Firm-Level Climate Risk and Big 4 Audit Firms: A Cross-Country Study

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Abstract

This research examines the role of Big4 Auditors in mitigating climate risk. Primarily, this research is motivated by the lack of studies on the role of Big Four auditors on climate risk. This study, then, employs the firm-level climate risk based on the analyst calls. Subsequently, this research employs various statistical methodologies to examine the relationship between Big 4 auditors and climate risk and found that Big 4 auditors are negatively related to firm-level climate risk. This correlation remains stable across various climate-related variables and is supported by multiple statistical approaches, such as fixed effects. To address the selection issue, furthermore, this research employs the Heckman selection model and finds that the inverse mills ratio is significantly related to climate risk. This research also uses a propensity score model to address the endogeneity problem, and our results still hold. Our empirical finding in this study, therefore, may significantly contribute to the literature in understanding the substantial influence of Big Four Auditors' practice on climate change risk at the firm level.

Keywords: Firm-level climate risk, Big 4 Auditors, Heckman selection model, PSM.

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1. Introduction:

Climate change has a profound impact on the way businesses operate. Scientists have developed complex models to predict how the global climate responds to greenhouse gas emissions (Sautner et al., 2023) as temperature serves as a critical indicator of climate (Huang et al., 2018). This implies that as global temperatures rise, we witness a rise in the intensity of extreme weather events (Stott, 2016; Yuan et al., 2023). We believe the concept of climate risk covers the potential adverse consequences of climate change on various aspects of human beings and ecological systems. This includes negative effects on health, livelihoods, social structures, well-being, economic stability, ecosystems, cultural heritage, investments, infrastructure, service provision, and biodiversity (cervest.earth, 18 September 2022). Essentially, temperature, as a fundamental factor, influences nearly all chemical, biological, and ecological processes, contributing to climate risk (Burke et al., 2015).

On the other hand, this study is motivated by observing the auditors' essential role in the business world while checking the accuracy of financial statements or in fraud detection from legal and financial perspectives, as noted by Coffee and Fama (Coffee, 1986; Fama, 1980). Also, our study acknowledges the extreme climate change impact (rising global temperatures and severe climatic occurrences) on global business operations and the environment and emphasizes the need to address climate risk and sustainability practices of business operations in literature as outlined by (Flammer et al., 2021; Huang et al., 2018; Sautner et al., 2023; Stott, 2016; Wittneben et al., 2012). In this context, Auditing firms can play a pivotal role as their job is to verify the company's financial health; also, they can assess sustainability progress, evaluate CSR integration, and ensure compliance with environmental and social policies (Christensen et al., 2021; Hichri, 2023).

Consequently, we believe climate-related concerns in the field of auditing represent a significant aspect of corporate social responsibility (CSR). Many organizations now recognize the growing importance of not only managing climate risks but also establishing sustainable practices in their core operations (Wittneben et al., 2012). So, auditing firms are expected to play an active role in CSR initiatives. This includes thoroughly verifying additional financial information, assessing progress toward sustainability goals, evaluating the level of CSR integration, and ensuring compliance with environmental and social policies (Christensen et al., 2021).

However, it's worth noting that entities like ClientEarth have issued warnings (ClientEarth, 2021) regarding the major global audit firms for failing to adequately incorporate climate risk considerations into their audit assessments. We also believe, this neglect potentially raises concerns about legal obligations and market integrity. Additionally, the Carbon Accounting Project and Carbon Tracker have disclosed that in the 2020 financial statements of over 100 carbon-intensive companies; a significant number of auditors demonstrated limited attention to climate-related matters. This revelation urged ClientEarth to emphasize potential legal and regulatory risks while highlighting disparities between auditors' commitments to addressing climate issues and their actual practices (ClientEarth, 2021).

Again, we see climate change risks include floods, storms, and temperature rises, as well as regulatory vulnerabilities arising from government climate policies like carbon trading systems and energy efficiency standards. Additionally, there are other risks to consider, including damage to reputation, increased humanitarian demands, and shifts in consumer behaviour (Flammer et al., 2021). Likewise, climate change causes major risks to various aspects of society, humans, industries, wildlife, and companies, leading to severe disruptions and displacements (Li et al., 2023). Similarly, a company's engagement in climate-related initiatives and its carbon footprint can vary significantly, carrying potential harm, such as damage, legal liability, or financial losses, resulting from climate-related events (Flammer et al., 2021). As a result, possibly, academic interest has centred on participation in voluntary programs like the reporting of greenhouse gas emissions-related initiatives (Fisher-Vanden & Thorburn, 2011; Jira & Toffel, 2013). However, there are concerns regarding the actual integration of climate risk in audit assessments (ClientEarth, 2021; Ong, 2022). In summary, multiple studies highlight the apparent lack of focus on climate-related issues within auditor reports despite the critical importance of addressing this pressing global concern to protect the planet.

Moreover, despite the increasing recognition of the role of audit firms in addressing climate risk in the existing literature, there remains a significant scarcity of research exploring the specific relationship between climate risk and Big Four Auditors[1]. This study addresses this gap and investigates this area by suggesting hypotheses that firms audited by Big Four auditors produce better financial presentation, so it is expected that there are fewer chances of irregularities related to climate risk by their audited companies.

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[1] Ernst & Young (EY), Deloitte, KPMG, PricewaterhouseCoopers (PwC)

Afterwards, this research focuses on Climate Risk as the dependent variable, assessed through Climate Change indicators incorporating operational, regulatory, and physical aspects which further include exposure, risk, positivity, negativity, and sentiment categories. Besides, the main independent variable, Big4 Auditor, indicates whether a firm belongs to the Big 4 accounting firms. Also, firm-level control variables are considered as RoA, Tangibility, Firm Size, Capex Intensity, Cash Holdings, Leverage, and Market to Book ratio, along with GDP and Inflation are considered as country-level controls.

Primarily, the Mean Difference t-test presented in this research shows positive relation (Hypothesis-2) between the Big 4 auditor over non-Big 4 auditors, concerning various climate risk variables. Then, we find the prevailing dominance of Big4 auditors over non-Big4 auditors across multiple countries and believe that this global reach and influence of Big4 auditors may have significant implications for their role in mitigating climate risk.

Later, this research employs a various statistical approach to examine the correlation between climate risk and Big4 auditors. Initially, Ordinary Least Squares (OLS) analysis (Table 4) reveals negative correlation between climate risk and Big4 auditors. Subsequently, the Fixed Effects model at the firm-level further confirms the finding of reduced climate risk for firms which are audited by Big 4 auditors. Furthermore, to enhance the acceptability of the previous result and reduce potential bias, Heckman selection model (Heckman, 1979) is used while following the methodology of(Hafiz & Doukas, 2023). In the first stage, this model identifies the factors influencing Big4 auditor selection. Then, in the 2nd stage, the analysis proves (Hypothesis-2) the relationship positively between Big4 auditors and lower climate risk, supported by coefficients for climate-related variables. Finally, we conducted Propensity Score Matching (PSM) (Abadie & Imbens, 2011) to estimate causal effects across control variables of Big4 auditor and it scored 0.67 while providing the positive relationship between Big 4 auditors and lower climate risk.

In summary, this study has considered several models for enhancing the estimation of how Big Four audit firms impact a corporation's climate risk practices and, subsequently, found reduced climate risk impact at the firm-level which are audited by Big 4 auditors. We assume that this endeavour may reflect a dynamic relationship between the Big4 auditors and climate risk, bridging a significant knowledge gap in contemporary academia.

2. Literature Review

This study considers reviewing the literatures on varied areas of the Auditing and Climate Risk and finds valuable arguments which are discussed below.

2.1. Audit Firms:

To ensure the accuracy of financial statements, an auditor examines and inspects various accounting books and conducts a physical inventory check, ensuring all departments adhere to the documented transaction recording system (LawInsider). More specifically, an audit firm is an independent firm engaged by the client for an audit that assesses the company's financial statements and provides an opinion (Wikipedia).

Additionally, the legal perspective asserts that auditors and securities regulators are responsible for fraud detection (Coffee, 1986). Besides, the finance viewpoint expects that financial monitoring is carried out by individuals with their agents (analysts and auditors) and residual claims (equity and debt holders) (Fama, 1980). Another study found that the responsibility for financial statements lies with a combination of management, CPAs, and the SEC, auditors don't create these statements, and the SEC worries about auditors' independence when involved in management services, means accounting firms offering both management services and attest functions contribute to the communication gap in financial reporting (Briloff, 1965).

Furthermore, as per Brown's viewpoint, auditors should anticipate that accepted project forecasts will typically exceed actual outcomes on average and should refrain from attributing any issues to the forecasting process on the basis of audited reports (Brown, 1974), as well as understanding and controlling the decision-making process can be significantly assisted by the post-audit process, making it a valuable tool for decision-makers (Smidt, 1979). Similarly, during an interview, one of the four major accounting firms' CEO expressed that investors consider an audit as a guarantee of a company's financial well-being (Dyck et al., 2010). So, an audit requires validating a company's financial statements' accuracy by relying on the data supplied by the company (Taub, 2005) as auditors have to meet shareholders' needs (Dyck et al., 2010).

2.1.2 Overview of General Audit Firms and the Big4[2]:

The Big4 Auditors experience low competition for new clients, and their client turnover rate is also relatively low (Ghosh & Pawlewicz, 2009). The reason may be: all strengthened by standardized audit programs, national training programs, firm-wide knowledge-sharing practices, and information technology are in place at the Big4 firms (Francis & Yu, 2009). In contrast, lower quality auditors are chosen by poorly governed firms (Chen & Zhou, 2007). Nonetheless, considering non-Big4 auditors as inferior to Big4 auditors carries adverse consequences for smaller auditors in auditing, including biases in audit committee's auditor selection, potentially leading to a loss of both current and prospective clients (DeFond et al., 2017; Lawrence et al., 2011).

Also, the Big4 auditors, due to their higher concerns about reputation and litigation risks, are inclined to decrease their economic ties with clients by offering fewer non-audit services compared to non-Big4 auditors (Lim & Tan, 2008). Besides, small auditors, facing intense competition, are prone to lowering fees to persuade new clients, whereas large auditors, due to low competition in acquiring new clients, experience comparatively lower client turnover (Ghosh & Pawlewicz, 2009). Furthermore, for medium-sized and small public companies, the auditing market share has been captured by Grant Thornton, BDO Seidman, and other non-Big4 firms in recent years to compete with Big4 firms (Chan et al., 2012).

Furthermore, clients of non-Big4 compared to Big4, account higher absolute discretionary accruals[3] (Becker et al., 1998; Jaggi et al., 2012). Later on, another literature proposed the idea that limiting opportunistic and aggressive reporting, the Big4 auditors restrict their clients who demonstrate lower discretionary accruals but higher total accruals (Francis & Krishnan, 1999). Moving forward to 2004, between future earnings and discretionary accruals, other study identified a weaker link between Big4 clients than non-Big4 clients (Francis, 2004; Lawrence et al., 2011). Besides, according to the literature on valuation, Big4 auditors offers better market assurance than the auditors of non-Big4 (Lawrence et al., 2011).

Additionally, in the United States, non-Big4 clients faced a higher ex ante[4] cost of capital than their Big4 oppositions (Inder K. Khurana & K. K. Raman, 2004; Lawrence et al., 2011). Furthermore, when compared to the other type of auditor, if one type enhances the reliability of earnings reporting, then analysts working with clients of the superior type should be capable of making more precise future earnings forecasts than analysts serving non-superior type clients; means non-Big4's analysts

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[2] Ernst & Young (EY), Deloitte, KPMG, PricewaterhouseCoopers (PwC)
[3] Accounting adjustments known as discretionary accruals are made by management at their discretion, not relying on objective events or transactions. Source
[4] The ex-ante costs and charges are an estimated cost projection before expenses are accrued. Source

display lower accuracy in forecast when comparing with Big4's analysts (Behn et al., 2008). Thus, even though, there are mixed view in the literature, most of the researchers have found positive output on Big-4 auditors' activities.

2.1.3 Challenges and Concerns in the Audit Industry:

Discovering auditors' definite cost who blow the whistle presents a challenge; in cases of fraud, when the auditors blow the whistle, they are at risk to lose their clients, whereas there is no substantial evidence indicating that revealing the fraud leads to a greater number of accounts as a reward (Dyck et al., 2010). Additionally, legal liability consists of various crucial factors, such as the likelihood of the auditor facing legal consequences for an audit failure[5], an audit failing possibility to uncover a misrepresentation, and material misstatement possibility in financial reports (Choi et al., 2008). Likewise, business risk of auditor, which includes the possibility of facing litigation, regulatory penalties, or harm to one's professional reputation even when following auditing standards, is an inherent factor in all audit engagements (DeFond et al., 2016; Huss & Jacobs, 1991; Johnstone, 2000).

So, audit firms' roles are more challenging compared to the most of other general professions. For example, when analysts blow the whistle and journalists write about fraud or misrepresentation of a company, they are more likely to receive promotions, whereas auditors may risk losing their clients (Dyck et al., 2010).

Furthermore, changing auditors is often seen to transition to more favourable auditors, and this transition can lead to the perception of a firm having less effective internal controls, because of its past history of replacing external auditors (Chhaochharia & Grinstein, 2007). Moreover, In order to keep influential clients, especially when a client significantly outweighs the engagement office in size, auditors might choose to comply and provide a favourable report (Johnson et al., 2002). Besides, when the client faces increased litigation, auditors switch firms, which is considered bad news (DeFond & Subramanyam, 1998; Fried & Schiff, 1981; Shu, 2000). To resolve this issue, auditors must make note of any information accompanying audited financial statements that seems misleading, even if it is not subject to the audit, as per Section 550 of the AICPA Code of Professional Conduct (AICPA, 2021).In the time of audit of a firm's financial statement, for instance, the auditor may ask the manager to provide supporting data and analyses for their job, and if the auditor's suspicion arises regarding the manager's truthfulness in sharing information based on their prior experiences, knowledge and the supplied data, a more in-depth inquiry may become necessary (Trueman, 1983).

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[5] A situation where a company's accounts contain mistakes or false statements, yet an audit incorrectly affirms their correctness. Source

Therefore, by increasing audit quality, transferring risk through liability insurance, and avoiding high-risk clients audit firms mitigate their business risk (Bell et al., 2015).

2.1.4 Audit pricing:

The audit fees represent the anticipated costs of auditing business risk and the auditors' endeavours to mitigate inherent risk to an acceptable level (Bell et al., 2001). Even though, auditors compete over reporting policies and pricing like disagreement is found among auditors regarding the application of appropriate GAAP [6]for a client (Magee & Tseng, 1990). Also, previous research indicates that a premium[7] is charged when large auditors offer an audit assurance at higher level (Choi et al., 2008; Craswell et al., 1995; Simunic & Stein, 1996). Similarly, with a country's strong legal liability, audit fees rise which may lead larger auditing firms to charge premium fees due to their higher liability costs and encouraging them to put in more audit effort compared to smaller firms, ultimately leading to higher fees (Choi et al., 2008; Magnan, 2008). Another study shows that, offering a greater level of audit, a premium service from large auditors, and attracting new clients, the non-Big4 firms continued in offering discounted fees for their initial engagements (Ghosh & Pawlewicz, 2009). Similarly, within the audit market, discounting fees is limited to the small auditor zone (Ghosh & Lustgarten, 2006). Also, private-company audits generate lower fees and have lower risk compared to audits of SEC registrants (Badertscher et al., 2014). Nevertheless, audits require a notably greater audit effort in the first year regardless of receiving discounted fees (Bell et al., 2015; Francis, 1987; Simon, 1988).

2.1.5 Audit Quality and Auditor Tenure:

Audit quality is appropriately detecting, correcting and reporting material misstatement by the auditor (DeAngelo, 1981). Besides, between auditor tenure and audit quality, researchers found positive connection (Chen et al., 2008; Gul et al., 2009; Johnson et al., 2002; Myers et al., 2003; Palmrose, 1987). In the initial years of an engagement, whether voluntary or mandated change in an auditor, audit quality can be adversely affected and can incur significant costs, which means audit quality is initially lowest during the first year of audits, then it steadily improves, but as tenure becomes longer it starts to decline (Bell et al., 2015).

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[6] GAAP, which stands for Generally Accepted Accounting Principles, serve as the foundation for the comprehensive set of approved accounting methods and practices used by the Financial Accounting Standards Board (FASB), covering the intricacies, complexities, and legal aspects of business and corporate accounting.
[7] Excessive fee

2.1.6 Audit Quality and Audit Firms' Size:

The chance of compromising independence by large accounting firms is low which is reflected in the measure of auditor quality, and those large firms do not rely heavily on any single client compared to their smaller counterparts (DeAngelo, 1981). Similarly, higher quality services are provided by larger accounting firms due to their need to safeguard their greater reputations (Simunic, 1980). Moreover, in larger Big4 offices, audit quality tends to be higher on average as they prepare audit reports on going-concern, and clients in such offices present less forceful behaviour in managing their earnings (Francis & Yu, 2009). In contrast, the Big4 firms, across their offices, are unable to consistently attain uniform audit quality, possess office-specific audit expertise in their overall capabilities (Francis et al., 2005).

2.1.7 Earning Quality and Audit Quality:

In the auditing study, compared to the audit quality of non-Big4 auditors with Big4 auditors, the former is commonly viewed superior (Behn et al., 2008; Inder K. Khurana & K. K. Raman, 2004; Lawrence et al., 2011; Palmrose, 1988). Although equivalent regulatory and professional standards are followed by all firms, the Big4 possess greater knowledge of local markets and maintain stronger client relationships (Lawrence et al., 2011); these factors, as a result, may help Big4 firms more effectively uncover abnormalities, even as all of these firms are required to maintain an acceptable level of quality (Louis, 2005). Another study shows that, if other services are offered, audit quality will invariably raise suspicions to some extent (Francis, 2004).

Furthermore, to achieve insights into implied earnings management behaviour[8], one can assess the audit quality by examining abnormal accruals, earnings benchmark targets, and client earnings properties (Becker et al., 1998; Frankel et al., 2002). While generally accepted accounting principles do not inherently breach earnings management, lower earnings quality may be experienced by the firms which engaged in such practices (Frankel et al., 2002). Also, Levitt Arthur (ARTHUR, 1998) said that materially misleading financial reports can result from aggressive earnings management. Moreover, lower-quality earnings of a client is associated with a short tenure of auditor (Johnson et al., 2002). Also, within the smaller client segment in a similar market, as per a recent study, non-Big4 firms' higher merger activity is linked to reduced profitability among Big4 firms (Kitto, 2023).

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[8] The use of accounting techniques to create financial statements portraying an excessively favourable perspective of a company's financial status is known as earnings management. Source

2.1.8 Climate Issues in Audit:

Climate issues in audit is one of the CSR initiatives, and most of the organizations increasingly recognize the importance of addressing climate risk and integrating sustainability practices into their operations (Wittneben et al., 2012). So, to validate additional financial information thoroughly, measure advancements towards sustainability, evaluate CSR integration level, as well as confirm compliance with environmental and social policy standards, auditing firms are required to actively participate in CSR initiatives (Christensen et al., 2021). Additionally, another study (Ong, 2022) assumes that the communications conveyed by the Big4 through various publications have a broader reach and more significant impact than their assurance practices and reports. However, client Earth has cautioned (ClientEarth, 9 December 2021) that the world's Big4 audit firms, for neglecting to incorporate climate risk in audit assessments, potentially violating legal duties and market integrity. Likewise, instances of financial scandals have raised concerns about integrated reporting's[9] credibility and trustworthiness (TIMES, 2021). Besides, carbon Accounting Project and Carbon Tracker revealed that 80% of auditors showed little consideration for climate matters in 2020 financial statements of over 100 carbon-intensive companies, prompting ClientEarth to emphasize legal and regulatory threats, pointing out inconsistencies between auditors' climate commitments and practices (ClientEarth, 9 December 2021). Thus, numerous studies demonstrate the neglect of climate issues in auditor's reports, even though addressing this emerging global concern is crucial to safeguard the planet.

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[9]. Incorporating material data concerning an organization's strategy, performance, governance, and prospects, Integrated Reporting reflects its social, commercial, and environmental operations. Source

2.2. Literature Review on Climate Risk:

The way business is conducted is significantly impacted by climate change; also scientists have created intricate models to estimate the global climate's response to greenhouse gas emissions (Sautner et al., 2023).another study shows that temperature is a primary indicator of climate (Huang et al., 2018); which means with increasing frequency, greater impact, and more intensity, extreme climatic events are occurring due to rising temperatures globally (Stott, 2016; Yuan et al., 2023). And the possibility of climate change causing harmful outcomes for human or ecological systems is known as climate risk; this also includes detrimental effects on health, livelihoods, lives, social aspects, well-being, economic viability, ecosystems, cultural assets, investments, infrastructure, service delivery, and species (cervest.earth, 18 September 2022). So, the dynamics of almost all chemical, biological, and ecological processes are influenced by temperature means climate risk (Burke et al., 2015).

In general, climate change hazards are physical threats such as floods, storms, and extreme temperatures, as well as regulatory vulnerabilities from government climate policies like carbon trading systems and energy efficiency standards, alongside other risks like reputation, increased humanitarian demands, and consumer behaviour shifts (Flammer et al., 2021). Another study shows that significant risks are presented by climate change to human society, industries, wildlife and companies, resulting in extreme disruptions and displacements (Li et al., 2023). Similarly, a firm's involvement in climate-related efforts and its carbon footprint differ significantly, the latter causes the potential harm, including damage, liability, or loss, that a company might face due to occurrences related to climate (Flammer et al., 2021). Consequently, the involvement in voluntary programs like the Climate Leaders Program[10] and, recently, greenhouse gas emissions' reporting has been the main subjects of academic interest (Fisher-Vanden & Thorburn, 2011; Flammer et al., 2021; Jira & Toffel, 2013).

Moreover, environmental determinism[11] refers to the incorporation of environmental influences into a company's decisions and strategies (Hrebiniak & Joyce, 1985). Also, whittington (Whittington, 1988) assumes the necessity for an organisation to adjust to its surroundings. Besides, Jennings and Seaman (Jennings & Seaman, 1994) noted that any alteration in the environment prompts modifications in the organisation's structure. Furthermore, the concept of environmental determinism in auditing and accounting area proposes that the context influences the shaping of accounting and auditing methods (Hichri, 2023). Additionally, globalization has undeniably impacted the domain of

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[10] The Climate Leadership Program seeks to create a unique network of climate finance, to mobilize resources, share experiences, develop solutions, and produce practical application guides. Source
[11] Studying how societies and states are inclined towards specific development paths due to their physical environment is known as environmental determinism, climatic determinism, and sometimes geographical determinism. Source

accounting and finance, including a variety of accounting frameworks, standards, and numerous practices and conventions in the field (Hichri, 2023). So, the significance of environmental and social factors should be increasingly highlighted in financial reporting for the betterment of the earth.

2.2.1. Country-Level Climate Risk:

In 2022, climate-induced hazards could pose a threat to around 4% of the global GDP[12] (SPGR, 2022). Also, the rating system of a country is increasingly affected by climatic factors as climate risks gain greater importance (Sun et al., 2023). Besides, through various channels, including the depletion of natural capital and fiscal sustainability, sovereign ratings are affected (Beirne et al., 2021), which negatively impacts economic development resulting in reduced wages and heightened unemployment in that country (Dissanayake et al., 2020). Furthermore, Due to worries about potential future disasters, investors will pursue greater returns on their investments (Sun et al., 2023), which mean increased climate risk turns into higher borrowing costs for nations (Chen et al., 2022). Additionally, in contrast to developed nations, developing countries exhibit lower levels of government efficiency and economic development; their capacity for climate disaster management is also relatively lower, and climate risk could make their sovereign ratings more vulnerable (Sun et al., 2023).

Moreover, even when accounting for various control variables at the country and firm levels, there remains an important positive connection between social and environmental performance and the risk of climate change (William Mbanyele & Linda Tinofirei Muchenje, 2022). Besides, climate risks, a vital determinant with extensive economic and financial consequences, hold the foremost position among the leading 10 global risks across long-term, medium and short perspectives (McLennan, 2022; Sun et al., 2023). Similarly, researchers found a strong relationship between the legal origin a company and its CSR ratings (Liang & Renneboog, 2017). Likewise, climate risks along with transition and physical risks interrupt the financial system by causing systemic and structural issues within it as a negative externality (Bauer et al., 2022; Burke et al., 2015; Chen et al., 2022; Dell et al., 2012; Sun et al., 2023). Equally, climate serves as a vital factor when interpreting the variations in per capita income between affluent global regions and Africa (Nordhaus, 2006). However, investigating 28 nations in the Caribbean region, Hsiang (Hsiang & Solow, 2010) discovers that while certain industries are adversely affected by cyclones, they can bring about beneficial impacts in others, such as the real-estate sector. Through an in-depth study within a single country, Deryugina (Deryugina, 2013) determines that government assistance plays a mitigating role in lessening economic losses caused by hurricanes; this assistance results in, a decade after the hurricanes occurred, no significant impact on county-level earnings (Huang et al., 2018).

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[12] gross domestic product

Another study talks about the correlation between warm nations and poverty, where the global cross-sectional national income decreases by 8.5% for each Celsius degree rise (Dell et al., 2009). Similarly, in poor countries, significant impacts from temperature shocks that, within a year, a 1°C temperature increase can lead to an average reduction of 1.3% in economic growth; the findings imply that climate change might influence the pace of economic expansion (Dell et al., 2012). Additionally, by 2100, the poorest 40% of countries witness a 75% decline in their average income due to climate change, while the cooler regions generally benefit, leading to slight gains for the wealthiest 20% (Burke et al., 2015). Also, producing larger impacts, additional long-term effects may also occur as a result of sustained climatic changes on other natural elements like soil quality, water levels, and health, as demonstrated by Meehl et al. (Meehl et al., 2004). So, increasingly, many developing countries around the world are adopting public disclosure programs and environmental performance rating, which are generally seen as promising and cost-effective tools to enhance companies' environmental management and ensure compliance (Abdessalem, 2011).

2.2.2. Firm-Level Climate Risk:

The examination of how the environment affects firm valuation has arisen due to global climate change concerns (Chava, 2014; Konar & Cohen, 2001; Matsumura et al., 2014). During periods of extremely hot temperatures, the stock performance of carbon-intensive companies experiences a decline (Choi et al., 2020). Business harm can also occur from logistics issues or plant shutdowns causing interruptions, escalating operational costs due to water treatment expenditures or rising heating/cooling, compromised assets leading to reduced stock prices, and numerous other impacts (Goldstein et al., 2019). Other study (Flammer et al., 2019) shows that firms exhibiting weaker corporate governance tend to prioritize less well-being of stakeholders and participate in rent-seeking endeavours which might reduce business funds available for initiatives related to CSR; while on the contrary, companies with strong governance face fewer challenges from agency conflicts[13] and managerial entrenchment[14] (William Mbanyele & Linda T. Muchenje, 2022), allowing them to allocate greater resources to CSR undertakings amid elevated climate change risk. Further study shows, firms in countries with elevated climate risk, firm managers worry about repaying creditors after significant losses from extreme weather, selecting increased long-term borrowing, higher cash reserves, reduced cash dividends, and varied industry impact on firm performance (Huang et al., 2018). For example, firms with significant vulnerability to climate change shocks which are often underestimated by investors or even lead to disinvestment from such companies (Krueger et al.,

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[13] In any relationship where one party is anticipated to act in the best interest of another, there exists an inherent expectation, and this conflict of interest is known as an agency problem. Source

[14] The concept of managerial entrenchment involves a leader in an organization making decisions that favour their personal objectives. Source

2020); consequently, firm value might be affected (Matsumura et al., 2014). Also, firms' liquidity concerns are other driving force behind policies related to debt and cash reserves (Bates et al., 2009; Diamond, 1991). Therefore, (William Mbanyele & Linda Tinofirei Muchenje, 2022) discloses that in the face of uncertainty about climate change, companies might increase their investments in CSR activities as a safeguard against regulatory and physical vulnerabilities. Likewise, given that competitive advantage is significantly influenced by CSR performance, companies operating in competitive sectors are inclined to enhance their reputation, draw premium talent, and set themselves apart from competitors by prioritizing sustainability (Flammer, 2015; Liu et al., 2021). Additionally, if the marginal investor includes climate change factors in their decision process of investment, firms will be pushed towards adopting more climate-sensitive practices and the value of businesses could be adversely impacted by the climate change risks (William Mbanyele & Linda Tinofirei Muchenje, 2022). Therefore, firms may find motivation to enhance CSR efforts and protect themselves from capital market influences by understanding climate change risk through the eyes of risk management (Albuquerque et al., 2019; Dyck et al., 2019); (William Mbanyele & Linda Tinofirei Muchenje, 2022).

2.2.3. Climate Risk's impact on Economic Performance:

Since long, the acknowledgment of climate's impact on economic performance has been consistently documented, and between economic performance and temperature, research demonstrates a negative connection (Bansal, 2012; Dell et al., 2009, 2014; Ding et al., 2021; Gallup et al., 1999). Specifically, warmer regions tend to exhibit, compared to cooler areas, there is a lower per capita income, leading to slower economic growth and equity market expansion, as indicated by (Gallup et al., 1999) and (Bansal, 2012). There is also compelling evidence from Burke, Hsiang, and Miguel (Burke et al., 2015) that countries experience increased productivity with rising temperatures up to 13 °C (annual average). However, at higher temperatures, productivity shrinks remarkably which is a non-linear connection between economic output and temperature (Huang et al., 2018). Analysing municipal-level data from the US, (Dell et al., 2009) ascertain an adverse link between economic output and temperature. Continuing shifts in the climate will lead to adverse impacts on economic endeavours and results due to the increasing average temperatures (IPCC, 2007). According to Burke et al. (Burke et al., 2015), uncontrolled warming until 2100 could result in approximately a 23% decline in average worldwide income. The findings of Fuss (Fuss, 2016) suggest that climate change devastates monetary holdings and causes disturbances in interconnected economic operations. Additionally, Covington and Thamotheram (Covington, 2015) point out that if temperatures reach 4 °C or beyond, a globally diversified stock portfolio could experience a reduction in value ranging from 5% to 20%.

2.2.4. Climate Risk's Impact on People and Financial Gain:

Characterized by uncertainty, climate risks manifest differently across landscapes, decrease over sectors, and variable experiences can result for people (McClure et al., 2023; Solecki et al., 2017; Ziervogel, 2019; Ziervogel et al., 2022). Seasonal variations in daylight can impact human psychology and mood, subsequently influencing economic behaviour (Huang et al., 2018). This connection between daylight fluctuations and human experience can be observed in various ways. For instance, on stock returns, study demonstrates the influence of "seasonal affective disorder" (Kamstra et al., 2003), and sunny weather enhances trader optimism, thereby leading to favourable stock returns (Hirshleifer & Shumway, 2003). In contrast, (Cao & Wei, 2005) establishes a correlation between higher temperatures and reduced stock returns due to increased apathy, while lower temperatures relate to heightened aggressiveness and subsequently higher stock returns. A similar perspective is shared by Novy-Marx (2014), who highlights the correlation between New York City temperatures and stock returns. In the research by Kreft and Eckstein (Kreft, 2014), it is mentioned that, over the period 1993–2012, economic losses exceeding $2.5 trillion and more than 530,000 fatalities were caused by global extreme weather events. Examining the years 1980 to 2012, Jahn (Jahn, 2015) demonstrates a notable increase in both severe weather events and the related losses across the world. Yang (Yang, 2008), analysing cross-country data spanning 1970–2002, illustrates a connection between more intense storms and higher numbers of casualties and economic damages. Likewise, Hsiang and Narita (Hsiang & Narita, 2012) provide evidence that occurrences of severe weather, like windstorms, not only lead to economic losses but also bring about reduced growth rates. Besides, Firms heavily exposed to climate change shocks are often underestimated by investors (Krueger et al., 2020).

2.2.5. Climate risk disclosure & management:

IASB[15] along with AASB[16] emphasize that disclosure in financial statements is necessary due to climate-related risks, which can become material because of external factors and investor expectations (de Villiers et al., 2022). Increasing disclosure of climate change risks from companies can be prompted by shareholder activism focused on the environment, particularly when it originates from institutional investors, and such disclosures can lead to higher company valuations (Flammer et al., 2021). Revealing the disclosure could expose how the firm's supply chain and operations might be disrupted by severe weather events and temperatures (like hurricanes, droughts, flooding, and wildfires), impacting loan repayments and raising heating and cooling expenses (Cohen, 2019). However, institutional investors encounter challenges in pricing and hedging climate risks while

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[15] International Accounting Standards Board
[16] The Australian Accounting Standards Board

managing them (Krueger et al., 2020). In the regulatory filings of the SASB[17], around 50% of companies registered with the SEC offer standard or boilerplate sustainability details (Research, 2019). Also, Complaining about a deficiency in comparable and verifiable data is a common reaction from investors (Bernow, 2019). Indeed, the rising interest in sustainable investments has guided to CSR[18] and companies' ESG[19] policies and actions (Amel-Zadeh & Serafeim, 2018; Cohen et al., 2015).

Furthermore, Due to the close relationship between CSR and sustainability topics and a company's regular business operations, investors can utilize CSR information to predict upcoming cash flows and evaluate potential risks associated with the firms (Christensen et al., 2021; Dhaliwal et al., 2011; Dhaliwal et al., 2012; Grewal et al., 2021). Therefore, in terms of ESG activities, various organizations provide voluntary reporting guidelines in response to information demand and corporate disclosure needs; examples include SASB, which creates industry-specific disclosure standards for SEC filings, GRI[20]. This develops IFRS Foundation and global sustainability reporting standards, aiming to establish a unified global approach to tackle the abundance of reporting rules (Christensen et al., 2021; IFRS, 2020).

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[17] Sustainability Accounting Standards Board
[18] corporate social responsibility
[19] environmental, social, and governance
[20] Global Reporting Initiative

3. Hypothesis:

Our study is intended to explore the Big Four auditors' impact on climate change risk. The reason for this tends to be the lack of existing literature and the difficulty in establishing individual firms' disclosure on the climate change risks (Giglio et al., 2021; Sautner et al., 2023). As said by these authors, conducting this study may be challenging due to the limited while considering numerous factors that can affect climate risks by firms' exposure.

Conversely, lot of previous literature have been investigated into various aspects of audit firms discussed in this paper of the part of literature review. Those studies have looked into activities of the universal audit firms and the prominent Big4 Auditors, highlighted challenges and concerns within the industry, examined audit pricing dynamics, explored the relationship between auditor tenure and audit quality, along with investigating the size of an audit firm's impact on earning quality and audit. Furthermore, numerous research have also explored the understanding of climate risk in contemporary business, considered country-level and firm-level climate risks, explored climate risks' effects on economic performance and people, and measured the importance of climate risk disclosure and management. Thus, these investigations have collectively provided with a comprehensive knowledge on numerous complicated issues related to audit firms and the pressing concerns surrounding climate issues in auditing and contemporary business practices. However, so far, no research has examined the mutual influence of the big4 auditors on the impact of climate risk:

We assume that companies are likely to have better financial reporting quality if they are audited by the Big4 auditors. The reason maybe they are renowned audit firms and are known for their expertise and strict audit methods, which may encourage them careful financial reporting. Accordingly, the financial reports investigated by Big4 auditors are expected to be more transparent, reliable, and error free. Also, we believe that improved financial reporting quality should lead to fewer mistakes or omissions related to climate risks, ultimately reducing overall climate risk in their audited organizations. This hypothesis emphasizes the important role that audit firms play in managing

climate risk by providing stakeholders with more dependable information for making decisions related to climate issues.

Consequently, we planned to conduct a study to investigate how Big Four auditors impact climate risk believing that the firms audited by Big4 auditors may demonstrate better climate risk exposure due to their expertise to select clients as they may be engaged in more accurate and transparent auditing practice.

H1. Big 4 Auditors are positively related to firm level climate risk.

H2. Big 4 Auditors are negatively related to firm level climate risk.

4. Methodology, Data and Empirical Analysis:

The methodology employed in this study involves a literature review from previous studies and a thorough analysis using various statistical models to examine the correlation between climate risk and Big 4 auditors. Initially, an Ordinary Least Squares (OLS) analysis will be conducted. If the results of this analysis validate our hypothesis, means, if we detect a positive connection between Big4 auditors and climate change, then, to verify these findings, the study also will employ a Fixed Effects (FE) model.

After inspiring from the study of (Hafiz & Doukas, 2023), this empirical study uses the Heckman selection model (Heckman, 1979) for addressing endogenous concerns i.e. the potential selection bias. In the first stage of this model, Probit Model (selection equation) will be conducted that may examine the influencing factors considered by firms for the Big 4 auditors' selection. In the second stage of this model, Inverse Mills Ratio calculated from Probit Model will be used to conduct further analysis by OLS and FE models to reveal a relationship between Big 4 auditors and climate risk factors.

Furthermore, to mitigate causal effects in observational studies related to auditor selection, Propensity Score Matching (PSM) will be employed. This may improve the balance in control variables of Big 4 auditor.

4.1. Data Collection and Processing:

This study considers secondary sources for collecting data from 2000 to 2022 to investigate the impact of Big4 audit firms on climate risk influenced by companies. To start our analysis, the climate change data is obtained from Sautner (Sautner et al., 2023), and standardized according to the data owner's strategy i.e. multiplied by $10^3.$ Then, the data related to auditors and other potential firm-level control variables is collected from Compustat-WRDS (WRDS_Compustat). Afterwards, we matched the data considering Firm ID and year, and created dummy variable for Auditors where Big4 is 1 and non-Big4 is 0. Furthermore, for an in-depth analysis, we include country-level data, including Gross Domestic Product (GDP) and inflation rates, collected from the IMF website to consider as country-control variables, and matched the data with country and year with our earlier collections.

4.2. Dependent, Independent, and Control Variables:

In this study, Climate Risk is dependent variable, and Big4 Auditor is independent variable including other control variables related to firm and country which are described as follows:

- Climate Risk represents the dependent variable, is measured by Climate Change, which further considers operational factors, regulatory aspects, and physical conditions through exposure, risk, positive, negative, and sentiment categories (Details in Appendix B).

- Big4 Auditor is independent variable, (with a value of 1 and 0) (Details in Appendix D).

- Firm-level control variables: RoA, Tangibility, Firm Size, Capex Intensity, Cash Holdings, Leverage, and Market to Book ratio (Details in Appendix E).

- GDP and Inflation are country-level control variables.

4.3. Descriptive statistics:

The descriptive statistics (table 1) shows all variables i.e. dependent, independent, and control variables which reflect central tendency, variability, distribution, and characteristics of each variable in this dataset. Besides, these means, medians, and percentiles are calculated to know about the distribution of each variable and the spread of the data and the percentiles (P5 and P95). From these statistics, we assume that there are no potential outliers or patterns.

Table 1: Descriptive statistics

Variable	Mean	Median	SD	P5	P95
Dependent Variable X 10³					
CC_EXPO	0.989	0.297	2.513	0	4.299
CC_RISK	0.035	0	0.159	0	0.197
CC_POS	0.394	0.077	1.139	0	1.763
CC_NEG	-0.186	0	0.514	-0.885	0
CC_SENT	0.208	0	0.895	-0.273	1.15
OP_EXPO	0.38	0.059	1.31	0	1.67
OP_RISK	0.013	0	0.093	0	0.08
OP_POS	0.145	0	0.593	0	0.678
OP_NEG	-0.06	0	0.25	-0.325	0
OP_SENT	0.085	0	0.469	-0.105	0.477
RG_EXPO	0.058	0	0.29	0	0.285
RG_RISK	0.002	0	0.027	0	0
RG_POS	0.023	0	0.148	0	0.097
RG_NEG	-0.012	0	0.087	0	0
RG_SENT	0.012	0	0.132	0	0.057
PH_EXPO	0.013	0	0.099	0	0.078
PH_RISK	0.001	0	0.011	0	0
PH_POS	0.005	0	0.056	0	0
PH_NEG	-0.003	0	0.04	0	0
PH_SENT	0.001	0	0.055	0	0
Independent Variable					
Big4_Dummy	0.819	1	0.385	0	1
Non-Big4_Dummy	0.181	0	0.385	0	1
Firm-Level Control Variable					
RoA	0.047	0.096	0.414	-0.339	0.262
Tangibility	0.239	0.138	0.251	0.003	0.786
Firm Size	7.26	7.235	2.216	3.695	10.937
Capex Intensity	0.045	0.027	0.059	0	0.15
Cash Holdings	0.196	0.106	0.222	0.005	0.706
Leverage	0.268	0.221	0.374	0	0.702
Market to Book	1.48	0.92	2.44	0.12	4.67
Country-Level Variables					
GDP	2.831	2.295	2.020	.483	5.947
Inflation	2.673	2.131	5.779	.299	4.683
Extra Firm-Level variable					
S&P Rating	4.564	4	1.621	2	8

4.4. Mean difference t-test

This analysis is conducted to identify statistical variation between the means of two groups between the Big4 and Non-Big4 auditors for all climate risk variable. Here, the positive values indicate that the variable is higher for the Big4 auditor, while negative values are for the non-Big4 auditors. For maximum climate risk related variables, the statistics (Table 2) are positively correlated with Big4 Auditors.

Table 2: Mean difference t-test

Variable	Big 4	Non-Big 4	Mean difference t-test
Dependent Variable X 10^3			
CC_EXPO	0.987	0.998	0.4836
CC_RISK	0.035	0.036	0.8226
CC_POS	0.392	0.402	0.9217
CC_NEG	-0.185	-0.189	-0.8784
CC_SENT	0.207	0.213	0.6688
OP_EXPO	0.379	0.388	0.7625
OP_RISK	0.013	0.012	-0.8058
OP_POS	0.144	0.147	0.6254
OP_NEG	-0.060	-0.061	-0.7284
OP_SENT	0.084	0.086	0.4019
RG_EXPO	0.058	0.059	0.56
RG_RISK	0.002	0.002	0.0866
RG_POS	0.023	0.024	0.7991
RG_NEG	-0.011	-0.013	-1.7257
RG_SENT	0.012	0.012	-0.2469
PH_EXPO	0.012	0.016	4.2885
PH_RISK	0.000	0.001	2.8681
PH_POS	0.004	0.007	4.5807
PH_NEG	-0.003	-0.004	-2.5482
PH_SENT	0.001	0.003	2.7515
Control Variable			
RoA	0.070021	-0.06159	-32.1513
Tangibility	0.250057	0.189314	-25.4301
Firm Size	7.634092	5.540137	-110.00
Capex Intensity	0.045461	0.043168	-3.9236
Cash Holdings	0.18977	0.226211	16.7034
Leverage	0.578325	0.593295	3.1929
Market to Book	1.450132	1.625186	7.2462
Country Variables			
GDP	2.71	2.69	-1.56
Inflation	2.36	2.35	-0.38

4.5. Auditors' involvement by country:

Our dataset, (Table 3), presents the involvement of Big4 over Non-Big4 auditors across various countries in dominant trend which means the Big4 auditors in different countries is notably higher compared to non-Big4 auditors. This implies a strong dominance of the Big4 auditing firms in the global audit market. In the United States, for example, Big4 auditors are substantially more prevalent, with 53,804 engagements, compared to 13,468 by non-Big4 auditors. This discrepancy highlights the significant role played by Big4 firms in the U.S. auditing landscape. Similarly, in the United Kingdom, there is a substantial disparity, with 1,310 engagements by Big4 auditors compared to 24 by non-Big4 auditors. The trend is also evident in countries like Australia, Canada, and Japan, where Big4 auditors dominate the audit market, leaving little room for non-Big4 auditors to participate significantly. Overall, the data highlights the global reach and influence of Big4 auditors, who are engaged in a substantial majority of audit activities across various countries. This dominance may have significant contributions to Big4 Auditors for low climate risk.

Table-3: Country-wise involvement of Big4 and Non-Big4 auditors in the dataset:

Country Code	Country Name	Big4	Non_Big4	Total
AE	United Arab Emirates	3	3	6
AR	Argentina	185	5	193
AT	Austria	11	1	12
AU	Australia	196	0	211
BE	Belgium	43	9	52
BM	Bermuda	939	97	1044
BR	Brazil	498	18	530
BS	Bahamas	15	1	16
CA	Canada	6489	391	6918
CH	Switzerland	411	2	413
CL	Chile	203	0	207
CN	China	1222	190	1419
CO	Colombia	73	0	77
CR	Costa Rica	0	4	4
CY	Cyprus	12	1	13
CZ	Czech Republic	17	0	17
DE	Germany	382	16	404
DK	Denmark	81	10	95
ES	Spain	127	0	131
FI	Finland	76	0	76
FR	France	407	12	496
GB	United Kingdom	1310	24	1375
GG	Guernsey	4	0	4
GR	Greece	173	12	189
HK	Hong Kong	145	21	169
HU	Hungary	18	0	18
ID	Indonesia	7	20	27

Country Code	Country Name	Big4	Non_Big4	Total
IE	Ireland	493	27	521
IL	Israel	536	237	774
IN	India	137	65	202
IS	Iceland	7	0	7
IT	Italy	122	4	128
JE	Jersey	13	12	25
JO	Jordan	1	0	1
JP	Japan	435	14	477
KR	South Korea	155	9	164
KY	Cayman Islands	81	60	141
LU	Luxembourg	171	8	181
MC	Monaco	88	2	90
MH	Marshall Islands	13	0	13
MO	Macao	0	3	3
MX	Mexico	245	27	275
MY	Malaysia	1	0	1
NL	Netherlands	444	8	453
NO	Norway	94	1	95
NZ	New Zealand	15	0	15
PA	Panama	51	0	51
PE	Peru	28	16	44
PG	Papua New Guinea	5	0	5
PH	Philippines	3	18	21
PR	Puerto Rico	113	7	132
PT	Portugal	30	2	32
RU	Russia	102	6	109
SE	Sweden	210	11	222
SG	Singapore	147	5	152
TH	Thailand	12	0	12
TR	Turkey	17	2	19
TW	Taiwan	157	19	176
UA	Ukraine	5	0	5
US	United States	53804	13468	68137
UY	Uruguay	10	1	11
VE	Venezuela	0	5	5
VG	British Virgin Islands	10	0	11
VI	U.S. Virgin Islands	11	0	11
ZA	South Africa	210	3	213
Total		71023	14877	87050

4.6.   Analysis under Ordinary Least Squares (OLS):

At first, the OLS regression model is considered to analyse the primary relation between dependent variable (Climate Risk) and Big4 Auditor as the main independent variable including a set of control variables, along with firm-level and country-level. (Details in Appendix-G)

(All variables are described under Appendix-B, Appendix-D, Appendix-E).

The equation is:

Climate Risk = β_0 + β_1 * Big4 Auditor

+ β_2 * RoA + β_3 * Tangibility + β_4 * Firm Size + β_5 * Capex Intensity + β_6 * Cash Holdings + β_7 * Leverage + β_8 * Market to Book ratio

+ β_9 * GDP + β_{10} * Inflation + ε

(Details of the equation are described in Appendix-G)

Following the equation, we discover that the Big4 auditors present a lower-level climate risk. Table 4 shows that the Big4 Auditors have negative coefficient and t-statistic i.e. CC_EXPO (-0.281, -3.78), CC_RISK (-0.013, -3.47), CC_POS (-0.125, -3.58), CC_SENT (-0.072, -2.90), OP_EXPO (-0.124, -3.43), OP_RISK (-0.004, -2.66), OP_POS (-0.050, -3.14), OP_SENT (-0.030, -2.76), RG_EXPO (-0.034, -3.32), RG_RISK (-0.001, -1.82), RG_POS (-0.016, -3.53), RG_SENT (-0.009, -2.98), PH_EXPO (-0.004, -1.69), PH_RISK (-0.000, -1.65), PH_POS (-0.002, -1.73), PH_SENT (-0.001, -0.70). Additionally, other negative factors of climate risks i.e., CC_NEG (0.053, -3.84), OP_NEG (0.020, -3.20), RG_NEG (0.007, -2.93), and PH_NEG (0.002, -1.42) have positive coefficients and negative t-statistics. These also suggest that lower climate risk created by the firms who have Big4 auditor for their audit process, which is likely a good outcome (Hypothesis-2).

Table- 4: OLS Result (Panel A)

Variables	CC_EXPO	CC_RISK	CC_POS	CC_NEG	CC_SENT	OP_EXPO	OP_RISK	OP_POS	OP_NEG	OP_SENT
Big4 Auditor	-0.281***	-0.013***	-0.125***	0.053***	-0.072***	-0.124***	-0.004***	-0.050***	0.020***	-0.030***
	(-3.78)	(-3.47)	(-3.58)	(-3.84)	(-2.90)	(-3.43)	(-2.66)	(-3.14)	(-3.2)	(-2.76)
RoA	-0.577***	-0.019***	-0.203***	0.096***	-0.107***	-0.261***	-0.009***	-0.098***	0.040***	-0.058***
	(-4.96)	(-4.37)	(-4.59)	(-4.79)	(-4.09)	(-4.67)	(-3.10)	(-4.23)	(-4.37)	(-3.97)
Tangibility	2.571***	0.097***	0.809***	-0.472***	0.337***	0.921***	0.033***	0.313***	-0.149***	0.164***
	(-10.88)	(-8.52)	(-9.23)	(-11.70)	(-5.95)	(-8.17)	(-6.51)	(-7.43)	(-9.21)	(-5.64)
Firm Size	0.078***	0.003***	0.034***	-0.011***	0.023***	0.038***	0.001***	0.016***	-0.005***	0.011***
	(-3.98)	(-3.58	(-4.21	(-3.07)	(-4.38)	(-3.98)	(-4.14)	(-3.98)	(-3.42)	(-3.88)
Capex Intensity	-4.393***	-0.158***	-1.728***	0.886***	-0.841***	-1.529***	-0.034***	-0.625***	0.303***	-0.322***
	(-8.27)	(-5.80)	(-8.50)	(-9.26)	(-6.30)	(-5.83)	(-2.71)	(-6.05)	(-7.46)	(-4.33)
Cash Holdings	-0.109	-0.001	-0.057	0.028	-0.029	-0.008	-0.001	-0.012	0	-0.012
	(-0.98)	(-0.34)	(-1.19)	(-1.51)	(-0.83)	(-0.13)	(-0.25)	(-0.48)	(-0.01)	(-0.69)
Leverage	-0.281***	-0.011***	-0.109***	0.048***	-0.060***	-0.107**	-0.004**	-0.041**	0.018***	-0.023*
	(-3.74)	(-3.98)	(-3.82)	(-4.02)	(-3.26)	(-2.51)	(-2.35)	(-2.52)	(-3.32)	(-1.90)
Market to Book	-0.021***	-0.001***	-0.008**	0.006***	-0.003	-0.010**	-0.001***	-0.004***	0.003***	-0.001
	(-2.63)	(-3.54)	(-2.48)	(-4.38)	(-1.01)	(-2.29)	(-3.32)	(-2.62)	(-4.21)	(-1.22)
GDP	0.060***	0.001	0.031***	-0.005**	0.026***	0.032***	0.001***	0.015***	-0.004***	0.011***
	(-5.4)	(-1.54)	(-5.88)	(-2.40)	(-6.14)	(-5.55)	(-3.6)	(-5.76)	(-3.94)	(-5.06)
Inflation	0.065***	0.002***	0.028***	-0.009***	0.019***	0.020***	0	0.008***	-0.001	0.007***
	(-5.78)	(-2.87)	(-5.68)	(-4.29)	(-4.92)	(-3.58)	(-0.15)	(-3.18)	(-0.58)	(-3.58)
Constant	0.135	0.008	0.083	-0.081***	0.002	0.003	0	0.003	-0.02	-0.017
	(-0.86)	(-1.15)	(-1.17)	(-2.75)	(-0.04)	(-0.04)	(-0.02)	(-0.09)	(-1.53)	(-0.70)
R-sqr	0.05	0.018	0.027	0.039	0.011	0.028	0.007	0.016	0.018	0.009
N	81,206	81,206	81,206	81,206	81,206	81,206	81,206	81,206	81,206	81,206
BIC	242350.9	-43455.8	162382	78058.6	138917.5	173790.2	-96059.4	95834.4	4640.2	71882.8

> Coefficient and T-statistics based on cluster-adjusted (by Firm ID) standard errors (Petersen, 2009). [* p<0.10, ** p<0.05, *** p<0.01]

Table- 4 OLS Result (Panel B)

Variables	RG_EXPO	RG_RISK	RG_POS	RG_NEG	RG_SENT	PH_EXPO	PH_RISK	PH_POS	PH_NEG	PH_SENT
Big4 Auditor	-0.034***	-0.001*	-0.016***	0.007***	-0.009***	-0.004*	-0.000*	-0.002*	0.002	-0.001
	(-3.32)	(-1.82)	(-3.53)	(-2.93)	(-2.98)	(-1.69)	(-1.65)	(-1.73)	(-1.42)	(-0.70)
RoA	-0.043***	-0.002**	-0.019***	0.009**	-0.010***	-0.004	0	-0.001	0.001	0
	(-3.58)	(-2.44)	(-3.10)	(-2.49)	(-3.46)	(-1.04)	(-0.32)	(-0.65)	(-1.37)	(-0.2)
Tangibility	0.234***	0.007***	0.088***	-0.038***	0.050***	0.015***	0	0.001	-0.005***	-0.005**
	(-11.48)	(-6.74)	(-9.99)	(-9.41)	(-7.15)	(-2.61)	(-0.19)	(-0.34)	(-3.59)	(-2.25)
Firm Size	0.010***	0.000***	0.004***	-0.001***	0.003***	-0.001	0	0	0	-0.000*
	(-5.26)	(-3.7)	(-5.47)	(-3.13)	(-5.34)	(-1.19)	(-0.64)	(-1.57)	(-0.32)	(-1.68)
Capex Intensity	-0.407***	-0.011**	-0.170***	0.059***	-0.111***	-0.02	0.003	-0.007	-0.009	-0.016*
	(-7.41)	(-2.16)	(-7.51)	(-4.42)	(-6.39)	(-1.46)	(-0.8)	(-0.79)	(-0.68)	(-1.92)
Cash Holdings	0.003	0.001*	-0.001	0.001	-0.001	-0.013***	0	-0.008***	0.003***	-0.005**
	(-0.3)	(-1.82)	(-0.30)	(-0.27)	(-0.19)	(-3.10)	(-0.15)	(-3.09)	(-2.71)	(-2.23)
Leverage	-0.026***	-0.001***	-0.010***	0.006***	-0.004***	0.003	0	0.003	0	0.003
	(-3.89)	(-3.01)	(-3.04)	(-2.96)	(-2.24)	(-0.61)	(-1.16)	(-1.14)	(-0.36)	(-1.59)
Market to Book	-0.001	-0.000**	0	0	0	0.001	0	0	0	0
	(-1.26)	(-2.33)	(-1.00)	(-0.81)	(-0.93)	(-1.32)	(-0.30)	(-1.32)	(-0.90)	(-1.41)
GDP	0.012***	0.000*	0.007***	-0.001***	0.006***	0	0	0	0	0
	(-9.07)	(-1.92)	(-8.45)	(-3.54)	(-8.38)	(-1.28)	(-0.36)	(-0.12)	(-0.01)	(-0.12)
Inflation	0.014***	0.000**	0.006***	-0.002***	0.005***	0	0	0	0	0
	(-8.92)	(-2.48)	(-7.81)	(-3.92)	(-6.44)	(-0.67)	(-0.18)	(-1.02)	(-0.32)	(-1.42)
Constant	-0.074***	-0.001	-0.036***	0.003	-0.033***	0.019***	0.001*	0.010***	-0.004***	0.006**
	(-3.56)	(-1.15)	(-3.95)	(-0.56)	(-5.47)	(-4.07)	(-1.66)	(-3.64)	(-2.59)	(-2.44)
R-sqr	0.035	0.004	0.024	0.01	0.014	0.003	0.001	0.002	0.002	0.002
N	81,206	81,206	81,206	81,206	81,206	81,206	81,206	81,206	81,206	81,206
BIC	22738.9	-225471	-47190.4	-102429	-60900.3	-86668.5	-320113	-140341	-179048	-142065

> Coefficient and T-statistics based on cluster-adjusted (by Firm ID) standard errors (Petersen, 2009). [* p<0.10, ** p<0.05, *** p<0.01]

4.7. Fixed Effects Regression:

In addition to the OLS, the Firm Fixed Effects Regression Model is used to analyse again the association between Climate Risk, and Big4 Auditors while considering other control variables, i.e. firm-level and country-level. We have considered firm-fixed effects (α_i) model to capture unobserved characteristics or heterogeneity of firms and to identify the proposed relationship like (Imai & Kim, 2019). (Details in Appendix-H)

(All variables are described under Appendix-B, Appendix-D, Appendix-E)

The equation is:

Climate Risk = β_0 + β_1 * Big4 Auditor

$\quad$ + β_2 * RoA + β_3 * Tangibility + β_4 * Firm Size + β_5 * Capex Intensity + β_6 * Cash Holdings + β_7 * Leverage + β_8 * Market to Book ratio

$\quad$ + β_9 * GDP + β_{10} * Inflation + αi* Firm Fixed Effects + ε

(Details of the equation are described in Appendix-H)

Here, our analysis reveals that companies exposed to audits by Big 4 auditing firms demonstrate a reduced degree of climate risk. The outcomes (Table 5) imply that Big4 Auditors are associated with a negative coefficient and a corresponding negative t-statistic i.e. CC_EXPO (-0.085*, -1.94), CC_RISK (-0.004, -0.91), CC_POS (-0.056**, -2.39), CC_SENT (-0.037*, -1.79), OP_EXPO (-0.039, -1.44), OP_RISK (-0.003, -1.48), OP_POS (-0.022*, -1.67), OP_SENT (-0.012, -1.01), RG_EXPO (-0.01, -1.31), RG_RISK (0, -0.40), RG_POS (-0.005*, -1.68), RG_SENT (0, -0.12), PH_EXPO (0.002, -1.1), PH_RISK (0, -0.53), PH_POS (-0.001, -0.89), PH_SENT (0, -0.04). Furthermore, other adverse aspects related to climate risks, such as CC_NEG (0.019*, -1.65), OP_NEG (0.010**, -2.01), RG_NEG (0.005*, -1.94), and PH_NEG (0.001, -0.59), demonstrate positive coefficients along with negative t-statistics. These findings also indicate that the Big4 auditors' practice is linked to reduced climate risk, which is a favourable outcome as well (Hypothesis-2).

Table- 5: Result of Fixed Effect Regression (Panel A)

Variables	CC_EXPO	CC_RISK	CC_POS	CC_NEG	CC_SENT	OP_EXPO	OP_RISK	OP_POS	OP_NEG	OP_SENT
Big4 Auditor	-0.085*	-0.004	-0.056**	0.019*	-0.037*	-0.039	-0.003	-0.022*	0.010**	-0.012
	(-1.94)	(-0.91)	(-2.39)	(-1.65)	(-1.79)	(-1.44)	(-1.48)	(-1.67)	(-2.01)	(-1.01)
RoA	-0.070**	-0.004*	-0.029*	0.026***	-0.004	-0.031*	-0.002	-0.018	0.009**	-0.009
	(-2.26)	(-1.86)	(-1.95)	(-2.59)	(-0.28)	(-1.72)	(-0.95)	(-1.62)	(-2.03)	(-1.10)
Tangibility	0.566**	0.042**	0.175	-0.122**	0.054	0.245	0.020*	0.091	-0.058***	0.034
	(-2.22)	(-2.19)	(-1.49)	(-2.26)	(-0.53)	(-1.61)	(-1.71)	(-1.33)	(-2.68)	(-0.61)
Firm Size	0.173***	0.004***	0.088***	-0.022***	0.066***	0.086***	0.002**	0.039***	-0.011***	0.028***
	(-7.15)	(-2.68)	(-7.81)	(-4.19)	(-6.91)	(-6.37)	(-2.47)	(-6.12)	(-4.68)	(-5.27)
Capex Intensity	-0.262	-0.007	-0.441***	0.126**	-0.314***	-0.045	0.016	-0.129*	0.076**	-0.053
	(-1.18)	(-0.25)	(-3.69)	(-2.1)	(-3.06)	(-0.40)	(-1.28)	(-1.89)	(-2.45)	(-0.88)
Cash Holdings	0.207**	0.013*	0.107**	-0.025	0.082*	0.089*	0.010**	0.039	-0.025**	0.014
	(-2.17)	(-1.93)	(-2.02)	(-1.03)	(-1.71)	(-1.81)	(-2)	(-1.32)	(-2.25)	(-0.55)
Leverage	-0.016	-0.003	0.006	0.002	0.008	0.002	-0.002	0.003	0.002	0.005
	(-0.55)	(-1.51)	(-0.35)	(-0.24)	(-0.59)	(-0.11)	(-1.28)	(-0.29)	(-0.78)	(-0.55)
Market to Book	0.004	0	0.004*	0	0.004**	0.002	0	0.002	0.001*	0.003**
	(-0.37)	(-0.75)	(-1.74)	(-0.45)	(-2.21)	(-0.52)	(-1.21)	(-1.16)	(-1.69)	(-2.04)
GDP	0.057***	0.001**	0.029***	-0.005***	0.024***	0.029***	0.001**	0.016***	-0.003***	0.013***
	(-8.03)	(-1.97)	(-6.88)	(-2.96)	(-6.12)	(-7.16)	(-2.45)	(-6.98)	(-3.54)	(-6.09)
Inflation	0.078***	0.002**	0.038***	-0.011***	0.027***	0.027***	0	0.012***	-0.002*	0.011***
	(-9.82)	(-2.37)	(-8.59)	(-5.48)	(-6.82)	(-6.27)	(-0.41)	(-5.24)	(-1.84)	(-5.01)
Constant	-0.563***	-0.011	-0.351***	0.012	-0.339***	-0.375***	-0.011	-0.191***	0.031*	-0.160***
	(-2.70)	(-0.85)	(-3.61)	(-0.27)	(-4.06)	(-3.15)	(-1.36)	(-3.42)	(-1.67)	(-3.41)
R-sqr	0.015	0.001	0.012	0.003	0.008	0.01	0.001	0.007	0.002	0.005
N	81,206	81,206	81,206	81,206	81,206	81,206	81,206	81,206	81,206	81,206
BIC	166892.6	-73551.2	109883.8	35589.3	102342.6	108035	-118374.8	55273.4	-28503.8	41956.6

> Coefficient and T-statistics based on cluster-adjusted (by Firm ID) standard errors (Petersen, 2009). [* p<0.10, ** p<0.05, *** p<0.01]

Table- 5 Result of Fixed Effect Regression (Panel B)

Variables	RG_EXPO	RG_RISK	RG_POS	RG_NEG	RG_SENT	PH_EXPO	PH_RISK	PH_POS	PH_NEG	PH_SENT
Big4 Auditor	-0.01	0	-0.005*	0.005*	0	0.002	0	-0.001	0.001	0
	(-1.31)	(-0.40)	(-1.68)	(-1.94)	(-0.12)	(-1.1)	(-0.53)	(-0.89)	(-0.59)	(-0.04)
RoA	-0.014*	0	-0.009*	0.006	-0.003	0.001	0	0	0	0.001
	(-1.66)	(-0.61)	(-1.76)	(-1.56)	(-1.13)	(-0.96)	(-0.40)	(-0.61)	(-0.51)	(-0.81)
Tangibility	0.052**	0	0.041***	-0.014*	0.027**	-0.003	0	-0.009*	-0.003	-0.011**
	(-1.97)	(-0.09)	(-2.83)	(-1.96)	(-1.98)	(-0.48)	(-0.03)	(-1.91)	(-0.69)	(-2.05)
Firm Size	0.015***	0	0.009***	-0.002***	0.007***	-0.001	0	-0.001	0.001	0
	(-5.54)	(-0.64)	(-6.13)	(-2.86)	(-4.88)	(-0.90)	(-1.32)	(-1.34)	(-0.75)	(-0.49)
Capex Intensity	-0.101**	0.005	-0.067***	-0.009	-0.076***	0.013	-0.003	-0.01	-0.001	-0.011
	(-2.06)	(-0.7)	(-2.76)	(-0.57)	(-3.51)	(-1.03)	(-1.08)	(-1.62)	(-0.08)	(-1.34)
Cash Holdings	0.025	0.001	0.009	-0.003	0.006	0	0	-0.001	-0.001	-0.002
	(-1.42)	(-0.87)	(-1.07)	(-0.43)	(-1.01)	(-0.05)	(-0.43)	(-0.32)	(-0.49)	(-0.60)
Leverage	-0.006*	-0.001	-0.002	0.003*	0.001	0.003	0	0.004	0.001	0.005*
	(-1.67)	(-1.42)	(-0.84)	(-1.89)	(-0.5)	(-0.97)	(-1.02)	(-1.62)	(-1.55)	(-1.88)
Market to Book	0	0	0	0	0	0.000*	0	0	0	0
	(-0.37)	(-1.27)	(-1.17)	(-0.03)	(-1.49)	(-1.72)	(-0.01)	(-1.31)	(-0.80)	(-1.2)
GDP	0.015***	0.000***	0.008***	-0.002***	0.007***	0	0	0	0	0
	(-11.85)	(-2.63)	(-9.87)	(-4.16)	(-8.81)	(-0.14)	(-0.09)	(-0.82)	(-0.72)	(-1.22)
Inflation	0.018***	0.000***	0.008***	-0.002***	0.006***	0	0	0	0	0.000*
	(-12.66)	(-3.12)	(-8.84)	(-4.30)	(-6.91)	(-1.23)	(-0.99)	(-1.6)	(-0.25)	(-1.82)
Constant	-0.122***	-0.001	-0.082***	0.011	-0.071***	0.014**	0.003	0.013**	-0.007	0.006
	(-5.23)	(-0.38)	(-6.05)	(-1.61)	(-5.60)	(-2.43)	(-1.47)	(-2.47)	(-1.08)	(-1.03)
R-sqr	0.019	0.001	0.016	0.003	0.011	0	0	0.001	0	0.001
N	81,206	81,206	81,206	81,206	81,206	81,206	81,206	81,206	81,206	81,206
BIC	-15904.1	-242340.5	-72531.2	-124675.2	-75166.1	-129126.6	-335947.5	-171283.1	-196732.6	-161998

> Coefficient and T-statistics based on cluster-adjusted (by Firm ID) standard errors (Petersen, 2009). [* $p<0.10$, ** $p<0.05$, *** $p<0.01$]

4.8   Two-stage Heckman selection model:

This study is encouraged by (Hafiz & Doukas, 2023) to use the Heckman selection model (Heckman, 1979) for reducing potential selection bias by developing the selection process. Firstly, probit regression under Heckman model is used to calculate the possibility of firms who select BIG4 accounting firm to conduct their audit process based on the independent variables (S&P Rating). Secondly, to consider this probable selection bias, we use inverse Mills ratio (λi) as extra (independent) variable which is calculated in the first stage of this model.

This analysis enables us to better understand the determinants of firms' choice in conducting audit process by BIG4 accounting firms while considering the influence of various firm-level characteristics. The S&P Rating is taken as new independent variables assuming that it is one the key factors affecting this decision. By employing the Two-stage Heckman selection model, we considered potential selection bias at firm level, enhancing the robustness of our earlier findings under OLS and FE.

4.8.1 Probit Model (First Stage):

In the first stage, we employ a probit model to determine the result when dependent variable is 1 following the methodology application of (Hafiz & Doukas, 2023) to calculate the possibility of BIG4 auditors' selection including an additional independent variables (S&P Rating) and control variables.

First Stage (Selection Equation): (Appendix-I)

$Z_i = \alpha_0 + \alpha_1 * \text{S\&P Rating}_i + \alpha_2 * \text{RoA}\_i + \alpha_3 * \text{Tangibility}_i + \alpha_4 * \text{Firm Size}_i + \alpha_5 * \text{Capex\_Intensity\_i} + \alpha_6 * \text{Cash\_Holdings}_i + \alpha_7 * \text{Leverage}_i + \alpha_8 * \text{Market\_to\_Book\_i} + u\_i$

This regression analysis (Table-6) is with the dependent variable including the presence of a Big4 auditor. Here, the coefficients for S&P Rating (0.038), Tangibility (0.39), Firm Size (0.47), Cash Holdings (1.101), and Market to Book (0.023) exhibit positive values, indicating a positive relationship with Big4 auditor. Conversely, RoA (-0.053) and Capex Intensity (-0.836) show negative coefficients. These findings suggest that companies with higher S&P Ratings, greater tangibility, larger firm sizes, more cash holdings, and higher market-to-book ratios may select Big4 auditors, while lower Capex Intensity and Return on Assets (RoA) are associated with a reduced possibility of selecting Big4 auditors.

Table-6: Probit regression

Variables	Coef. Std.	Robust Std. Err.	z
S&P Rating	0.0380474	0.0060656	6.27
RoA	-0.0532991	0.0148368	-3.59
Tangibility	0.3904959	0.0475217	8.22
Firm Size	0.4698957	0.0065807	71.41
Capex Intensity	-0.8362043	0.1625129	-5.15
Cash Holdings	1.100963	0.0426189	25.83
Leverage	-0.0255661	0.0197414	-1.3
Market to Book	0.0229228	0.0045486	5.04
Constant	-2.491995	0.0432032	-57.68
R-sqr	0.2652		
N	48,550		
BIC	34020.4		

4.8.2 Second Stage – Regression Analysis:

In this stage, in the second stage, the Inverse Mills Ratio (IMR) estimated in the first stage, is used to assess Big4 Auditor's impact on Climate Risk.

Second Stage (Outcome Equation): (Appendix-I)

$Y\_i = \beta_0 + \beta_1 *$ S&P Rating$\_i + \beta_2 *$ RoA$\_i + \beta_3 *$ Tangibility$\_i + \beta_4 *$ Firm Size$\_i + \beta_5 *$ Capex Intensity$\_i + \beta_6 *$ Cash Holdings$\_i + \beta_7 *$ Leverage$\_i + \beta_8 *$ Market_to_Book$\_i + \rho * \lambda\_i + \varepsilon\_i$

4.8.3 Second Stage: Result under OLS

Our analysis of the statistics (Table 7) indicates a significant relationship between the presence of Big4 auditing firms and climate risk factors with small difference than earlier regression under OLS. Specifically, the Big 4 Auditor variable exhibits negative coefficients for several climate-related variables, including CC_EXPO (-0.193, -2.20), CC_RISK (-0.010, -2.24), CC_POS (-0.097, -2.29), CC_NEG (0.040, -2.46), CC_SENT (-0.056, -1.89), OP_EXPO (-0.079, -1.80), OP_RISK (-0.002, -1.35), OP_POS (-0.034, -1.83), OP_NEG (0.009, -1.3), OP_SENT (-0.024, -1.96), RG_EXPO (-0.027, -2.30) RG_RISK (-0.001, -1.60) RG_POS (-0.012, -2.38) RG_NEG (0.006, -2.22) RG_SENT (-0.007, -1.81), PH_EXPO (-0.005, -1.79) PH_RISK (-0.001, -1.51) PH_POS (-0.003, -1.85) PH_NEG (0.002, -1.38) PH_SENT (-0.001, -0.79). These negative coefficients are accompanied by corresponding negative t-statistics, suggesting a statistically positive correlation (Hypothesis-2) between reduced climate risk and Big 4 auditors. Additionally, Big 4 auditors demonstrate positive coefficients for climate-related variables such as CC_NEG (0.040), OP_NEG (0.009, -1.30), RG_NEG (0.006, -2.22), and PH_NEG (0.002, -1.38) and OP_NEG (0.009), with the former showing a positive t-statistic of 2.46. These findings further support the belief that Big 4 auditors' practice is related to a favourable reduction in climate risk factors, which is a notable outcome in our analysis (Hypothesis-2).

Table- 7: Second Stage: OLS (Panel A)

Variables	CC_EXPO	CC_RISK	CC_POS	CC_NEG	CC_SENT	OP_EXPO	OP_RISK	OP_POS	OP_NEG	OP_SENT
Big4 Auditor	-0.193**	-0.010**	-0.097**	0.040**	-0.056*	-0.079*	-0.002	-0.034*	0.009	-0.024**
	(-2.20)	(-2.24)	(-2.29)	(-2.46)	(-1.89)	(-1.80)	(-1.35)	(-1.83)	(-1.3)	(-1.96)
RoA	-0.609***	-0.022***	-0.217***	0.106***	-0.111***	-0.253***	-0.008***	-0.089***	0.036***	-0.053***
	(-3.59)	(-3.29)	(-3.37)	(-3.48)	(-3.03)	(-3.38)	(-3.15)	(-3.26)	(-3.45)	(-2.99)
Tangibility	2.963***	0.118***	0.934***	-0.537***	0.396***	1.072***	0.039***	0.370***	-0.171***	0.199***
	(-9.95)	(-8.38)	(-8.44)	(-10.62)	(-5.65)	(-7.66)	(-6.57)	(-6.94)	(-8.52)	(-5.44)
Firm Size	0.209***	0.007***	0.088***	-0.030***	0.058***	0.101***	0.003***	0.042***	-0.013***	0.030***
	(-3.96)	(-3.35)	(-3.99)	(-3.33)	(-3.99)	(-4.03)	(-2.74)	(-3.96)	(-3.51)	(-3.85)
Capex Intensity	-5.428***	-0.201***	-2.095***	1.056***	-1.039***	-1.920***	-0.044***	-0.764***	0.345***	-0.418***
	(-8.35)	(-6.14)	(-8.63)	(-9.04)	(-6.77)	(-6.08)	(-3.08)	(-6.37)	(-7.12)	(-5.01)
Cash Holdings	0.363*	0.016*	0.121	-0.042	0.079	0.233**	0.006	0.087**	-0.034**	0.053*
	(-1.73)	(-1.81)	(-1.38)	(-1.22)	(-1.3)	(-2.24)	(-1.33)	(-2.06)	(-2.22)	(-1.82)
Leverage	-0.318***	-0.013***	-0.124***	0.057***	-0.067***	-0.109**	-0.003**	-0.040**	0.018***	-0.023*
	(-3.62)	(-3.91)	(-3.70)	(-3.94)	(-3.14)	(-2.28)	(-2.05)	(-2.31)	(-3.06)	(-1.74)
Market to Book	-0.021	-0.001**	-0.006	0.006***	0.001	-0.012	-0.001**	-0.004	0.003***	-0.001
	(-1.43)	(-2.46)	(-0.96)	(-2.68)	(-0.13)	(-1.42)	(-2.20)	(-1.37)	(-3.33)	(-0.27)
GDP	0.056***	0.001	0.030***	-0.005**	0.025***	0.031***	0.001***	0.016***	-0.004***	0.012***
	(-4.48)	(-1.61)	(-5.13)	(-2.19)	(-5.26)	(-4.7)	(-3.09)	(-5.4)	(-3.72)	(-4.63)
Inflation	0.060***	0.002**	0.027***	-0.009***	0.019***	0.019***	0	0.008***	0	0.008***
	(-4.87)	(-2.23)	(-4.72)	(-3.59)	(-4.05)	(-3)	(-0.00)	(-2.9)	(-0.19)	(-3.45)
invmills1	0.904***	0.029**	0.366***	-0.134***	0.232***	0.444***	0.008	0.176***	-0.055***	0.121***
	(-3.16)	(-2.45)	(-2.95)	(-2.73)	(-2.7)	(-3.12)	(-1.5)	(-2.93)	(-2.72)	(-2.73)
Constant	-1.204**	-0.037*	-0.462**	0.121	-0.341**	-0.663***	-0.016*	-0.277***	0.069*	-0.208***
	(-2.36)	(-1.77)	(-2.10)	(-1.38	(-2.30)	(-2.67)	(-1.65)	(-2.61)	(-1.92)	(-2.72)
R-sqr	0.055	0.021	0.03	0.044	0.012	0.031	0.011	0.021	0.022	0.012
N	76412	76412	76412	76412	76412	76412	76412	76412	76412	76412
BIC	204794.4	-32830.3	137280.5	66349.7	117284.7	146639.1	-91307.3	76346.4	248.9	57461.1

> Coefficient and T-statistics based on cluster-adjusted (by Firm ID) standard errors (Petersen, 2009). [* p<0.10, ** p<0.05, *** p<0.01]

Table- 7: Second Stage: OLS (Panel B)

Variables	RG_EXPO	RG_RISK	RG_POS	RG_NEG	RG_SENT	PH_EXPO	PH_RISK	PH_POS	PH_NEG	PH_SENT
Big4 Auditor	-0.027**	-0.001	-0.012**	0.006**	-0.007*	-0.005*	-0.001	-0.003*	0.002	-0.001
	(-2.30)	(-1.60)	(-2.38)	(-2.22)	(-1.81)	(-1.79)	(-1.51)	(-1.85)	(-1.38)	(-0.79)
RoA	-0.043**	-0.001**	-0.020**	0.011*	-0.009**	-0.004	0	-0.001	0.001	0
	(-2.36)	(-2.07)	(-2.10)	(-1.86)	(-2.24)	(-1.55)	(-0.79)	(-0.44)	(-1.59)	(-0.32)
Tangibility	0.277***	0.009***	0.105***	-0.044***	0.061***	0.016**	0	0.001	-0.006***	-0.005*
	(-10.65)	(-6.3)	(-9.44)	(-8.62)	(-6.96)	(-2.26)	(-0.31)	(-0.31)	(-3.02)	(-1.89)
Firm Size	0.031***	0.001***	0.013***	-0.004***	0.009***	-0.002*	0	-0.001	0	0
	(-6.17)	(-4.95)	(-5.88)	(-4.60)	(-5.18)	(-1.75)	(-0.82)	(-0.84)	(-0.52)	(-0.74)
Capex Intensity	-0.489***	-0.012*	-0.207***	0.074***	-0.133***	-0.027*	0.004	-0.005	-0.01	-0.015
	(-6.98)	(-1.78)	(-7.24)	(-4.38)	(-6.28)	(-1.65)	(-0.75)	(-0.43)	(-0.56)	(-1.40)
Cash Holdings	0.068***	0.003***	0.025***	-0.008*	0.016***	-0.022***	0	-0.010**	0.004***	-0.006*
	(-3.64)	(-3.98)	(-3.05)	(-1.69)	(-2.94)	(-3.18)	(-0.28)	(-2.54)	(-2.97)	(-1.84)
Leverage	-0.031***	-0.001***	-0.012***	0.008***	-0.004**	-0.001	0	0.001	0.001*	0.002
	(-3.48)	(-2.68)	(-2.74)	(-2.75)	(-2.01)	(-0.49)	(-1.05)	(-0.57)	(-1.8)	(-1.22)
Market to Book	0	0	0	0	0	0.001	0	0.001	0	0
	(-0.1)	(-0.89)	(-0.26)	-0.03	(-0.63)	(-1.58)	(-0.30)	(-1.39)	(-1.45)	-1.22
GDP	0.014***	0	0.008***	-0.001***	0.007***	0	0	0	0	0
	(-8.54)	(-1.64)	(-7.7)	(-3.14)	(-7.6)	(-1.35)	(-0.09)	(-0.40)	0	(-0.37)
Inflation	0.014***	0.000***	0.007***	-0.002***	0.005***	0.001	0	0	0	0
	(-7.87)	(-2.68)	(-6.43)	(-3.14)	(-5.42)	(-1.36)	(-0.42)	(-0.6)	(-0.11)	(-0.77)
invmills1	0.138***	0.005***	0.061***	-0.021***	0.040***	-0.012**	0	-0.002	0.001	-0.001
	(-5.03)	(-4.33)	(-4.86)	(-3.58)	(-4.28)	(-1.98)	(-0.59)	(-0.42)	(-0.54)	(-0.19)
Constant	-0.289***	-0.009***	-0.128***	0.034***	-0.094***	0.036***	0	0.013*	-0.006*	0.008
	(-6.01)	(-4.23)	(-5.70)	(-3.79)	(-5.38)	(-2.8)	(-0.29)	(-1.71)	(-1.74)	(-1.19)
R-sqr	0.04	0.005	0.028	0.011	0.016	0.003	0.001	0.001	0.003	0.001
N	76412	76412	76412	76412	76412	76412	76412	76412	76412	76412
BIC	22604.3	-188227.4	-36078.3	-82319.9	-47319	-76357.1	-262533.9	-115959.5	-147979.1	-116902

> Coefficient and T-statistics based on cluster-adjusted (by Firm ID) standard errors (Petersen, 2009). [* p<0.10, ** p<0.05, *** p<0.01]

4.8.4 Second Stage: Result under Fixed Effects Regression

Our analysis of the statistics presented in Table 8 also indicates a significant correlation between climate risk factors and Big 4 audit firms including a small difference than earlier FE model in climate risk physical indicators. Precisely, the Big 4 Auditor variable shows negative coefficients for several climate-related variables, including CC_EXPO (-0.098, -2.05), CC_RISK (-0.004, -0.79), CC_POS (-0.062, -2.40), CC_SENT (-0.043, -1.91), OP_EXPO (-0.051, -1.81), OP_RISK (-0.002, -1.21), OP_POS (-0.028, -2.00), OP_SENT (-0.022, -1.71), RG_EXPO (-0.008, -0.98), RG_RISK (0, -0.12), RG_POS (-0.004, -1.15), RG_SENT (-0.006, -1.91), PH_EXPO (0.002, -0.48), PH_RISK (0.003, -1.46), PH_POS (0-.001, -087), PH_SENT (0, -0.17). These negative coefficients are accompanied by corresponding negative t-statistics, suggesting a statistically positive correlation (Hypothesis-2) between reduced degree of climate risk and Big 4 auditors. Additionally, Big 4 auditors demonstrate positive coefficients for climate-related variables such as CC_NEG (0.018, -1.45), OP_NEG (0.007, -1.31), RG_NEG (0.006, -1.91), and PH_NEG (0.001, -0.43). These findings further support the belief that Big 4 auditors' practice is correlated to a favourable reduction in climate risk factors with minor differences, which is an important outcome in our analysis (Hypothesis-2).

Table- 8: Second Stage: Fixed Effects Regression (Panel A)

Variables	CC_EXPO	CC_RISK	CC_POS	CC_NEG	CC_SENT	OP_EXPO	OP_RISK	OP_POS	OP_NEG	OP_SENT
Big4 Auditor	-0.098**	-0.004	-0.062**	0.018	-0.043*	-0.051*	-0.002	-0.028**	0.007	-0.022*
	(-2.05)	(-0.79)	(-2.40)	(-1.45)	(-1.91)	(-1.81)	(-1.21)	(-2.00)	(-1.31)	(-1.71)
RoA	-0.046	-0.003	-0.012	0.021**	0.009	-0.015	0.001	-0.007	0.004	-0.003
	(-1.42)	(-1.26)	(-0.82)	(-2)	(-0.56)	(-0.76)	(-0.76)	(-0.77)	(-1.56)	(-0.38)
Tangibility	0.903***	0.060***	0.357**	-0.131**	0.226*	0.480***	0.027**	0.206**	-0.073***	0.132**
	(-3.09)	(-2.65)	(-2.5)	(-2.51)	(-1.94)	(-2.78)	(-2.01)	(-2.53)	(-2.87)	(-2.06)
Firm Size	0.463***	0.014***	0.245***	-0.066***	0.179***	0.230***	0.007***	0.112***	-0.025***	0.086***
	(-8.16)	(-4.8)	(-8.43)	(-6.45)	(-7.4)	(-6.66)	(-3.77)	(-6.6)	(-5.13)	(-5.96)
Capex Intensity	-0.634**	-0.018	-0.679***	0.151**	-0.528***	-0.232	0.012	-0.238***	0.087**	-0.151*
	(-2.37)	(-0.53)	(-4.60)	(-2.2)	(-4.11)	(-1.61)	(-0.81)	(-2.77)	(-2.54)	(-1.91)
Cash Holdings	1.038***	0.043***	0.569***	-0.153***	0.416***	0.508***	0.019***	0.239***	-0.061***	0.177***
	(-5.43)	(-3.91)	(-5.83)	(-4.19)	(-5.05)	(-4.84)	(-2.93)	(-4.58)	(-3.57)	(-3.9)
Leverage	-0.076**	-0.005**	-0.021	0.012	-0.009	-0.017	-0.002	-0.006	0.004	-0.002
	(-2.37)	(-2.32)	(-1.18)	(-1.5)	(-0.59)	(-0.91)	(-1.52)	(-0.61)	(-1.55)	(-0.22)
Market to Book	0.036***	0.001*	0.016***	-0.003*	0.013***	0.017***	0	0.007***	0	0.006***
	(-5.44)	(-1.69)	(-4.65)	(-1.72)	(-4.22)	(-4.1)	(-1.5)	(-3.28)	(-0.16)	(-3.55)
GDP	0.047***	0.001	0.026***	-0.004**	0.022***	0.024***	0.001**	0.014***	-0.003***	0.011***
	(-6.05)	(-1.34)	(-5.46)	(-2.24)	(-4.93)	(-5.48)	(-2.3)	(-5.74)	(-3.42)	(-4.85)
Inflation	0.081***	0.002**	0.039***	-0.011***	0.028***	0.029***	0	0.013***	-0.001	0.011***
	(-9.06)	(-1.97)	(-7.81)	(-4.98)	(-6.33)	(-5.95)	(-0.12)	(-4.82)	(-1.29)	(-4.8)
invmills1	1.693***	0.059***	0.924***	-0.277***	0.648***	0.799***	0.025***	0.409***	-0.081***	0.328***
	(-5.98)	(-3.58)	(-6.29)	(-4.49)	(-5.21)	(-4.87)	(-3.09)	(-4.78)	(-3.14)	(-4.37)
Constant	-3.324***	-0.106***	-1.848***	0.426***	-1.422***	-1.756***	-0.054***	-0.883***	0.170***	-0.713***
	(-5.94)	(-3.53)	(-6.46)	(-4.15)	(-5.99)	(-5.17)	(-2.96)	(-5.26)	(-3.48)	(-5.00)
R-sqr	0.019	0.002	0.016	0.004	0.011	0.014	0.002	0.011	0.003	0.008
N	76412	76412	76412	76412	76412	76412	76412	76412	76412	76412
BIC	143752.1	-57072.6	95372.8	32714.9	88957.7	94370.1	-112700.1	41815.2	-26001.6	33594.2

> Coefficient and T-statistics based on cluster-adjusted (by Firm ID) standard errors (Petersen, 2009). [* p<0.10, ** p<0.05, *** p<0.01]

Table- 8: Second Stage: Fixed Effects Regression (Panel B)

Variables	RG_EXPO	RG_RISK	RG_POS	RG_NEG	RG_SENT	PH_EXPO	PH_RISK	PH_POS	PH_NEG	PH_SENT
Big4 Auditor	-0.008	0	-0.004	0.006*	0.002	0.003	0	-0.001	0.001	0
	(-0.98)	(-0.12)	(-1.15)	(-1.91)	(-0.48)	(-1.46)	(-0.52)	(-0.87)	(-0.43)	(-0.17)
RoA	-0.01	0	-0.006	0.006	0	0	0	0	0	0
	(-0.96)	(-0.07)	(-0.98)	(-1.2)	(-0.01)	(-0.19)	(-0.02)	(-0.11)	(-0.13)	(-0.19)
Tangibility	0.122***	0.004	0.069***	-0.020**	0.049***	0	0.001	-0.008*	-0.005	-0.013**
	(-4.21	(-0.79)	(-3.93)	(-2.42)	(-2.97)	(-0.04)	(-0.53)	(-1.66)	(-1.22)	(-2.18)
Firm Size	0.064***	0.001**	0.033***	-0.009***	0.024***	0	0	0	-0.002*	-0.001
	(-8.44	(-2.18)	(-7.72)	(-5.13)	(-6.55)	(-0.34)	(-1.35)	(-0.4)	(-1.78)	(-1.21)
Capex Intensity	-0.175***	0.005	-0.116***	-0.002	-0.117***	0.008	-0.005	-0.013	0.004	-0.008
	(-2.99)	(-0.65)	(-3.87)	(-0.10)	(-4.18)	(-0.5)	(-1.33)	(-1.57)	(-0.33)	(-0.81)
Cash Holdings	0.168***	0.005***	0.078***	-0.021***	0.057***	0.001	0.001	0.003	-0.007*	-0.004
	(-5.75	(-2.68)	(-5.5)	(-3.17)	(-4.68)	(-0.28)	(-1.47)	(-0.83)	(-1.89)	(-1.16)
Leverage	-0.015***	-0.001	-0.006**	0.005**	-0.001	0.001	0	0.002	0.001*	0.004*
	(-2.94)	(-1.48)	(-2.14)	(-2.41)	(-0.62)	(-0.36)	(-1.20)	(-1.23)	(-1.68)	(-1.76)
Market to Book	0.004**	0	0.002***	-0.001	0.001**	0.001*	0	0.001	0	0
	(-2.37	(-0.59)	(-2.59)	(-0.95)	(-2.5)	(-1.86)	(-0.4)	(-1.64)	(-1.57)	(-1.02)
GDP	0.014***	0.000**	0.008***	-0.001***	0.007***	0	0	0	0	0
	(-10.01	(-2.01)	(-8.51)	(-3.06)	(-7.79)	(-0.53)	(-0.07)	(-1.08)	(-0.41)	(-1.30)
Inflation	0.018***	0.000***	0.009***	-0.002***	0.007***	0.001	0	0	0	0
	(-11.62	(-2.89)	(-8.74)	(-3.95)	(-6.94)	(-1.41)	(-1.33)	(-1.17)	(-0.1)	(-1.28)
invmills1	0.292***	0.006*	0.144***	-0.042***	0.102***	0.007	0.003**	0.007	-0.013**	-0.006
	(-7.04)	(-1.95)	(-6.4)	(-3.81)	(-5.16)	(-0.91)	(-2.03)	(-1.53)	(-2.26)	(-1.01)
Constant	-0.600***	-0.012**	-0.312***	0.075***	-0.237***	0.002	-0.002	0.002	0.013	0.015*
	(-8.00)	(-1.96)	(-7.49)	(-4.27)	(-6.61)	(-0.17)	(-0.97)	(-0.29)	(-1.47)	(-1.68)
R-sqr	0.022	0.001	0.019	0.003	0.012	0	0.001	0.001	0.001	0.001
N	76412	76412	76412	76412	76412	76412	76412	76412	76412	76412
BIC	-9347.3	-200382.7	-56735.5	-100252.4	-58298.8	-104842.2	-275776.5	-138460.5	-160486.3	-131682

> Coefficient and T-statistics based on cluster-adjusted (by Firm ID) standard errors (Petersen, 2009). [* p<0.10, ** p<0.05, *** p<0.01]

4.9   Propensity Score Matching Model:

This model is used to estimate the causal effect of a treatment (Imbens, 2004) in our samples and to control for control variables for matching the control variables between treated and control groups, making them comparable, which may allow us for a more acceptable approximation of the treatment effect (Imai et al., 2008). **(Appendix-H)**

The propensity score (e) is estimated using probability regression as follows:

$e(X) = Pr$ (Treatment $= 1 \mid X$)

Where:

- ➢ $e(X)$ = Calculated propensity score.

- ➢ Treatment is a binary variable (1 for treated, 0 for control); in our case Big4 Auditor=1, and Non-big4 Auditors=0.

- ➢ X represents control variables.

We have considered the following variables in the propensity score model:

Big4 Auditor: A binary variable of the Big4 audit firms (1 for audited, 0 for unaudited).

Control Variables: RoA (Return on Assets), Tangibility, Firm Size, Capex Intensity, Cash Holdings, Leverage, Market to Book.

We believe that Propensity Score Matching will help us get a more reliable assessment of the causal effect of the Big4 Auditors on Climate Risk while considering observable differences between treated and control groups.

4.9.1 Results under Propensity Score Matching:

Primarily, this model provides the PSM score 0.68 for Big4 Auditors. Afterward, considering the matched sample, we again conduct regression analysis. Details of the results are under Table-9 and Table-10.

Table-9 Summary of the PSM score:

psmatch2: Treatment assignment	psmatch2: Common support		
	Off suppo	On suppor	Total
Untreated	0	9,549	9,549
Treated	34,225	7,694	41,919
Total	34,225	17,243	51,468

PS score as follows:

Variable	Mean Treated Control	%bias	t-test t p>t	V(T)/ V(C)	
pscore2	.67501 .68894	-7.3	-4.82 0.000	0.92*	

* if variance ratio outside [0.96; 1.05]

Ps R2	LR chi2	p>chi2	Mean Bias	Med Bias		B	R	%Var	
0.001	23.23	0.000	7.3	7.3		7.8	0.92	100	
* if B>25%, R outside [0.5; 2]									

Below is a summary of the results (Table-9) under <u>OLS after considering PSM</u> reflect consistency with our earlier analysis as Big 4 auditors' practice is correlated to a favourable reduction in climate risk factors with minor differences.

CC_EXPO (-0.281***, -3.78), CC_RISK (-0.013***, -3.47), CC_POS (-0.125***, -3.58), CC_NEG (0.053***, 3.84), CC_SENT (-0.072***, -2.90), OP_EXPO (-0.124***, -3.43), OP_RISK (-0.004***, -2.66), OP_POS (-0.050***, -3.14), OP_NEG (0.020***, 3.20), OP_SENT (-0.030***, -2.76), RG_EXPO (-0.034***, -3.32), RG_RISK (-0.001*, -1.82), RG_POS (-0.016***, -3.53), RG_NEG (0.007***, 2.93), RG_SENT (-0.009***, -2.98), PH_EXPO (-0.004*, -1.69), PH_RISK (-0.000*, -1.65), PH_POS (-0.002*, -1.73), PH_NEG (0.002, 1.42), PH_SENT (-0.001, -0.70)

Additionally, the results (Table-10) under <u>FE after considering PSM</u> also indicate similarity with our earlier analysis as Big 4 auditors' practice is correlated to a favourable reduction in climate risk factors with minor differences.

CC_EXPO (-0.085, -1.94), CC_RISK (-0.004, -0.91), CC_POS (-0.056**, -2.39), CC_NEG (0.019*, 1.65), CC_SENT (-0.037*, -1.79), OP_EXPO (-0.039, -1.44), OP_RISK (-0.003, -1.48), OP_POS (-0.022*, -1.67), OP_NEG (0.010**, 2.01), OP_SENT (-0.012, -1.01), RG_EXPO (-0.010, -1.31), RG_RISK (-0.000, -0.40), RG_POS (-0.005*, -1.68), RG_NEG (0.005*, 1.94), RG_SENT (-0.000, -0.12), PH_EXPO (0.002, 1.10), PH_RISK (-0.000, -0.53), PH_POS (-0.001, -0.89), PH_NEG (0.001, 0.59), PH_SENT (0.000, 0.04).

Graphical representation of Propensity Score Matching:
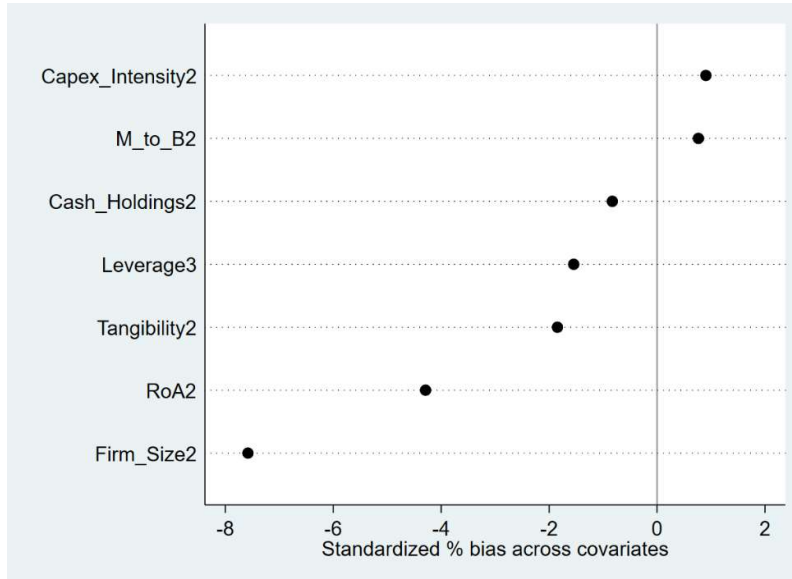
Graph-1
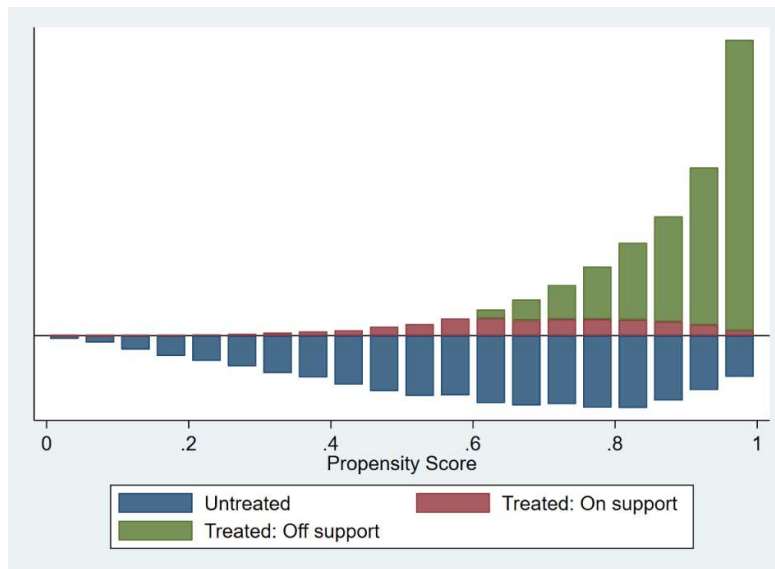
Graph-2

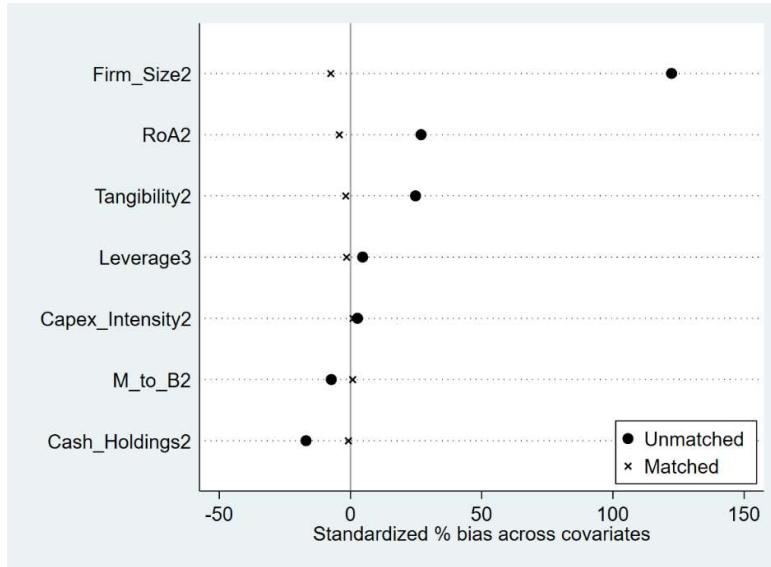**Graphical representation of PSM (Continued….):**

Graph-3

Table- 10: OLS Result after Propensity Score Matching (Panel A)

Variables	CC_EXPO	CC_RISK	CC_POS	CC_NEG	CC_SENT	OP_EXPO	OP_RISK	OP_POS	OP_NEG	OP_SENT
Big4 Auditor	-0.281***	-0.013***	-0.125***	0.053***	-0.072***	-0.124***	-0.004***	-0.050***	0.020***	-0.030***
	(-3.78)	(-3.47)	(-3.58)	(3.84)	(-2.90)	(-3.43)	(-2.66)	(-3.14)	(3.20)	(-2.76)
RoA	-0.577***	-0.019***	-0.203***	0.096***	-0.107***	-0.261***	-0.009***	-0.098***	0.040***	-0.058***
	(-4.96)	(-4.37)	(-4.59)	(4.79)	(-4.09)	(-4.67)	(-3.10)	(-4.23)	(4.37)	(-3.97)
Tangibility	2.571***	0.097***	0.809***	-0.472***	0.337***	0.921***	0.033***	0.313***	-0.149***	0.164***
	(10.88)	(8.52)	(9.23)	(-11.70)	(5.95)	(8.17)	(6.51)	(7.43)	(-9.21)	(5.64)
Firm Size	0.078***	0.003***	0.034***	-0.011***	0.023***	0.038***	0.001***	0.016***	-0.005***	0.011***
	(3.98)	(3.58)	(4.21)	(-3.07)	(4.38)	(3.98)	(4.14)	(3.98)	(-3.42)	(3.88)
Capex Intensity	-4.393***	-0.158***	-1.728***	0.886***	-0.841***	-1.529***	-0.034***	-0.625***	0.303***	-0.322***
	(-8.27)	(-5.80)	(-8.50)	(9.26)	(-6.30)	(-5.83)	(-2.71)	(-6.05)	(7.46)	(-4.33)
Cash Holdings	-0.109	-0.001	-0.057	0.028	-0.029	-0.008	-0.001	-0.012	0.000	-0.012
	(-0.98)	(-0.34)	(-1.19)	(1.51)	(-0.83)	(-0.13)	(-0.25)	(-0.48)	(0.01)	(-0.69)
Leverage	-0.281***	-0.011***	-0.109***	0.048***	-0.060***	-0.107**	-0.004**	-0.041**	0.018***	-0.023*
	(-3.74)	(-3.98)	(-3.82)	(4.02)	(-3.26)	(-2.51)	(-2.35)	(-2.52)	(3.32)	(-1.90)
Market to Book	-0.021***	-0.001***	-0.008**	0.006***	-0.003	-0.010**	-0.001***	-0.004***	0.003***	-0.001
	(-2.63)	(-3.54)	(-2.48)	(4.38)	(-1.01)	(-2.29)	(-3.32)	(-2.62)	(4.21)	(-1.22)
GDP	0.060***	0.001	0.031***	-0.005**	0.026***	0.032***	0.001***	0.015***	-0.004***	0.011***
	(5.40)	(1.54)	(5.88)	(-2.40)	(6.14)	(5.55)	(3.60)	(5.76)	(-3.94)	(5.06)
Inflation	0.065***	0.002***	0.028***	-0.009***	0.019***	0.020***	-0.000	0.008***	-0.001	0.007***
	(5.78)	(2.87)	(5.68)	(-4.29)	(4.92)	(3.58)	(-0.15)	(3.18)	(-0.58)	(3.58)
Constant	0.135	0.008	0.083	-0.081***	0.002	0.003	-0.000	0.003	-0.020	-0.017
	(0.86)	(1.15)	(1.17)	(-2.75)	(0.04)	(0.04)	(-0.02)	(0.09)	(-1.53)	(-0.70)
R-sqr	0.050	0.018	0.027	0.039	0.011	0.028	0.007	0.016	0.018	0.009
N	51,468	51,468	51,468	51,468	51,468	51,468	51,468	51,468	51,468	51,468
BIC	242350.9	-43455.8	162382.0	78058.6	138917.5	173790.2	-96059.4	95834.4	4640.2	71882.8

> Coefficient and T-statistics based on cluster-adjusted (by Firm ID) standard errors (Petersen, 2009). [* p<0.10, ** p<0.05, *** p<0.01]

Table- 10: OLS Result after Propensity Score Matching (Panel B)

Variables	RG_EXPO	RG_RISK	RG_POS	RG_NEG	RG_SENT	PH_EXPO	PH_RISK	PH_POS	PH_NEG	PH_SENT
Big4 Auditor	-0.034***	-0.001*	-0.016***	0.007***	-0.009***	-0.004*	-0.000*	-0.002*	0.002	-0.001
	(-3.32)	(-1.82)	(-3.53)	(2.93)	(-2.98)	(-1.69)	(-1.65)	(-1.73)	(1.42)	(-0.70)
RoA	-0.043***	-0.002**	-0.019***	0.009**	-0.010***	-0.004	-0.000	-0.001	0.001	0.000
	(-3.58)	(-2.44)	(-3.10)	(2.49)	(-3.46)	(-1.04)	(-0.32)	(-0.65)	(1.37)	(0.20)
Tangibility	0.234***	0.007***	0.088***	-0.038***	0.050***	0.015***	0.000	0.001	-0.005***	-0.005**
	(11.48)	(6.74)	(9.99)	(-9.41)	(7.15)	(2.61)	(0.19)	(0.34)	(-3.59)	(-2.25)
Firm Size	0.010***	0.000***	0.004***	-0.001***	0.003***	-0.001	0.000	-0.000	0.000	-0.000*
	(5.26)	(3.70)	(5.47)	(-3.13)	(5.34)	(-1.19)	(0.64)	(-1.57)	(0.32)	(-1.68)
Capex Intensity	-0.407***	-0.011**	-0.170***	0.059***	-0.111***	-0.020	0.003	-0.007	-0.009	-0.016*
	(-7.41)	(-2.16)	(-7.51)	(4.42)	(-6.39)	(-1.46)	(0.80)	(-0.79)	(-0.68)	(-1.92)
Cash Holdings	0.003	0.001*	-0.001	0.001	-0.001	-0.013***	0.000	-0.008***	0.003***	-0.005**
	(0.30)	(1.82)	(-0.30)	(0.27)	(-0.19)	(-3.10)	(0.15)	(-3.09)	(2.71)	(-2.23)
Leverage	-0.026***	-0.001***	-0.010***	0.006***	-0.004**	0.003	-0.000	0.003	0.000	0.003
	(-3.89)	(-3.01)	(-3.04)	(2.96)	(-2.24)	(0.61)	(-1.16)	(1.14)	(0.36)	(1.59)
Market to Book	-0.001	-0.000**	-0.000	0.000	-0.000	0.001	-0.000	0.000	-0.000	0.000
	(-1.26)	(-2.33)	(-1.00)	(0.81)	(-0.93)	(1.32)	(-0.30)	(1.32)	(-0.90)	(1.41)
GDP	0.012***	0.000*	0.007***	-0.001***	0.006***	-0.000	-0.000	0.000	0.000	0.000
	(9.07)	(1.92)	(8.45)	(-3.54)	(8.38)	(-1.28)	(-0.36)	(0.12)	(0.01)	(0.12)
Inflation	0.014***	0.000**	0.006***	-0.002***	0.005***	0.000	0.000	0.000	0.000	0.000
	(8.92)	(2.48)	(7.81)	(-3.92)	(6.44)	(0.67)	(0.18)	(1.02)	(0.32)	(1.42)
Constant	-0.074***	-0.001	-0.036***	0.003	-0.033***	0.019***	0.001*	0.010***	-0.004***	0.006**
	(-3.56)	(-1.15)	(-3.95)	(0.56)	(-5.47)	(4.07)	(1.66)	(3.64)	(-2.59)	(2.44)
R-sqr	0.035	0.004	0.024	0.010	0.014	0.003	0.001	0.002	0.002	0.002
N	51,468	51,468	51,468	51,468	51,468	51,468	51,468	51,468	51,468	51,468
BIC	22738.9	-225470.9	-47190.4	-102428.8	-60900.3	-86668.5	-320112.7	-140340.7	-179047.9	-142065.2

> Coefficient and T-statistics based on cluster-adjusted (by Firm ID) standard errors (Petersen, 2009). [* p<0.10, ** p<0.05, *** p<0.01]

Table- 11: FE Result after Propensity Score Matching (Panel A)

Variables	CC_EXPO	CC_RISK	CC_POS	CC_NEG	CC_SENT	OP_EXPO	OP_RISK	OP_POS	OP_NEG	OP_SENT
Big4 Auditor	-0.085*	-0.004	-0.056**	0.019*	-0.037*	-0.039	-0.003	-0.022*	0.010**	-0.012
	(-1.94)	(-0.91)	(-2.39)	(1.65)	(-1.79)	(-1.44)	(-1.48)	(-1.67)	(2.01)	(-1.01)
RoA	-0.070**	-0.004*	-0.029*	0.026***	-0.004	-0.031*	-0.002	-0.018	0.009**	-0.009
	(-2.26)	(-1.86)	(-1.95)	(2.59)	(-0.28)	(-1.72)	(-0.95)	(-1.62)	(2.03)	(-1.10)
Tangibility	0.566**	0.042**	0.175	-0.122**	0.054	0.245	0.020*	0.091	-0.058***	0.034
	(2.22)	(2.19)	(1.49)	(-2.26)	(0.53)	(1.61)	(1.71)	(1.33)	(-2.68)	(0.61)
Firm Size	0.173***	0.004***	0.088***	-0.022***	0.066***	0.086***	0.002**	0.039***	-0.011***	0.028***
	(7.15)	(2.68)	(7.81)	(-4.19)	(6.91)	(6.37)	(2.47)	(6.12)	(-4.68)	(5.27)
Capex Intensity	-0.262	-0.007	-0.441***	0.126**	-0.314***	-0.045	0.016	-0.129*	0.076**	-0.053
	(-1.18)	(-0.25)	(-3.69)	(2.10)	(-3.06)	(-0.40)	(1.28)	(-1.89)	(2.45)	(-0.88)
Cash Holdings	0.207**	0.013*	0.107**	-0.025	0.082*	0.089*	0.010**	0.039	-0.025**	0.014
	(2.17)	(1.93)	(2.02)	(-1.03)	(1.71)	(1.81)	(2.00)	(1.32)	(-2.25)	(0.55)
Leverage	-0.016	-0.003	0.006	0.002	0.008	0.002	-0.002	0.003	0.002	0.005
	(-0.55)	(-1.51)	(0.35)	(0.24)	(0.59)	(0.11)	(-1.28)	(0.29)	(0.78)	(0.55)
Market to Book	0.004	0.000	0.004*	0.000	0.004**	0.002	0.000	0.002	0.001*	0.003**
	(0.37)	(0.75)	(1.74)	(0.45)	(2.21)	(0.52)	(1.21)	(1.16)	(1.69)	(2.04)
GDP	0.057***	0.001**	0.029***	-0.005***	0.024***	0.029***	0.001**	0.016***	-0.003***	0.013***
	(8.03)	(1.97)	(6.88)	(-2.96)	(6.12)	(7.16)	(2.45)	(6.98)	(-3.54)	(6.09)
Inflation	0.078***	0.002**	0.038***	-0.011***	0.027***	0.027***	0.000	0.012***	-0.002*	0.011***
	(9.82)	(2.37)	(8.59)	(-5.48)	(6.82)	(6.27)	(0.41)	(5.24)	(-1.84)	(5.01)
Constant	-0.563***	-0.011	-0.351***	0.012	-0.339***	-0.375***	-0.011	-0.191***	0.031*	-0.160***
	(-2.70)	(-0.85)	(-3.61)	(0.27)	(-4.06)	(-3.15)	(-1.36)	(-3.42)	(1.67)	(-3.41)
	0	0	0	0	0	0	0	0	0	0
R-sqr	0.015	0.001	0.012	0.003	0.008	0.010	0.001	0.007	0.002	0.005
N	51,468	51,468	51,468	51,468	51,468	51,468	51,468	51,468	51,468	51,468
BIC	166892.6	-73551.2	109883.8	35589.3	102342.6	108035.0	-118374.8	55273.4	-28503.8	41956.6

> Coefficient and T-statistics based on cluster-adjusted (by Firm ID) standard errors (Petersen, 2009). [* p<0.10, ** p<0.05, *** p<0.01]

Table- 11: FE Result after Propensity Score Matching (Panel B)

Variables	RG_EXPO	RG_RISK	RG_POS	RG_NEG	RG_SENT	PH_EXPO	PH_RISK	PH_POS	PH_NEG	PH_SENT
Big4 Auditor	-0.010	-0.000	-0.005*	0.005*	-0.000	0.002	-0.000	-0.001	0.001	0.000
	(-1.31)	(-0.40)	(-1.68)	(1.94)	(-0.12)	(1.10)	(-0.53)	(-0.89)	(0.59)	(0.04)
RoA	-0.014*	-0.000	-0.009*	0.006	-0.003	0.001	-0.000	0.000	0.000	0.001
	(-1.66)	(-0.61)	(-1.76)	(1.56)	(-1.13)	(0.96)	(-0.40)	(0.61)	(0.51)	(0.81)
Tangibility	0.052**	0.000	0.041***	-0.014*	0.027**	-0.003	-0.000	-0.009*	-0.003	-0.011**
	(1.97)	(0.09)	(2.83)	(-1.96)	(1.98)	(-0.48)	(-0.03)	(-1.91)	(-0.69)	(-2.05)
Firm Size	0.015***	0.000	0.009***	-0.002***	0.007***	-0.001	-0.000	-0.001	0.001	-0.000
	(5.54)	(0.64)	(6.13)	(-2.86)	(4.88)	(-0.90)	(-1.32)	(-1.34)	(0.75)	(-0.49)
Capex Intensity	-0.101**	0.005	-0.067***	-0.009	-0.076***	0.013	-0.003	-0.010	-0.001	-0.011
	(-2.06)	(0.70)	(-2.76)	(-0.57)	(-3.51)	(1.03)	(-1.08)	(-1.62)	(-0.08)	(-1.34)
Cash Holdings	0.025	0.001	0.009	-0.003	0.006	-0.000	-0.000	-0.001	-0.001	-0.002
	(1.42)	(0.87)	(1.07)	(-0.43)	(1.01)	(-0.05)	(-0.43)	(-0.32)	(-0.49)	(-0.60)
Leverage	-0.006*	-0.001	-0.002	0.003*	0.001	0.003	-0.000	0.004	0.001	0.005*
	(-1.67)	(-1.42)	(-0.84)	(1.89)	(0.50)	(0.97)	(-1.02)	(1.62)	(1.55)	(1.88)
Market to Book	0.000	-0.000	0.000	-0.000	0.000	0.000*	0.000	0.000	-0.000	0.000
	(0.37)	(-1.27)	(1.17)	(-0.03)	(1.49)	(1.72)	(0.01)	(1.31)	(-0.80)	(1.20)
GDP	0.015***	0.000***	0.008***	-0.002***	0.007***	-0.000	0.000	-0.000	-0.000	-0.000
	(11.85)	(2.63)	(9.87)	(-4.16)	(8.81)	(-0.14)	(0.09)	(-0.82)	(-0.72)	(-1.22)
Inflation	0.018***	0.000***	0.008***	-0.002***	0.006***	0.000	0.000	0.000	0.000	0.000*
	(12.66)	(3.12)	(8.84)	(-4.30)	(6.91)	(1.23)	(0.99)	(1.60)	(0.25)	(1.82)
Constant	-0.122***	-0.001	-0.082***	0.011	-0.071***	0.014**	0.003	0.013**	-0.007	0.006
	(-5.23)	(-0.38)	(-6.05)	(1.61)	(-5.60)	(2.43)	(1.47)	(2.47)	(-1.08)	(1.03)
	0	0	0	0	0	0	0	0	0	0
R-sqr	0.019	0.001	0.016	0.003	0.011	0.000	0.000	0.001	0.000	0.001
N	51,468	51,468	51,468	51,468	51,468	51,468	51,468	51,468	51,468	51,468
BIC	-15904.1	-242340.5	-72531.2	-124675.2	-75166.1	-129126.6	-335947.5	-171283.1	-196732.6	-161998.2

> Coefficient and T-statistics based on cluster-adjusted (by Firm ID) standard errors (Petersen, 2009). [* $p<0.10$, ** $p<0.05$, *** $p<0.01$]

5   Summary of Empirical Findings and Robustness:

Primarily, we conduct empirical analysis under OLS (Table 4) which validates our hypothesis 2, revealing a negative correlation between Big 4 auditors and firm level climate risk. For example, all coefficient estimates, and associated t-statistics demonstrate negative relationship between climate risk and Big4 auditors. Also, correlation remains significantly positive when negative risk factors relating to climate risk are found. Thus, we observed that companies tend to have lower levels of climate risk if audited by Big 4 auditors. Table 4 provides evidence of this with negative coefficients and t-statistics for various climate-related variables.

To validate the findings under OLS, this study considers Fixed Effects model (Table 5) under firm-level, and subsequently, our analysis revealed that companies subject to audits by Big 4 auditing firms show reduced levels of climate risk. As indicated in Table 5, the results again demonstrated negative coefficients and corresponding negative t-statistics for the climate-related variables with a minor deviation.

In addition to the OLS and FE models, the Heckman selection model is used to enhance robustness of earlier findings, to address potential bias and to minimize the selection bias. The Probit Model- first stage examines factors (Inverse Mills Ratio) influencing the presence of Big4 auditors. Then, positive coefficients in variables like S&P Rating, Tangibility, Firm Size, Cash Holdings, and Market to Book suggest these factors increase the probability of Big4 auditor engagement, while negative coefficients in RoA and Capex Intensity indicate a minor probability.

In the second stage, we use Inverse Mills Ratio calculated from Probit Model with OLS and FE to reveal the relationship between climate risk factors and Big 4 auditors. Negative coefficients suggest lower climate risk impact contributed by Big 4 auditors' practice, supported by the coefficients for most of the climate-related variables. Similarly, these findings highlight the positive effect (Hypothesis-2) of Big4 on reducing climate risk in this study with minor deviation.

Finally, alongside aforesaid statistical methods i.e. OLS, FE, and the Heckman selection model, we use PSM to reduce unmatched bias in control variables of Big4 Auditors. Afterwards, the results showed improved balance in control variables, particularly in Firm Size, Market to Book, and Leverage, indicating reduced selection bias. However, some variables demonstrated a little bias in the matched group. This analysis revealed varying impacts of control variables on the Big4 Auditor selection, and suggest further research is needed on improving control variable balance to analyse the impact of Big4 Auditor selection by firms.

In sum, the study employs multiple statistical methods, including OLS, FE, Two-stage Heckman selection model and PSM, to evaluate the correlation between climate risk and Big 4 auditors. Subsequently, findings consistently show that the firms audited by Big 4 auditors, with minor deviation, are likely to have lower levels of climate risk (Hypothesis-2).

6 Conclusion:

At first, this study addresses the literatures about critical role of auditors in ensuring financial accuracy and addressing climate risk. Besides, it points out the scarcity of research exploring the link between climate risk and Big Four Auditors. After that, this research employs a comprehensive methodology to investigate the Big 4 auditors' influence on climate risk. Subsequently, the analysis consistently reveals negative coefficients (Hypothesis-2), indicating a strong relationship between lower levels of climate risk and Big 4 auditors. This correlation remains robust with minor deviation across various climate-related variables and is supported by multiple statistical approaches which are OLS, FE, the Two-stage Heckman model, and PSM.

In summary, our findings indicate a negative relationship between Big Four auditors and climate risk, supported by various statistical analyses. So, this analysis supports our hypothesis-2 that negative correlation exists between Big 4 auditors and firm level climate risk and assume that they play a vital role in mitigating climate risk,. Additionally, this research contributes to the existing literature with an understanding of the relationship between climate risk and Big4 auditors. Finally, we believe that this study may contribute to bridging a significant knowledge gap in contemporary academia, tend to be a pioneer on considering relationship between the Big Four Auditors and climate risk. Also, this study suggests that further in-depth research may be conducted on improving the minor deviation of the impact of Big4 Auditor practice to climate risk.

Appendix A: Definition of Climate Risk Data:

The following table lists the Climate related data, abbreviations and the associated definition which are used as dependent variables in this study [Source: (Sautner et al., 2023):

Variable	Data Years	Definition
Climate Change Exposure	2002 to 2020	Relative frequency with which bigrams related to climate change occur in the transcripts of earnings conference calls. We count the number of such bigrams and divide by the total number of bigrams in the transcripts.
Climate Change Exposure-Operational	2002 to 2020	Relative frequency with which bigrams that capture opportunities related to climate change occur in the transcripts of earnings conference calls. We count the number of such bigrams and divide by the total number of bigrams in the transcripts.
Climate Change Exposure-Regulatory	2002 to 2020	Relative frequency with which bigrams that capture regulatory shocks related to climate change occur in the transcripts of earnings conference calls. We count the number of such bigrams and divide by the total number of bigrams in the transcripts.
Climate Change Exposure - Physical	2002 to 2020	Relative frequency with which bigrams that capture physical shocks related to climate change occur in the transcripts of earnings conference calls. We count the number of such bigrams and divide by the total number of bigrams in the transcripts.
Climate Change Exposure Q&A	2002 to 2020	Relative frequency with which bigrams related to climate change occur in the Q&A session part of transcripts of earnings conference calls. We count the number of such bigrams and divide by the total number of bigrams in the Q&A session.
Climate Change Sentiment (Positive)	2002 to 2020	Relative frequency with which bigrams related to climate change are mentioned together with positive tone words that are summarized by Loughran and McDonald (2011) in one sentence in the transcripts of earnings conference calls. We count the number of such bigrams and divide by the total number of bigrams in the transcripts.
Climate Change Sentiment (Negative)	2002 to 2020	Relative frequency with which bigrams related to climate change are mentioned together with the negative tone words that are summarized by Loughran and McDonald (2011) in one sentence in the transcripts of earnings conference calls.
Climate Change Risk	2002 to 2020	Relative frequency with which bigrams related to climate change are mentioned together with the words "risk" or "uncertainty" (or synonyms thereof) in one sentence in the transcripts of earnings conference calls. We count the number of such bigrams and divide by the total number of bigrams in the transcripts.
Climate Change Exposure 10k	2002 to 2020	Climate change exposure constructed by applying algorithm to the "Management Discussion and Analysis" (MD&A) section in firms' annual 10K filings.

Total Emissions	2004 to 2020	Sum of annual Scope 1 and Scope 2 carbon emissions (metric tons of CO_2) at the end of the year. Scope 1 emissions are caused by the combustion of fossil fuels or releases during manufacturing. Scope 2 emissions originate from the purchase of electricity, heating, or cooling. Source: Trucost.

Appendix B: Variables of Climate Risk Measures

Climate Risk related abbreviation used in this study [Source: (Sautner et al., 2023):

Abbreviation	Definition
CC_EXPO	Climate Change Exposure
CC_RISK	Climate Change Risk
CC_POS	Climate Change Positive Impact
CC_NEG	Climate Change Negative Impact
CC_SENT	Climate Change Sentiment
OP_EXPO	Operational Exposure
OP_RISK	Operational Risk
OP_POS	Operational Positive Impact
OP_NEG	Operational Negative Impact
OP_SENT	Operational Sentiment
RG_EXPO	Regulatory Exposure
RG_RISK	Regulatory Risk
RG_POS	Regulatory Positive Impact
RG_NEG	Regulatory Negative Impact
RG_SENT	Regulatory Sentiment
PH_EXPO	Physical Exposure
PH_RISK	Physical Risk
PH_POS	Physical Positive Impact
PH_NEG	Physical Negative Impact
PH_SENT	Physical Sentiment

Appendix C: List of Auditors

The following table lists the auditor codes and the associated auditor names which are used as independent variables in this study (WRDS_Compustat):

Auditor's Code	Auditor's Description (Name)
00	Unaudited
01	Arthur Andersen
02	Arthur Young (prior to October 1, 1989)
03	Coopers & Lybrand (known as Coopers & Lybrand Deloitte in the United Kingdom since April 29, 1990; Coopers & Lybrand merged with Price Waterhouse on July 1, 1998)
04	Ernst & Young (Ernst & Whinney from July 1, 1989 to September 29, 1989; Ernst & Ernst prior to July 1, 1989)
05	Deloitte & Touche (Deloitte, Haskins and Sells prior to December 4, 1989; Haskins & Sells prior to May 1, 1978)
06	KPMG (Peat, Marwick, Mitchell prior to April 1, 1987)
07	PricewaterhouseCoopers (Price Waterhouse prior to July 1, 1998 merger with Coopers and Lybrand)
08	Touche Ross (merged with Deloitte, Haskins and Sells on December 4, 1989)
09	Other
10	Altschuler, Melvoin and Glasser
11	BDO International (BDO USA in North America)(Seidman and Seidman prior to September 1, 1988)
12	BKD LLP (Baird, Kurtz and Dobson prior to June 1, 2001)
13	Cherry Bekaert LLP (Cherry, Bekaert and Holland prior to January 16, 2013)
14	Clarkson, Gordon
15	CliftonLarsonAllen LLP (Clifton Gunderson prior to January 2, 2012)
16	Crowe Horwath
17	Grant Thornton
18	CohnReznick LLP (J H Cohn prior to October 10, 2012)
19	Kenneth Leventhal
20	Laventhol and Horwath
21	RSM (McGladrey LLP prior to October 26, 2015; McGladrey and Pullen prior to May 1, 2012; McGladrey, Hendrickson and Pullen prior to May 1988)
22	Moore Stephens
23	Moss Adams
24	PKF International (Pannell Kerr Foster prior to December 2004)
25	Plante & Moran
26	EisnerAmper LLP (Richard A. Eisner prior to August 16, 2010)
27	Spicer & Oppenheim

Appendix D: Big4 Auditors

The following table lists the big4 auditors which are used as main independent variables in this study: Name of Big4 auditors is widely known in the field of accounting and auditing. However, several previous studies have mentioned the following auditors as Big4 which may be found in these articles (ClientEarth, 2021; Francis & Yu, 2009; I. K. Khurana & K. K. Raman, 2004; Lawrence et al., 2011; Louis, 2005; Magnan, 2008).

Big Four Auditors in the dataset:

Code	Auditor's Name
04	Ernst & Young (EY)
05	Deloitte
06	KPMG
07	PricewaterhouseCoopers (PwC)

Appendix E: Control Variables

The following table lists the control variables used in this study.

Firm-Level Control Variable	Description
RoA	Return on assets (ROA) represents the ratio of EBITDA to the book value of total assets.
Tangibility	Tangibility of assets equals to property, plant, and equipment divided by total assets.
Firm Size	Firm Size is the log value of total assets.
Capex Intensity	Capital Intensity is CAPEX (Capital Expenditure) divided by total assets.
Cash Holdings	Cash holdings is the ratio of cash and short-term investments to the total assets.
Leverage	Leverage refers to the ratio of debt (comprising long-term debt and debt in current liabilities) to the book value of total assets.
Market to Book	Market-to-book is the ratio of the market or fair value of assets to their book value.
Profitability	Profitability is the ratio of EBITDA to total assets.
Extra Firm-Level variable	
S&P Rating	S&P Rank represents the numerical ranking in Stata based on the S&P (Standard & Poor's) ranking, where lower values indicate poorer rankings, and higher values indicate better rankings.
Country-Level Variables	
GDP	Gross domestic product, constant prices as percentage
Inflation	Inflation, average consumer prices as percentage

Appendix F: All Auditors' Data

Tabulation of all auditors in the dataset by Country and year (WRDS_Compustat):

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Country																						
AE	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	1	1	6
AR	0	1	6	5	6	6	5	6	7	7	6	9	7	7	10	13	14	19	19	20	20	193
AT	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1	0	0	0	12
AU	0	0	0	0	7	11	12	11	13	14	12	12	11	12	12	14	15	13	15	13	14	211
BE	0	0	1	1	1	1	2	2	2	2	2	2	2	3	5	4	5	4	4	4	5	52
BM	1	15	29	34	45	54	57	59	57	59	57	57	58	61	61	61	61	58	55	53	52	1044
BR	0	9	23	22	25	24	25	23	21	21	26	29	27	28	27	27	30	33	34	39	37	530
BS	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	0	0	1	1	1	16
CA	8	97	156	172	232	274	324	368	354	352	436	444	314	373	362	342	445	463	457	461	484	6918
CH	3	11	20	20	20	21	20	20	19	19	19	19	21	24	22	23	22	21	22	23	24	413
CL	0	2	10	9	11	11	10	10	9	9	9	10	10	11	12	12	13	13	13	12	11	207
CN	0	1	2	5	19	30	51	78	81	99	103	94	80	83	77	63	77	95	124	128	129	1419
CO	0	0	2	2	2	2	2	3	3	3	3	3	5	5	5	6	6	6	6	6	7	77
CR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	4
CY	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	2	2	3	13
CZ	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	17
DE	2	11	22	20	20	21	20	19	17	17	17	17	17	19	18	19	22	22	28	27	29	404
DK	0	1	5	5	5	4	4	5	4	4	4	4	3	3	4	4	6	6	8	8	8	95
ES	0	2	5	4	7	7	7	7	8	8	7	7	8	7	7	6	7	7	7	7	6	131
FI	1	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	76
FR	1	11	28	28	30	26	26	23	20	20	22	23	24	26	24	27	26	26	27	28	30	496
GB	5	29	60	63	65	63	63	62	60	60	60	64	67	73	77	77	79	86	88	85	89	1375
GG	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	0	0	0	0	0	0	4
GR	0	0	5	5	8	8	9	13	15	11	15	16	11	14	13	8	8	5	6	10	9	189
HK	0	2	4	5	6	10	9	8	9	10	8	11	8	9	8	9	10	10	11	10	12	169

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
HU	0	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	**18**
ID	0	0	1	1	0	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	**27**
IE	4	16	20	21	25	25	28	29	28	28	27	28	22	25	26	26	28	27	29	28	31	**521**
IL	2	17	34	35	38	35	39	39	43	39	40	36	23	34	35	35	43	39	50	53	65	**774**
IN	0	2	6	7	6	7	11	10	8	8	13	15	11	11	11	10	13	13	13	14	13	**202**
IS	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	**7**
IT	0	2	6	7	7	7	6	6	6	6	6	7	6	6	6	7	8	7	7	7	8	**128**
JE	0	0	1	1	1	1	1	1	1	1	2	1	1	1	2	2	2	1	2	2	1	**25**
JO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	**1**
JP	0	2	5	7	9	29	34	33	31	32	34	29	29	27	24	24	28	27	25	23	25	**477**
KR	0	2	2	3	7	10	10	11	10	10	10	9	9	9	9	9	9	8	8	8	11	**164**
KY	0	1	2	2	4	4	6	7	6	7	8	8	8	11	9	7	9	10	11	9	12	**141**
LU	0	3	8	6	6	6	6	4	4	5	6	8	9	9	11	12	13	16	16	16	17	**181**
MC	0	0	0	0	0	1	1	1	1	2	4	7	7	8	9	7	8	9	9	9	7	**90**
MH	0	0	0	0	0	0	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	**13**
MO	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	**3**
MX	1	7	14	9	13	14	14	16	16	13	14	14	12	15	15	13	14	15	15	15	16	**275**
MY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	**1**
NL	1	12	22	21	22	22	22	23	23	21	22	24	24	24	24	24	25	25	24	23	25	**453**
NO	1	2	4	4	4	4	4	4	4	4	4	5	5	5	4	4	4	5	7	7	7	**95**
NZ	0	0	0	0	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	**15**
PA	0	0	0	0	2	1	1	3	3	3	3	3	1	4	4	4	4	4	4	4	3	**51**
PE	0	0	1	1	1	1	1	1	1	1	1	1	2	3	3	3	3	5	5	5	5	**44**
PG	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	**5**
PH	0	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	**21**
PR	0	4	4	4	2	4	2	2	4	8	9	11	9	7	9	9	9	9	9	9	8	**132**
PT	0	1	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	**32**
RU	0	0	4	5	5	7	9	7	7	7	7	7	6	6	6	5	5	5	4	4	3	**109**
SE	1	3	11	10	8	9	9	12	11	11	11	11	12	12	12	11	12	13	13	14	16	**222**

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
SG	1	4	3	3	5	7	7	4	7	9	8	8	8	8	9	6	8	10	10	12	15	**152**
TH	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	**12**
TR	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	**19**
TW	0	4	5	7	9	10	10	10	10	10	11	11	11	9	9	9	8	9	8	8	8	**176**
UA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	**5**
US	278	2,309	2,824	3,013	3,286	3,395	3,534	3,661	3,567	3,518	3,548	3,532	3,228	3,536	3,635	3,452	3,536	3,519	3,524	3,523	3,719	**68137**
UY	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	2	**11**
VE	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
VG	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	2	2	2	1	1	**11**
VI	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	3	1	1	1	0	0	**11**
ZA	1	0	5	5	8	8	10	12	13	10	12	13	12	12	12	13	13	13	13	14	14	**213**
Total	311	2,590	3,373	3,585	3,994	4,197	4,428	4,631	4,521	4,486	4,625	4,629	4,144	4,561	4,651	4,427	4,669	4,699	4,752	4,760	5,017	**87050**

Appendix G: Ordinary Least Squares (OLS) regression:

Above, at first, the OLS regression model is considered to analyse the primary relation between dependent variable (Climate Risk) and Big4 Auditor as the main independent variable including some control variables from firm-level and country-level.

The equation is:

Climate Risk = $\beta_0 + \beta_1$ * Big4 Auditor

$+ \beta_2$ * RoA $+ \beta_3$ * Tangibility $+ \beta_4$ * Firm Size $+ \beta_5$ * Capex Intensity $+ \beta_6$ * Cash Holdings $+ \beta_7$ * Leverage $+ \beta_8$ * Market to Book ratio

$+ \beta_9$ * GDP $+ \beta_{10}$ * Inflation $+ \varepsilon$

Where:

- Climate Risk represents the dependent variable, is measured by Climate Change, which further considers operational factors, regulatory aspects, and physical conditions through exposure, risk, positive, negative, and sentiment categories **(Appendix B)**.

- Big4 Auditor is the leading independent variable, indicating whether a firm is part of the Big 4 accounting firms (with a value of 1 for yes and 0 for no).

- RoA, Tangibility, Firm Size, Capex Intensity, Cash Holdings, Leverage, and Market to Book ratio are firm-level control variables.

- GDP and Inflation are country-level control variables.

- β_0 represents the expected value of Climate Risk when zero is for all other variables.

- β_1 to β_{10} represent the coefficients which may impact the Climate Risk.

- ε represents the error term.

Appendix H: Firm Fixed Effects Regression:

In this analysis, inspired by (Hafiz & Doukas, 2023; Imai & Kim, 2019), we have used Fixed Effects (FE) Regression Model to control unobserved characteristics or heterogeneity of the firms and investigate the relationship involving dependent variable, Climate Risk, and other control variables, with a focus on the main independent variable, Big4 Auditors. Additionally, several control variables are included to account for potential confounding factors.

The model is as follows:

Climate Risk = β_0 + β_1 * Big4 Auditor

   + β_2 * RoA + β_3 * Tangibility + β_4 * Firm Size + β_5 * Capex Intensity + β_6 * Cash Holdings + β_7 * Leverage + β_8 * Market to Book ratio

      + β_9 * GDP + β_{10} * Inflation + α_i* Firm Fixed Effects + ε

Where:

- Climate Risk: This is the dependent variable under investigation, representing a comprehensive measure of climate risk, which considers various dimensions related to climate change and associated factors **(Appendix B)**.

- Big4 Auditors: The primary independent variable (1 for presence, 0 for absence).

- RoA, Tangibility, Firm Size, Capex Intensity, Cash Holdings, Leverage, and Market to Book are firm-level control variables.

- GDP and Inflation are country-level control variables.

- β_0 represents the expected value of Climate Risk when zero is for all other variables.

- β_1 to β_{10} represent the coefficients which may impact the Climate Risk.

- α_i represents firm fixed effects.

- ε represents the errors.

We have included firm FE (α_i) to control unobserved factors that may impact Climate Risk; the Firm Fixed Effects Regression Model may estimate the coefficients (β_0 to β_{10}) and assess their statistical significance while accounting for firm-specific effects (Imai & Kim, 2019).

Appendix I: Two-stage Heckman selection model:

In this empirical analysis, Two-Stage Heckman Selection Model (Heckman, 1979) is used to consider potential sample selection bias in the presence of self-selection among firms which are audited by Big4 accounting firms.

The following variables are considered in this study:

Dependent Variable:

Big4_Dummy: This binary variable takes a value of 1 if a firm is audited by Big4 auditor and 0 if otherwise.

Main Independent Variable in the 1st stage:

S&P Rating: The S&P Rating is considered the primary independent variable in this analysis assuming that it may influence a firm's decision to choose a Big4 accounting firm for auditing. It will capture the firm by rated by Standard & Poor's (S&P).

Other Control Variables:

The following control variables are included to consider various firm-level characteristics that could impact the audit selection process:

RoA: A measure of a firm's strength, may indicate the return generated from a firm's total assets.

Tangibility: This variable reflects the degree of tangibility of a firm's assets, may provide insights into a firm's asset structure.

Firm Size: Measured by log of Total Assets, which could influence the choice of audit.

Capex Intensity (Capital Expenditure Intensity): This variable measures the ratio of capital expenditures to total assets of a firm, may reflect investment decisions.

Cash Holdings: The level of cash liquidity held by a firm, which may affect a firm's financial stability and, consequently, its audit choice.

Leverage: It indicates the level on which a firm determines debt financing, may impact its financial risk profile.

Market to Book Ratio: This ratio measures how the market values a firm's assets related to their book value which may reflect firms' strength and auditor choice.

The Two-stage Heckman selection model is expressed as follows:

First Stage (Selection Equation):

$Z\_i = \alpha_0 + \alpha_1 * \text{S\&P Rating\_i} + \alpha_2 * \text{RoA\_i} + \alpha_3 * \text{Tangibility\_i} + \alpha_4 * \text{Firm Size\_i} + \alpha_5 * \text{Capex\_Intensity\_i} + \alpha_6 * \text{Cash\_Holdings\_i} + \alpha_7 * \text{Leverage\_i} + \alpha_8 * \text{Market\_to\_Book\_i} + u\_i$

Where:

➢ Z_i represents the hidden selection variable that indicate a firm is audited by a Big4 Auditor or not (1 if audited, 0 otherwise).

➢ S&P Rating_i is the S&P Rating for firm i.

➢ RoA_i, Tangibility_i, FirmSize_i, Capex_Intensity_i, Cash_Holdings_i, Leverage_i, and Market_to_Book_i are firm-level control variables.

➢ $\alpha_0, \alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6, \alpha_7, \alpha_8$ are the respective coefficients.

➢ u_i is the error.

Inverse Mills Ratio (IMR):

$\lambda\_i = [\varphi(\hat{Z}\_i)] / [1 - \Phi(\hat{Z}\_i)]$

Where:

$\hat{Z}\_i$ is the predicted value of Z_i from the first stage (probit regression).

Second Stage (Outcome Equation):

➢ $Y\_i = \beta_0 + \beta_1 * \text{S\&P Rating\_i} + \beta_2 * \text{RoA\_i} + \beta_3 * \text{Tangibility\_i} + \beta_4 * \text{Firm Size\_i} + \beta_5 * \text{Capex Intensity\_i} + \beta_6 * \text{Cash Holdings\_i} + \beta_7 * \text{Leverage\_i} + \beta_8 * \text{Market\_to\_Book\_i} + \rho * \lambda\_i + \varepsilon\_i$

Where:

➢ Y_i is the dependent variable; here, 1 if audited by a Big4 firm, 0 otherwise.

➢ S&P Rating_i, RoA_i, Tangibility_i, FirmSize_i, Capex_Intensity_i, Cash_Holdings_i, Leverage_i, and Market_to_Book_i are the same firm-level control variable.

➢ ρ represents the coefficient of the Inverse Mills Ratio (λ_i), that captures the effect of the sample selection bias on the outcome equation.

➢ λ_i is calculated as $[\varphi(\hat{Z}\_i)] / [1 - \Phi(\hat{Z}\_i)]$, where $\hat{Z}\_i$ is the predicted value of Z_i from the probit regression at the first stage.

➢ ε_i is the error term in the outcome equation.

Appendix J: Propensity Score Matching Model:

This model is used to estimate the causal effect of a treatment (Imbens, 2004) in our samples and to control for control variables for matching the control variables between treated and control groups, making them comparable, which may allow us for a more acceptable approximation of the treatment effect (Imai et al., 2008).

The propensity score (e) is estimated using probability regression as follows:

e(X) = Pr (Treatment = 1 | X)

Where:

- ➢ e(X) = Calculated propensity score.

- ➢ Treatment is a binary variable (1 for treated, 0 for control); in our case Big4 Auditor=1, and Non-big4 Auditors=).

- ➢ X = control variables.

We also consider the below variables in the propensity score model:

Big4 Auditor: A binary variable of the Big4 audit firms (1 for audited, 0 for unaudited).

Control Variables: RoA (Return on Assets), Tangibility, Firm Size, Capex Intensity, Cash Holdings, Leverage, Market to Book.

Appendix K: Collected Data

1. Climate Risk Data_OSF.csv
2. Audit Data-2000-2023=st7apkgpztu4ng52.csv
3. Firm-Level Data.csv
4. Firm-Level Data.csv
5. WEO_Data -GDP.csv
6. WEO_Data -Inflation.csv
7. Working.xlsx

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The above work was initially submitted as an Independent Project for the MSc International Accounting & Finance coursework at Swansea University.

COURSEWORK ASSIGNMENT COVER SHEET 2022-23
IMPORTANT: A completed copy of this coversheet MUST be pasted to the beginning of your coursework

STUDENT NUMBER	██████
MODULE CODE and TITLE	2223_MN-D015_Independent Project
ASSIGNMENT TITLE	Firm Level Climate Risk and Big 4 Audit Firms: A Cross Country Study

WORD COUNT (Actual document wordcount, but excluding reference list or footnotes)*: 11,500 Approximately
***Please refer to the Faculty Overlength Wordcount Policy included in your student handbook.*

IMPORTANT:

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- **Work must be submitted in electronic format (Word or other stated format) by the stated deadline. A penalty of zero will be applied for late submission unless you have an approved extension. It is your responsibility to submit the work in the correct format and to ensure that you allow enough time to submit by the deadline.**

DECLARATION
In submitting this assessment, I certify that this is my own work (except, where indicated as group work) and that the use of material from other sources has been appropriately acknowledged in the text. Neither this work, nor any part of it, has been submitted in the same format in connection with any other assessment.
I have read and understood the University's Academic Misconduct Policy and University Proofreading Policy, and definitions including plagiarism, collusion and commissioning therein, and I therefore understand that the consequences of committing Academic Misconduct will result in an investigation for academic misconduct and, if proven, may result in cancellation of marks for the paper, a mark of zero for the module, cancellation of marks for the level of study, or cancellation of all marks and disqualification from the programme.

In making a submission of work for assessment I hereby confirm the above declaration to be true:

Student Number: ██████

Approval Date: 28/06/2023

Research Ethics Approval Number: 1 2023 7290 5974

Thank you for completing a research ethics application for ethical approval and submitting the required documentation via the online platform.

Project Title	MN-D015-MSc dissertation
Applicant name	DR Jafar Ojra
Submitted by	DR Jafar Ojra /

Full application form link https://swansea.forms.ethicalreviewmanager.com/Project/Index/9076

The Humanities and Social Sciences ethics committee has approved the ethics application, subject to the conditions outlined below:

Approval conditions

1. The approval is based on the information given within the application and the work will be conducted in line with this. It is the responsibility of the applicant to ensure all relevant external and internal regulations, policies and legislations are met.
2. This project may be subject to periodic review by the committee. The approval may be suspended or revoked at any time if there has been a breach of conditions.
3. Any substantial amendments to the approved proposal will be submitted to the ethics committee prior to implementing any such changes.

Specific conditions in respect of this application:

The application has been classified as Low risk to the University.

No additional conditions.

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees. It complies with the guidelines of UKRI and the concordat to support Research Integrity.

Humanities and Social Sciences Research and Ethics Chair

Swansea University.

If you have any query regarding this notification, then please contact your research ethics administrator for the faculty.

- For Science and Engineering contact FSE-Ethics@swansea.ac.uk
- For Medicine, Health and Life Science contact FMHLS-Ethics@swansea.ac.uk For
- Humanities and Social Sciences contact FHSS-Ethics@swansea.ac.uk

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