination between *IND_SPEC* and *CLIMATE_SPEC* is the square of their mutual correlation coefficient and about 15.21%. Hence, about 84.79% of the variability in the audit partner's climate expertise is not explained by the linear relationship with the audit partner's industry expertise. This result supports the argument that although climate and industry expertise have some common features, they are different covariates.

Table 2
Descriptive statistics and univariate tests.

Panel A: Descriptive statistics

	N	Mean	Median	SD	Min	Max
DISCLOSURE	1000	0.181	0.000	0.385	0.000	1.000
COMPOSITE	1000	0.980	0.000	2.125	0.000	5.849
CLIMATE_SPEC	1000	0.149	0.000	0.356	0.000	1.000
IND_SPEC	1000	0.301	0.000	0.459	0.000	1.000
CLIMATE_AND_IND	1000	0.109	0.000	0.312	0.000	1.000
CLIMATE_NOT_IND	1000	0.040	0.000	0.196	0.000	1.000
IND_NOT_CLIMATE	1000	0.192	0.000	0.394	0.000	1.000
SIZE	1000	19.723	19.581	2.047	15.694	25.743
ROA	1000	−3.986	3.014	25.755	−131.996	36.237
EP	1000	−4.575	−3.763	4.336	−11.121	10.866
BETA	1000	0.856	0.834	0.755	−1.097	3.452
LVG	1000	41.977	41.515	24.548	1.492	103.518
CURRENT	1000	3.884	1.822	7.052	0.050	50.013
MB	1000	4.034	2.180	5.360	−0.728	34.039
FINANCE	1000	10.172	0.000	24.112	0.000	132.285
BOARD_SIZE	1000	6.048	6.000	1.816	1.000	15.000
SUS_COMM	1000	0.209	0.000	0.407	0.000	1.000
SUS_REPORT	1000	0.268	0.000	0.443	0.000	1.000
SUS_AUDIT	1000	0.082	0.000	0.275	0.000	1.000
SPILLOVER	1000	0.056	0.000	0.230	0.000	1.000
BIG4	1000	0.714	1.000	0.452	0.000	1.000
R_LENGTH	1000	10.440	10.463	0.575	5.318	12.272

Panel B: Univariate tests

	Non-climate expert auditors (n = 851)	Climate expert auditors (n = 149)	Pr (|T| > |t|)	Industries with no material climate risks (n = 382)	Industries with material climate risks (n = 618)	Pr (|T| > |t|)
DISCLOSURE	0.121	0.523	0.000	0.081	0.243	0.000
COMPOSITE	0.643	2.903	0.000	0.416	1.329	0.000
CLIMATE_AND_IND	0.000	0.732	0.000	0.042	0.150	0.000
CLIMATE_NOT_IND	0.000	0.268	0.000	0.021	0.052	0.016
IND_NOT_CLIMATE	0.226	0.000	0.000	0.332	0.105	0.000
SIZE	19.379	21.692	0.000	19.339	19.961	0.000
ROA	−4.839	0.880	0.012	−4.425	−3.715	0.672
EP	−4.459	−5.239	0.043	−3.048	−5.519	0.000
BETA	0.850	0.896	0.490	0.791	0.897	0.030
LVG	41.295	45.871	0.036	42.689	41.537	0.471
CURRENT	3.992	3.268	0.248	3.399	4.183	0.088
MB	4.277	2.642	0.001	5.437	3.166	0.000
FINANCE	10.318	9.338	0.648	11.472	9.368	0.180
BOARD_SIZE	5.811	7.403	0.000	5.995	6.081	0.466
SUS_COMM	0.166	0.456	0.000	0.186	0.223	0.157
SUS_REPORT	0.199	0.664	0.000	0.196	0.312	0.000
SUS_AUDIT	0.051	0.262	0.000	0.034	0.112	0.000
SPILLOVER	0.031	0.201	0.000	0.024	0.076	0.000
BIG4	0.667	0.980	0.000	0.707	0.718	0.693
R_LENGTH	10.380	10.778	0.000	10.381	10.476	0.011

Notes: This Table provides the descriptive statistics in Panel A and the results of the mean tests (*t*-test assuming independent samples) in Panel B. See Appendix 1 for variable definitions.

4. Empirical results

4.1. Audit partner expertise and climate risk disclosures

Table 3 reports the estimation results of the regression equation (2). Columns 1 and 2 show the results of logit regression with *DISCLOSURE* as the dependent variable and Columns 3 and 4 show the results of OLS regression with *COMPOSITE* as the dependent variable.

Column 1 shows that the coefficient of *CLIMATE_SPEC* is not significant. However, the coefficient of *IND_SPEC* is positive and significant (0.899, *p*-value <0.05), suggesting that industry specialization is associated with higher likelihood of disclosing climate risks in annual reports.[21] This could be due to the overlap between the two types of expertise because a more detailed analysis of this

[21] The marginal effect of *IND_SPEC* is 4 percentage points, estimated by calculating the difference of probability Prob (*DISCLOSURE* = 1) for both cases with and without industry specialist (*IND_SPEC* equals 1 and 0, respectively) while keeping other independent variables at their mean values.

Table 3
The effect of audit partner expertise on climate risk disclosure.

	DV: *DISCLOSURE*		DV: *COMPOSITE*	
	(1)	(2)	(3)	(4)
CLIMATE_SPEC	0.200		0.675***	
	(0.547)		(2.835)	
IND_SPEC	0.899**		0.198	
	(2.038)		(0.931)	
CLIMATE_AND_IND		1.068**		0.857**
		(2.240)		(2.429)
CLIMATE_NOT_IND		0.907*		0.724*
		(1.645)		(1.944)
IND_NOT_CLIMATE		1.255**		0.213
		(2.288)		(1.057)
SIZE	0.584***	0.574***	0.322***	0.323***
	(3.327)	(3.265)	(4.457)	(4.448)
ROA	0.038***	0.038***	0.001	0.001
	(2.783)	(2.850)	(0.472)	(0.483)
EP	0.014	0.009	−0.014	−0.015
	(0.341)	(0.233)	(-0.982)	(-0.985)
BETA	−0.045	−0.049	−0.002	−0.002
	(-0.193)	(-0.210)	(-0.032)	(-0.023)
LVG	−0.003	−0.003	−0.005	−0.005
	(-0.357)	(-0.438)	(-1.495)	(-1.499)
CURRENT	−0.014	−0.014	−0.005	−0.005
	(-0.405)	(-0.422)	(-0.510)	(-0.515)
MB	0.032	0.036	0.034***	0.034***
	(0.865)	(0.946)	(3.516)	(3.516)
FINANCE	0.012**	0.012**	0.007**	0.007**
	(2.385)	(2.444)	(2.537)	(2.531)
BOARD_SIZE	−0.119	−0.119	−0.017	−0.017
	(-1.188)	(-1.183)	(-0.404)	(-0.402)
SUS_COMM	0.020	−0.016	0.220	0.219
	(0.054)	(-0.043)	(0.891)	(0.888)
SUS_REPORT	0.163	0.164	0.285	0.286
	(0.493)	(0.494)	(1.256)	(1.256)
SUS_AUDIT	0.984*	0.977	1.439***	1.441***
	(1.699)	(1.644)	(2.769)	(2.768)
SPILLOVER	0.370	0.369	0.153	0.154
	(0.476)	(0.471)	(0.266)	(0.268)
BIG4	0.635	0.594	−0.066	−0.068
	(1.116)	(1.039)	(-0.554)	(-0.569)
R_LENGTH	1.896***	1.896***	0.441***	0.441***
	(3.994)	(4.095)	(3.865)	(3.866)
Constant, Industry FE, Year FE	Yes	Yes	Yes	Yes
N	1000	1000	1000	1000
Pseudo R-squared/R-squared	0.535	0.538	0.457	0.457

Notes: The logistic regression results are provided in columns 1 and 2 and the OLS regression results in columns 3 and 4. *DISCLOSURE* is a binary variable indicating whether a firm discloses climate risks in its annual report. *COMPOSITE* is a continuous measure for the quality of disclosure, calculated using the log of the average ranking of three components. *CLIMATE_SPEC* is a binary variable indicating audit partner expertise on climate-related issues. *IND_SPEC* is a binary variable indicating industry specialization. *CLIMATE_AND_IND* is a binary variable indicating an audit partner who has both climate-related and industry expertise. *CLIMATE_NOT_IND* is a binary variable indicating an audit partner who has only climate-related expertise and not industry expertise. *IND_NOT_CLIMATE* is a binary variable indicating an audit partner who has only industry expertise and not climate-related expertise. See Appendix 1 for other variable definitions. The *z*-statistics (*t*-statistics) in parentheses are based on robust standard errors clustered by the firm. *, **, and *** denote statistical significance levels of 10%, 5%, and 1%, respectively (two-tailed). *SIZE* had the highest VIF (6.12), followed by *SUS_AUDIT* (3.51), and *SPILLOVER* (3.06).

expertise in Column 2 reveals that all three detailed measures of climate and industry expertise (*CLIMATE_AND_IND, CLIMATE_NOT_IND, IND_NOT_CLIMATE*) are positively and significantly related to the likelihood of a client firm disclosing climate risks.

Regarding the control variables, client firm size (*SIZE*), profitability (*ROA*), and new debt and stock issuance (*FINANCE*) are positively related to a higher likelihood of disclosing climate risk, which is consistent with the literature (Cowen et al., 1987; Darrell & Schwartz, 1997; Francis et al., 2005; Singhvi & Desai, 1971). Firms with sustainability reports audited by an external party (*SUS_AUDIT*) are more likely to disclose climate risks. However, whether this assurance is provided by the same auditor (*SPILLOVER*) is not significant. Industry-adjusted environmental performance (*EP*) is an important determinant of environmental disclosures in the literature (Clarkson et al., 2008; Patten, 2002) but is not associated with the likelihood of climate risk disclosures. Finally, consistent with (Loughran et al., 2007), the length of annual reports (*R_LENGTH*) is positively related to the likelihood of disclosing climate risks.

Columns 3 and 4 report the results of the tests regarding the relationship between audit partner expertise and the quality of climate-risk disclosures (*COMPOSITE*). The coefficient of climate expertise (*CLIMATE_SPEC)* in Column 3 is positively associated with a higher quality of disclosure (0.675, p-value <0.01). Column 4 shows that when partners have both types of expertise (*CLIMATE_AND_IND*), they have the strongest association with disclosure quality (0.857, p-value <0.05). Partners with only climate expertise (*CLIMATE_NOT_IND*) have a slightly smaller association (0.724, p-value <0.1), whereas partners with only industry expertise (*IND_NOT_CLIMATE*) are unrelated to the quality of disclosure (0.213, p-value >0.1).

Regarding the control variables, client firm size (*SIZE*), growth prospects (*MB*), new issuance of debt and stock (*FINANCE*), the existence of an audited sustainability report (*SUS_AUDIT*), and the length of annual reports (*R_LENGTH*) are significant and positive, consistent with the literature. Again, we find that environmental performance (*EP*) is not associated with the quality of climate risk disclosure.

We rerun the regressions of equation (2) using the alternative measures of climate expertise presented in Section 3.1 and discuss the untabulated results here. The results of *CLIMATE_SPEC* based on alternative cut-off values of 30% and 50% yield similar inferences as those from Table 3. Moreover, the measure of climate expertise based on total GHG emissions of previous years is associated with higher quality of client climate risk disclosures (*COMPOSITE*), and this result is driven by the auditors who have both climate and industry expertise (*CLIMATE_AND_IND)*. All three coefficients for three categories of audit partner expertise (*CLIMATE_AND_IND, CLIMATE_NOT_IND, IND_NOT_CLIMATE)* are significantly associated with the likelihood of disclosing climate risks (*DISCLOSURE*). Finally, when using the climate expertise measure based on audited assets of the clients in industries with material climate risks, the results indicate that climate expertise significantly increases the likelihood and quality of disclosure, but also that these findings can be mainly attributed to those partners who have both climate and industry expertise (*CLIMATE_AND_IND)*. When considering the results as a whole, we conclude that climate expertise appears to play a role in the likelihood of client climate risk disclosure and especially in its quality, but the association is more consistent when the partner has both climate and industry expertise.

Table 4 investigates the influence of audit partner expertise on the climate risk disclosure practices of companies, specifically examining where within the annual reports these disclosures are made. Panel A of Table 4 provides a descriptive breakdown of the number of instances where climate risks were mentioned across various sections: Chairman's letter, Directors' report, Corporate Governance statement, Sustainability brief section, Sustainability report, Notes to the financial statements, and Other sections. The total count exceeds the 181 disclosures reported in Table 2 because some companies disclosed climate risks in multiple sections. A notable increase in climate risk disclosures from 2018 to 2019 across almost all sections can observed, with the most significant increase in the Directors' report, a statutory reporting section under the Corporations Act 2001. Especially regarding the financial implications of climate risk, disclosing in the Directors' report highlights the relevance of the topic, facilitates the connectivity of climate risk and financial information, and more likely reaches financial stakeholders such as investors.

Panel B of Table 4 presents the results of logit regression analyses estimating the impact of audit partner expertise on the likelihood of climate risk disclosure in different parts of the annual reports. The regressions are run separately for disclosures in the Directors' report (Column 1), combined sections of Chairman's letter, Corporate governance statement, Notes to the financial statements, and other sections (Column 2), the Sustainability brief section (Column 3), and the Sustainability report (Column 4). This disaggregation allows for a nuanced examination of how different types of audit partner expertise differentially influence the placement and prominence of climate risk disclosures within these specific sections of annual reports.

Combined expertise, *CLIMATE_AND_IND*, shows a statistically significant positive association with climate risk disclosure in the Directors' report and the Sustainability brief section. *CLIMATE_NOT_IND* is significantly associated with disclosure in the Directors' report but shows no significant effect in other sections. *IND_NOT_CLIMATE* mirrors the pattern of *CLIMATE_AND_IND*, with a significant positive effect in the Directors' report and the Sustainability brief section. Overall, the findings suggest that all of the three indicators for expertise increases the likelihood of climate risk disclosures in the Directors' report, suggesting its key role in influencing integrated corporate narratives. This inference is further supported by the finding that expertise does not increase the likelihood of disclosure in the sustainability report section.

4.2. Audit partner expertise and climate risk disclosures in different industries

Table 5 presents the results of estimating our model in Equation (2) separately for firms in industries with and without material climate risks.

Panel A shows the estimation results for the occurrence of disclosure. Columns 1 and 2 of Panel A show the effect of audit partner expertise on the occurrence of climate risk disclosures in industries with material climate risk. Although the coefficient of *CLIMATE_SPEC* is not statistically significant, decomposition analysis in Column 2 of Panel A shows that all three coefficients for the different expertise categories (*CLIMATE_AND_IND, CLIMATE_NOT_IND, IND_NOT_CLIMATE)* are highly significant (1.523, 1.467, 2.193, respectively, p-value <0.01).

Column 3 of Panel A shows the regression results for the sample of industries *without material* climate risk. In contrast to the results in Column 1, the coefficient of *CLIMATE_SPEC* in Column 3 is negative and statistically insignificant. Column 4 shows that partners with both types of expertise (*CLIMATE_AND_IND*) are negatively associated with the likelihood of disclosing climate risk. Other categories had negative, but not statistically significant, parameter values. The lack of a coefficient for auditors with climate but not industry expertise (*CLIMATE_NOT_IND*) in Column 4 is due to multicollinearity.

The findings from Panel A affirm our hypothesis H2: in industries with material climate risks, audit partner expertise is positively associated with a higher likelihood of disclosing climate risks. The results also tentatively suggest that clients in industries with lower climate risk exposure, who engage audit partners with specific expertise, may be less inclined to disclose climate risks. This could be attributed to expert auditors guiding their clients to avoid unnecessary disclosures in contexts where climate risks are less material,

Table 4
The effect of audit partner expertise on climate risk disclosure in different parts of annual reports.

Panel A: The position of annual reports where companies disclose climate risks in 2018 and 2019.

Position in annual reports	Chairman's letter	Director's report	Corporate Governance statement	Sustainability brief section	Sustainability report	Notes to the financial statements	Other sections of annual reports
Year 2018	19	46	6	23	12	4	7
Year 2019	28	82	12	24	18	23	14
Total	47	128	18	47	30	27	21

Notes: The sum of the "Total" row is 318 and exceeds 181 firm-year observations (mean of *DISCLOSURE* 0.181 reported in Panel A of Table 2) because some firms can disclose climate risks in multiple sections of their annual reports.

Panel B: Logit regressions estimating the effect of audit partner expertise on climate risk disclosure in different parts of annual reports.

	Director's report	Chairman's letter, Corporate governance statement, Notes to the FS, and other sections	Sustainability brief section	Sustainability report
	(1)	(2)	(3)	(4)
CLIMATE_AND_IND	1.455***	0.313	1.800**	−2.065*
	(2.720)	(0.544)	(2.354)	(-1.952)
CLIMATE_NOT_IND	1.682***	0.157	0.023	0.319
	(2.908)	(0.208)	(0.025)	(0.384)
IND_NOT_CLIMATE	1.471**	0.728	1.788**	−0.124
	(2.292)	(1.161)	(2.268)	(-0.126)
Control variables	Yes	Yes	Yes	Yes
Industry FE, Year FE	Yes	Yes	Yes	Yes
N	1000	1000	1000	1000
Log likelihood	−176.711	−153.993	−118.320	−85.164
P-value	0.000	0.000	0.000	0.000
Pseudo R squared	0.534	0.442	0.354	0.308

Notes: All variable definitions can be found in Appendix 1. The *z*-statistics in parentheses are based on robust standard errors clustered by the firm. *, **, and *** denote statistical significance levels of 10%, 5%, and 1%, respectively (two-tailed). "Other sections" in Panels A and B includes contents with titles: business value driver, how we create value, additional information, and similar. "Director's report" in Panels A and B includes Operating and Financial Review (OFR) as per Australian Corporations Act 2001, even though OFRs are not always located in the Director's Report sections.

highlighting the nuanced role that auditors play in shaping climate risk disclosures.

In Panel B of Table 5, where the dependent variable is disclosure quality (*COMPOSITE*), the results are similar to those in Panel A. In column 1, for the materially exposed industries, both climate expertise (*CLIMATE_SPEC*) and industry expertise (*IND_SPEC*) have positive and significant coefficients (0.627 and 0.742, respectively, p-value <0.05). The expertise decomposition analysis in Column 2 shows that partners with both types of expertise (*CLIMATE_AND_IND*) are associated with higher composite levels (1.244, p-value <0.01). The same results apply for partners with only industry or climate expertise (*CLIMATE_NOT_IND, IND_NOT_CLIMATE*), with parameter values of 1.184 and 1.092, respectively, p-value <0.01.

Columns 3 and 4 present the results for industries not materially exposed. Overall, the results from Panel B further confirm our conjecture in H2 that auditor specialization is related only to increasing the quality of disclosure in industries with material climate risks. The results also weakly suggest that expert auditors are associated with shorter and narrower disclosures from clients in industries where climate risk is relatively less material.

Again, we rerun the regressions using the alternative measures of climate expertise. The untabulated results of *CLIMATE_SPEC* based on alternative cut-off values of 30% and 50%, and the results of climate expertise based on previous years' emissions yield similar inferences as those from Table 5. When using the climate expertise measure based on audited assets of clients in industries with material climate risks, the results generally confirm the inferences from Table 5, but the findings suggest more strongly that expertise regarding both climate and industry combined matter.

In conclusion, the empirical evidence presented in Sections 4.1 and 4.2 lends support to our research hypotheses. Specifically, H1 suggests a positive link between audit partner expertise in climate-related issues and clients' climate risk disclosures. We find supporting evidence particularly in the quality and location of the risk disclosures and when this expertise spans both climate-related issues and industry knowledge. Moreover, H2 posits that this positive link is stronger in industries with material climate risks. The detailed analysis provided in Table 5 corroborates this hypothesis, demonstrating that the influence of audit partner expertise is notably stronger in sectors identified as materially at risk by the TCFD. Altogether, these findings highlight the significant role of audit partner expertise in enhancing the transparency and detail of climate risk reporting.

4.3. Addressing potential endogeneity concerns

We address endogeneity problems using three approaches: entropy balancing, the Heckman selection model, and the impact threshold for confounding variable analysis.

Table 5
Audit partner expertise and climate risk disclosure, analyzed separately for industries with and without material climate risks.

Panel A: The occurrence of climate risk disclosures.

DV: DISCLOSURE	Industries with material climate risks		Industries with no material climate risks	
	(1)	(2)	(3)	(4)
CLIMATE_SPEC	0.343		−1.552	
	(0.718)		(-1.354)	
IND_SPEC	1.214**		−0.909	
	(2.348)		(-1.242)	
CLIMATE_AND_IND		1.523***		−2.280*
		(2.859)		(-1.760)
CLIMATE_NOT_IND		1.467**		
		(2.359)		
IND_NOT_CLIMATE		2.193***		−0.951
		(3.524)		(-1.263)
Control variables	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	618	618	382	374
P-value	0.000	0.000	0.000	0.000
Pseudo R-squared	0.589	0.598	0.422	0.422

Panel B: The quality of climate risk disclosures.

DV: COMPOSITE	Industries with material climate risks		Industries with no material climate risks	
	(1)	(2)	(3)	(4)
CLIMATE_SPEC	0.627**		−0.537	
	(2.209)		(-1.203)	
IND_SPEC	0.742**		−0.216	
	(2.060)		(-1.022)	
CLIMATE_AND_IND		1.244***		−0.777
		(3.175)		(-1.074)
CLIMATE_NOT_IND		1.184***		−0.487*
		(2.802)		(-1.836)
IND_NOT_CLIMATE		1.092***		−0.211
		(3.091)		(-0.976)
Control variables	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	618	618	382	382
P-value	0.000	0.000	0.000	0.000
R-squared	0.527	0.531	0.262	0.260

Notes: All variable definitions can be found in Appendix 1. The *z*-statistics (*t*-statistics) in parentheses are based on robust standard errors clustered by the firm. *, **, and *** denote statistical significance levels of 10%, 5%, and 1%, respectively (two-tailed). In Column 4 of Panel A, *CLIMATE_NOT_IND* is dropped by Stata due to due to perfect prediction.

4.3.1. *Entropy balancing*

The effect of specialist auditors could arise due to selection bias; that is, specialist auditors have a larger market share and their portfolios are more likely to have larger clients than non-specialist auditors (Minutti-Meza, 2013). Therefore, the observed association could potentially be due to the client's size-related characteristics rather than the auditor's expertise. To overcome this selection bias problem, we used the entropy balancing method introduced by Hainmueller (2012) to balance the covariates between the two groups with and without specialist auditors.

We have two types of auditor expertise that overlap, and thus create four different categories: three categories with auditor expertise (both types of expertise, industry expertise alone, and climate expertise alone) and one category with no auditor expertise at all. We focus on one category of expertise at a time and compare it with the category of no expertise at all. The regression results after entropy balancing are presented in Table 6 and the inferences are consistent with those from the results of the main analysis (in Tables 3 and 5).

4.3.2. *Heckman selection model*

As entropy balancing and other matching methods only deal with the selection of observables, we further address the problem of selection based on unobservable attributes using the Heckman selection model. The Heckman selection model, including a two-stage procedure, has been used in auditing studies to deal with selection bias in auditor choice (Chaney et al., 2004; Clatworthy et al., 2009; Lennox et al., 2012).

In the first stage, we run a probit regression of the treatment (*CLIMATE_SPEC, IND_SPEC,* or *CLIMATE_AND_IND*) on a list of control variables, following previous studies (Chaney et al., 2004; Clatworthy et al., 2009; Lennox et al., 2012; Zerni, 2012). These variables

Table 6
Entropy balancing results.

Panel A: Entropy balancing with the treatment variable *CLIMATE_AND_IND*

Dependent variables:	(1)	(2)	(3)	(4)	(5)	(6)
	DISCLOSURE	*COMPOSITE*	*DISCLOSURE*	*COMPOSITE*	*DISCLOSURE*	*COMPOSITE*
	All industries		Industries with material climate risks		Industries with no material climate risks	
CLIMATE_AND_IND	1.893**	1.179**	2.473***	1.248**	6.478	−2.332***
	(2.453)	(2.035)	(2.633)	(2.101)	(0.009)	(-2.815)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	768	768	521	521	247	247
P-value	0.000	0.000	0.018	0.000	0.000	0.000
Pseudo R-squared/R-squared	0.650	0.579	0.731	0.606	0.986	0.827

Panel B. Entropy balancing with the treatment variable *CLIMATE_NOT_IND*

Dependent variables:	(1)	(2)	(3)	(4)
	DISCLOSURE	*COMPOSITE*	*DISCLOSURE*	*COMPOSITE*
	All industries		Industries with material climate risks	
CLIMATE_NOT_IND	0.690	0.745***	1.266**	1.159***
	(1.205)	(2.929)	(2.275)	(3.745)
Control variables	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	699	699	460	460
P-value	0.000	0.000	0.000	0.000
Pseudo R-squared/R-squared	0.583	0.475	0.610	0.519

Panel C: Entropy balancing with the treatment variable *IND_NOT_CLIMATE*

Dependent variables:	(1)	(2)	(3)	(4)	(5)	(6)
	DISCLOSURE	*COMPOSITE*	*DISCLOSURE*	*COMPOSITE*	*DISCLOSURE*	*COMPOSITE*
	All industries		Industries with material climate risks		Industries with no material climate risks	
IND_NOT_CLIMATE	1.177*	0.584**	1.722**	1.438***	−0.494	−0.099
	(1.881)	(2.120)	(2.320)	(2.940)	(-0.586)	(-0.325)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	851	851	493	493	358	358
P-value	0.000	0.000	0.000	0.000	0.000	0.000
Pseudo R-squared/R-squared	0.391	0.385	0.473	0.462	0.398	0.306

Notes: This table provides the regression results after using the entropy balancing method to balance the covariates between the two groups with and without specialist auditors. All variable definitions can be found in Appendix 1. The *z*-statistics (*t*-statistics) in parentheses are based on robust standard errors clustered by the firm. *, **, and *** denote statistical significance levels of 10%, 5%, and 1%, respectively (two-tailed). In Panel B, there are no columns for *Industries with no material climate risks* due to a lack of observations in the subsample.

include client company size (*SIZE*), profitability (*ROA*), measures of risks (*BETA, LVG, CURRENT*), measures of growth (*MB*), and new issuance of stock and debt (*FINANCE*). We also included environmental performance (*EP*), other board-related variables (*BOARD_SIZE, SUS_COMM*), and sustainability-related variables (*SUS_REPORT, SUS_AUDIT*), as in the second-stage regression.

We add two exogenous variables (*PORTF_ASSET* and *PORTF_GHGE)* to the first-stage regressions, as we predict that these two variables are highly correlated with the likelihood of auditor expertise. *PORTF_ASSETS* is calculated as the total audited assets in a partner's portfolio in a certain industry, excluding the focal firm's assets. Similarly, *PORTF_GHGE* is the total GHG Emissions in the partner's portfolio excluding the focal firm's emissions. Since these two variables do not include either total assets or emissions of the focal firms, they are expected to be correlated to the outcomes (*DISCLOSURE* and *COMPOSITE*) only through the measure of auditor expertise and are thus excluded from the second-stage regressions. We obtain the inverse Mills ratios (*IMR_CLIMATE, IMR_IND, IMR_BOTH*) from the first stage and include the ratios as additional explanatory variables in the second stage. Table 7 presents the results of the Heckman two-step regression.

Columns 1–3 of Table 7 present the results of the first-stage regression while columns 4–6 show the results of the second-stage regressions. The exogenous variable *PORTF_GHGE* (*PORTF_ASSET*) is positive and highly correlated with the treatment variable *CLIMATE _SPEC* (*IND _SPEC*) in column 1 (2), and both variables are highly correlated with the treatment variable *CLIMATE_AND_IND* in Column 3. In the three models, the percentages of correct classifications were 98%, 94%, and 96%, respectively.

Columns 4 and 5 report the second stage, in which the inverse Mills ratios (*IMR_ CLIMATE* and *IMR_ IND*) are included as additional

Table 7
Heckman two-stage estimation results.

Dependent variables:	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	First Stage *CLIMATE_SPEC*	First Stage *IND_SPEC*	First Stage *CLIMATE_AND_IND*	Second stage *DISCLOSURE*	Second stage *COMPOSITE*	Second stage *DISCLOSURE*	Second stage *COMPOSITE*
CLIMATE_SPEC				−0.233	0.578***		
				(-0.515)	(2.978)		
IND_SPEC				1.357**	0.267		
				(2.421)	(1.117)		
IMR_CLIMATE				0.626*	0.229		
				(1.703)	(1.053)		
IMR_IND				−0.341	−0.021		
				(-0.759)	(-0.117)		
CLIMATE_AND_IND						1.137**	1.480***
						(2.164)	(5.872)
IMR_BOTHSPEC						−0.679**	−0.736***
						(-2.008)	(-5.082)
PORTF_ASSETS	−0.396***	1.464***	0.226***				
	(-2.636)	(6.578)	(4.298)				
PORTF_GHGE	7.138***	0.057	0.372***				
	(6.496)	(0.901)	(6.869)				
Constant	−23.843***	−32.319***	−22.325***	−32.346***	−9.479***	−31.976***	−8.769***
	(-6.331)	(-10.415)	(-7.555)	(-7.004)	(-6.625)	(-7.199)	(-6.722)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE, Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1000	1000	1000	1000	1000	1000	1000
Log likelihood	−65.801	−153.948	−104.426	−220.246	−1850.295	−223.079	−1842.148
Correctly classified	98%	94%	96%				
Pseudo R-squared/ R-squared				0.534	0.456	0.528	0.466

Notes: The first-stage regressions are probit regressions. The inverse Mills ratios *IMR_CLIMATE, IMR_IND*, and *IMR_BOTHSPEC* obtained from the first-stage regressions in Columns 1, 2, and 3, respectively, are added to the second-stage regressions. All variable definitions can be found in Appendix 1. The *z*-statistics (*t*-statistics) are given in parentheses. *, **, and *** denote statistical significance levels of 10%, 5%, and 1%, respectively (two-tailed).

explanatory variables. The coefficient of *CLIMATE_SPEC* is significant in Column 5 (0.578, *p*-value <0.01), and *IND_SPEC* is positive and significant (1.357, *p*-value <0.05) in Column 4. Moreover, in Columns 6 and 7, where the inverse Mills ratio *IMR_BOTHSPEC* is included, the coefficients of *CLIMATE_AND_IND* are positive and significant. Our results are robust to potential selection biases.

4.3.3. *Impact threshold for confounding variables*

We further addressed the problem of unobservable confounders by applying the Impact Threshold for Confounding Variable (ITCV) method by Frank (2000). The ITCV method calculates the lowest partial correlation that an omitted variable should have with the outcome and explanatory variables to make a significant coefficient insignificant (Frank, 2000). In our case, an omitted variable would have to be correlated at 0.136 with *DISCLOSURE* and 0.136 with *IND_SPEC* (ITCV $= 0.136 \times 0.136 = 0.018$) to invalidate the inference in Column 1 of Table 3. Similarly, an omitted variable would have to be correlated at 0.278 with *COMPOSITE* and 0.278 with *CLIMATE_SPEC* (ITCV $= 0.278 \times 0.278 = 0.077$) to make the coefficient of *CLIMATE_SPEC* insignificant in Column 3 of Table 3.

To put these numbers into perspective, we calculated the partial correlations and ITCV of the control variables in our model (untabulated). *IND_SPEC* and *LVG* had the highest partial correlation with *CLIMATE_SPEC* (0.166 and −0.131, respectively), whereas *SIZE* and *R_LENGTH* had the highest partial correlation with *COMPOSITE* (0.195 and 0.138, respectively). However, none of these variables have a product of partial correlation (ITCV) higher than the threshold of 0.077. Therefore, we conclude that an omitted variable is not likely to be strong enough to change our inferences.

4.4. *Additional analysis*

Panel A of Table 8 shows regression results using data without estimated GHG Emissions. The sample is reduced to 584 observations but the main inferences remain unchanged: both *CLIMATE_AND_IND* and *CLIMATE_NOT_IND* have positive and significant regression coefficients.

Panel B of Table 8 shows the results of the Tobit regression where the dependent variable is *COMPOSITE*. This method takes into consideration the imbalance in the number of observations with climate risk disclosures, and that disclosures can only have values that are either zero or positive. All three coefficients for auditor expertise measures in Panel B are strongly significant in the full sample (Column 1) and in the subsample of industries with material climate risks (Column 2).

Thirdly, Panel C of Table 8 presents the results of the main tests by calculating the standard error using the bootstrapping technique with 500 replications. The regression coefficients are similar to those documented in Table 3, confirming that our result does not suffer from low statistical power and reliability.

There are several additional analyses that are untabulated. We examine regression results for different components of disclosure

Table 8
Additional analyses.

Panel A: The estimation results using data without estimated GHG Emissions.

	DV: *DISCLOSURE*		DV: *COMPOSITE*	
	(1)	(2)	(3)	(4)
CLIMATE_SPEC	0.396		0.771***	
	(1.004)		(3.039)	
IND_SPEC	0.833*		0.094	
	(1.716)		(0.384)	
CLIMATE_AND_IND		1.216**		0.829**
		(2.167)		(2.414)
CLIMATE_NOT_IND		1.235*		1.042**
		(1.897)		(2.100)
IND_NOT_CLIMATE		1.260**		0.172
		(2.029)		(0.697)
Controls, Industry FE, Year FE	Yes	Yes	Yes	Yes
N	584	584	584	584
Pseudo R-squared/R-squared	0.519	0.523	0.461	0.461

Panel B: Tobit regression for *COMPOSITE* variable.

	All industries	Industries with material climate risks	Industries with no material climate risks
	(1)	(2)	(3)
CLIMATE_AND_IND	2.191**	3.166***	−7.625**
	(2.213)	(3.274)	(-2.113)
CLIMATE_NOT_IND	2.456**	3.451***	−28.666***
	(2.155)	(3.276)	(-8.437)
IND_NOT_CLIMATE	2.366**	3.481***	−3.122
	(2.366)	(3.380)	(-1.514)
Controls, Industry FE, Year FE	Yes	Yes	Yes
N	1000	618	382
Pseudo R-squared	0.271	0.273	0.267

Panel C: Main tests with standard errors calculated using the bootstrapping technique (500 replications).

	DV: *DISCLOSURE*		DV: *COMPOSITE*	
	(1)	(2)	(1)	(2)
CLIMATE_SPEC	0.200		0.675***	
	(0.545)		(3.270)	
IND_SPEC	0.899**		0.198	
	(1.996)		(1.087)	
CLIMATE_AND_IND		1.068**		0.857***
		(2.022)		(2.762)
CLIMATE_NOT_IND		0.907*		0.724**
		(1.663)		(2.531)
IND_NOT_CLIMATE		1.255*		0.213
		(1.922)		(1.121)
Controls, Industry FE, Year FE	Yes	Yes	Yes	Yes
N	1000	1000	1000	1000
PseudoR-squared/R-squared	0.535	0.538	0.457	0.457

Notes: This table presents the results of the additional tests. Panel A shows regression results using data without estimated GHG Emissions. Panel B shows Tobit regression results. Panel C presents the results of the main test after calculating the standard errors using the bootstrapping technique with 500 replications. All variable definitions can be found in Appendix 1. z-statistics (t-statistics) based on clustered standard errors are given in parentheses. *, **, and *** denote statistical significance levels of 10%, 5%, and 1%, respectively (two-tailed).

quality: the length of disclosures (*LENGTH*), the number of categories discussed (*CAT_NUM*), and the inverse measure of boilerplate disclosure (*ORIGINALITY*). These untabulated results are consistent with the main results in Table 3.

Furthermore, our study focuses on expertise at the individual partner level. To rule out the possibility that the obtained results could be due to expertise at the audit firm level and not the individual partner level, we ran two additional analyses. First, we add additional dummy variables to our model: four dummies for Big4 audit firms, and one dummy variable for all other non-Big4 audit firms. Second, we drop non-Big4 clients from the sample and control for Big4 firm fixed effects. The results in both analyses show that the coefficients of *CLIMATE_SPEC* and *IND_SPEC* are positive and significant as in the main results even after controlling for audit firm fixed effect. Therefore, our results are not due to expertise at the audit-firm level.

5. Summary and conclusions

We examine the effect of the audit partner's climate risk expertise on the likelihood and quality of clients' climate risk disclosures.

Using data from the top 500 Australian listed companies in a setting where both auditors and management have to consider climate risks in the financial statements, we find that the likelihood and quality of clients' climate risk disclosures is higher when clients are audited by audit partners with climate-related expertise. However, we observe this positive association only in industries with material climate risks.

Our results are robust for alternative definitions of climate-related expertise. Furthermore, an entropy balancing approach generates similar results, mitigating concerns that our findings are driven by covariate imbalance. Regarding unobservable confounding variables, our results from the Heckman selection model and ITCV analysis show that it is less likely that omitted variables could change our inference. While these analyses provide further causal interpretation of the expert auditor impact by alleviating concerns related to omitted variables and selection effects, we acknowledge that with observational data, these issues cannot be entirely ruled out.

This study deals with the timely topic of climate-related risk reporting and contributes to both audit and disclosure literature. This study adds to the scarcely researched area of auditor involvement in sustainability reporting and is the first paper that demonstrates the role of audit partners' climate expertise (either independently or combined with industry expertise) in clients' climate risk reporting. Moreover, we document a new dimension of audit partner expertise, namely climate-related expertise. Recent frameworks and regulations have further increased pressure on companies to explain the impact of climate risks on their financial performance, creating demand for assurance of this information. Our findings add to the extant literature by documenting that the audit partner's expertise in climate risks plays an important role in the client's decisions to report climate risks in the financial statements and/or the annual report. These findings should be of interest to regulators and legislators. Furthermore, the results are useful to all parties interested in climate change, to investors and firms seeking sustainable financing, and to the auditing profession itself.

Future research may be able to extend the examination of these issues to other settings beyond Australia and to examine climate risk disclosures that are expected to be made in other countries such as the United Kingdom (Morales, 2021), the United States (Ramonas, 2022), Europe (Directive 2022/2464, 2022) or New Zealand (Ministry for the Environment, 2022). Recent machine learning applications in natural language processing may also provide a fruitful avenue for capturing new quality aspects of risk disclosures (Huang et al., 2022).

Data availability

Data were obtained from publicly available sources described in the article.

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Appendix 1. Variable definitions

Variable	Definition	Years covered	Data sources
DISCLOSURE	A binary variable indicating whether a firm discloses climate risks in its annual report.	2018–2019	Annual report (PDF from Thomson Reuters EIKON)
COMPOSITE	A continuous measure for the quality of disclosure, calculated using the log of the average ranking of three components: *LENGTH*, *CAT_NUM*, and *ORIGINALITY*.	2018–2019	Annual report (PDF from Thomson Reuters EIKON)
LENGTH	Continuous, the number of sentences in the climate risk disclosures.	2018–2019	Annual report (PDF from Thomson Reuters EIKON)
CAT_NUM	Count, the number of categories in the climate risk disclosures, based on the TCFD framework.	2018–2019	Annual report (PDF from Thomson Reuters EIKON)
ORIGINALITY	Continuous, the percentage of words in the climate risk disclosures that are not part of boilerplate phrases.	2018–2019	Annual report (PDF from Thomson Reuters EIKON)

(*continued on next page*)

(*continued*)

Variable	Definition	Years covered	Data sources
CLIMATE_SPEC	A binary variable indicating audit partner expertise on climate-related issues, 1 if partner's share of emissions is higher than the cut-off value (1.2 × 1/total number of audit partners) and 0 otherwise.	2018–2019	Calculated. In one robustness test, calculated using data from 2016 to 2017
IND_SPEC	A binary variable indicating industry specialization, 1 if partner's market share is higher than the cut-off value (1.2 × 1/total number of audit partners in an industry) and 0 otherwise.	2018–2019	Calculated
CLIMATE_AND_IND	A binary variable indicating audit partner who has both climate-related and industry expertise	2018–2019	Calculated
CLIMATE_NOT_IND	A binary variable indicating audit partner who has only climate-related expertise and not industry expertise	2018–2019	Calculated
IND_NOT_CLIMATE	A binary variable indicating audit partner who has only industry expertise and not climate-related expertise	2018–2019	Calculated
SIZE	Continuous, natural logarithm of total assets.	2018–2019	Calculated using data from Thomson Reuters EIKON
ROA	Continuous, return on assets.	2018–2019	Calculated using data from Thomson Reuters EIKON
EP	Continuous, environmental performance, calculated as GHG Emissions × 1000/total revenues and adjusted for industry.	2018–2019	Data from Thomson Reuters EIKON and NGER website. Missing data is replaced by estimated numbers as in Appendix 4
BETA	Continuous, stock beta.	2018–2019	Thomson Reuters EIKON, Orbis
LVG	Continuous, total liabilities divided by total assets.	2018–2019	Calculated using data from Thomson Reuters EIKON
CURRENT	Continuous, current assets divided by current liabilities.	2018–2019	Calculated using data from Thomson Reuters EIKON
MB	Continuous, market capitalization divided by book value of equity.	2018–2019	Calculated using data from Thomson Reuters EIKON
FINANCE	Continuous, new debt and stock issuance in 3 consecutive years, multiplied by 100 and divided by assets.	2018–2019	Calculated using data from Thomson Reuters EIKON
BOARD_SIZE	Continuous, the number of board members.	2018–2019	Thomson Reuters EIKON, Orbis
SUS_COMM	Binary, existence of sustainability committee.	2018–2019	Thomson Reuters EIKON, Orbis
SUS_REPORT	Binary, existence of sustainability report.	2018–2019	Thomson Reuters EIKON, Orbis
SUS_AUDIT	Binary, the sustainability report is assured by a third party.	2018–2019	Thomson Reuters EIKON, Orbis
SPILLOVER	Binary, the sustainability report assurance and financial statement audit are from the same audit firm.	2018–2019	Thomson Reuters EIKON, Orbis
BIG4	Binary, indicating if the external auditor is one of the Big Four (PwC, KPMG, Deloitte, or EY).	2018–2019	Thomson Reuters EIKON, Orbis
R_LENGTH	Continuous, the natural logarithm of the number of words in an annual report.	2018–2019	Annual report (PDF from Thomson Reuters EIKON)
*IMR_**	Continuous, the Inverse Mills Ratio of an exogenous variable.	2018–2019	Calculated using data from Thomson Reuters EIKON
PORTF_ASSET	Continuous, total audited assets in audit partner's portfolio by industry, excluding the focal client firm's assets.	2018–2019	Calculated using data from Thomson Reuters EIKON
PORTF_GHGE	Continuous, total GHG Emissions in audit partner's portfolio, excluding the focal client firm's GHG Emissions.	2018–2019	Calculated using data from Thomson Reuters EIKON
Variables in the GHG Emissions estimation model (Appendix 4):			
GHGE	Continuous, the natural logarithm of reported GHG Emissions.	2016–2020	Calculated using data from Thomson Reuters EIKON
logREVT	Continuous, the natural logarithm of revenues.	2016–2020	Calculated using data from Thomson Reuters EIKON
logCAPX	Continuous, the natural logarithm of capital expenditure.	2016–2020	Calculated using data from Thomson Reuters EIKON
logPPEDP	Continuous, the natural logarithm of asset age, calculated as the properties, plant, and equipment gross value divided by the depreciation expenses.	2016–2020	Calculated using data from Thomson Reuters EIKON
logINTAN	Continuous, the natural logarithm of intangible asset value.	2016–2020	Calculated using data from Thomson Reuters EIKON
GMAR	Continuous, the gross margin.	2016–2020	Calculated using data from Thomson Reuters EIKON
logPPE	Continuous, the natural logarithm of property, plant, and equipment.	2016–2020	Calculated using data from Thomson Reuters EIKON
D_NO_SALES	A binary variable indicating if there are no revenues.	2016–2020	Calculated using data from Thomson Reuters EIKON
D_NO_CAPEX	A binary variable indicating if there is no CAPEX.	2016–2020	Calculated using data from Thomson Reuters EIKON
D_NO_PPE	A binary variable indicating if there is no PPE.	2016–2020	Calculated using data from Thomson Reuters EIKON

Appendix 2. Examples of climate risk disclosures – Excerpts from annual reports

Example 1. Climate risk disclosure in **directors' report** – AusNet Services, Annual report 2019

As an owner and operator of energy networks, AusNet Services is focused on the identification and management of both transition and physical risks of climate change. Transition risks include the impacts of potential changes to energy policy, legislation and regulations as the energy industry moves to a lower carbon future, with increasing renewable and distributed generation. The implications of these changes are outlined in the Industry and Regulatory Risks and Network Risks sections. Other transition risks and opportunities arise from changes in customer preferences and developments in renewable energy and energy storage technology. As part of our active monitoring of new technology we undertake trials (including mini-grids), and partner with other organizations to better understand the risks and benefits for our business.

Physical risks include the impacts of changing environmental conditions (both short- and longer-term) on our network assets and the potential damage to assets and interruptions to supply from severe weather events such as storms, bushfires or floods. Risk management for these risks includes reviewing engineering standards and ratings for equipment, a significant investment in bushfire mitigation activities and the ongoing development and testing of emergency response plans. In addition, we have continued our network resilience program to strengthen critical parts of the network and enhance contingency planning. In FY2019 we further increased customer engagement on community resilience, including …

Example 2. Climate risk disclosure in **the notes to the financial statements** – Aurizon Network Pty Ltd, Annual report 2019

Significant judgements

Depreciation

… The Group reviews useful life assumptions on an annual basis having given consideration to variables including historical and forecast usage rates, technological advancements, climate-related emerging risks and changes in legal and economic conditions …

Impairment

… There is a risk that the judgements applied in relation to the terminal growth rate will be impacted by climate-related emerging risks which have been considered for impairment testing through sensitivity on terminal growth rates. There is also a risk that the assumptions made and growth rates applied don't reflect the actual impact of climate-related emerging risks in the future.

Example 3. Climate risk disclosure in directors' report – SEEK Limited, Annual report 2019 – **No material risks**

… SEEK actively manages the risks that could materially impact our ability to sustain our future financial performance and deliver our long-term strategy. The following are the key risks and the actions we are taking to manage these risks. Climate change risk is not considered financially material at this time and will be addressed separately in SEEK's Sustainability Report …

Appendix 3. The text mining process for finding climate risk disclosures

In this Appendix, we elaborate on our text mining process for identifying climate risk disclosures. Our keyword list was carefully designed based on guidance from key documents like AASB and AUASB's "Climate-related and other emerging risks disclosures" Bulletin (2018) and TCFD's "Recommendations of the Task Force on Climate-related Financial Disclosures" (2017), focusing on variations of "climate" and "risk" used together. We meticulously tested this list, focusing on precision and recall properties, while maintaining simplicity for replicability. Sophisticated natural language processing technologies and comprehensive manual assessments were employed to optimize the list's performance. While alternative keywords like "climate change" and "climate disaster" were considered, they did not significantly improve our findings and potentially increased false positives without enhancing recall.

The automated textual analyses are conducted using these steps.

1. Split the document into pages.
2. Identify the pages that contain the keyword climate risk and its different versions: "climate risk(s)","climate change risk(s)", "climate related risk(s)", "climate-related risks", "climate-related risk(s)", "climate change related risks", "risks associated with climate", "risk(s) of climate change", "climate and other risks", "climate-related emerging risks", "climate-related and other emerging risks."
3. Extract only the pages that contain the keywords above. Split into sentences.
4. Extract the sentences that contain keywords relating to climate change risks.
   - The basic list of keywords originally developed by (Haque & Deegan, 2010) which was adopted by other papers (for example, Kouloukoui et al. (2019) includes: 'climate change', 'global warming', 'greenhouse gas', 'emissions', 'EU ETS', 'carbon', 'CO2', 'GRI', 'GHG Protocol', 'corporate governance, 'management', 'risk', 'environment', 'pollution' and 'energy'
   - We expand this list by randomly examining 20 reports that contain climate risk disclosure. The reason is that Haque and Deegan (2010) built the lists on 2010, which can be outdated because in recent years there are new reporting frameworks and requirements. Then we continue to add another 10 reports, the list of top words in climate risk disclosure does not change much.

- From the list of top words in the disclosures, additional keywords are added to identify the relevant sentences: opportunities, material, renewable, assessment, natural, scenario, physical, framework, ESG, sustainability, TCFD, resilience, assumption, impaired, impairment, recoverable. These words are relevant in the context of climate-related risks disclosures, as we have been narrowing down the areas with climate risks disclosures.

5. Following the majority of papers in disclosure literature (Elshandidy & Neri, 2015; Elzahar & Hussainey, 2012; Oliveira et al., 2011), we use the number of sentences as unit of analysis.
6. Identify boilerplate disclosure: Following Dyer et al. (2017), we split the disclosures into four-word phrases, five-word phrases, and six-word phrases to see their frequency and determine the commonly used phrases that have low information value. We then count the number of words that belong to the boilerplate phases and use it to calculate the *ORIGINALITY* measure.

Appendix 4. Greenhouse Gas (GHG) Emissions and Environmental Performance

In this study, we use GHG emissions for two purposes: to construct the measure for auditor expertise (*CLIMATE_SPEC*) and to control for environmental performance (*EP*) in our models. We use the total level of GHG emissions deflated by total revenues (Clarkson et al., 2011; Luo & Tang, 2014; Patten, 2002), and then subtract the mean value of the industry to get an industry-adjusted environmental performance (*EP*).

Since 2007 the Australian Government has required GHG emissions disclosure for entities that produce large quantities of carbon emissions under the National Greenhouse and Energy Reporting Scheme (NGERS). The threshold for mandatory reporting changes over the years. At the corporate level, the threshold for the first reporting years 2008 and 2009 is 125 kt of greenhouse gases (scope 1 and scope 2 emissions), being reduced to 87.5 kt in 2010, and then to 50 kt in 2011, which is the current threshold. Firms can also voluntarily report when their emissions are lower than this value.

As reporting on GHG emissions is not mandatory for all companies, there are missing values in our sample. We follow Griffin et al. (2017) to estimate the GHG emissions for non-disclosing firms.

This estimation process has two steps. First, following the idea of the production function, the natural log of reported GHG emissions (*GHGE*) is regressed on a set of other covariates: natural log of revenues as firm output (*logREVT*), natural log of capital expenditure (log*CAPX*), natural log of asset age being calculated as the properties, plant, and equipment gross value divided by the depreciation expenses (*logPPEDP*), the industry sector (*SECT*), the natural log of intangible asset value (*logINTAN*), the gross margin (*GMAR*), and leverage (*LVG*). We supplement this model with the natural log of property, plant, and equipment (*logPPE*). Since there are many firms in the energy and materials industries that are still in the research and development phase and thus do not generate sales, we add an indicator for observations with zero sales (*D_NO_SALES*). Similarly, we add indicators for observations with no capital expenditure (*D_NO_CAPEX*), and no PPE (*D_NO_PPE*). To have better estimation of regression coefficients, we make use of a larger panel data from 2016 to 2020.

Then, we estimate the GHG emissions and supplement our data where GHG emission is missing.

The estimated coefficients for the regression in the first step are as follows:

Dependent variable: GHGE		
	Coefficients	*t*-value
logREVT	0.649***	(26.32)
logCAPX	0.0914**	(2.97)
logPPEDP	0.0591***	(3.34)
logINTAN	−0.0105	(-1.59)
GMAR	0.000239***	(4.00)
LVG	−0.0174	(-0.11)
logPPE	0.252***	(8.69)
D_NO_SALES	11.22***	(15.66)
D_NO_CAPEX	4.010***	(7.02)
D_NO_PPE	5.542***	(8.53)
Intercept	−7.402***	(-20.92)
Industry FE, Year FE	Yes	
N	1551	
P-value	0.00	
R-squared	0.80	

The t-statistics in parentheses. *, **, and *** denote statistical significance levels of 10%, 5%, and 1%, respectively (two-tailed).

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