Auditors’ Carbon Risk Consideration under the EU Emission Trading System

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Abstract

This paper addresses the effects of carbon risk on audit pricing. Using data from 438 EU companies over the years from 2013 to 2019, we find a positive relationship between carbon risk and audit fees. Furthermore, we find that the European Union’s Emission Trading System, a limited market and regulation scheme to mitigate special industries’ Greenhouse Gas emissions, strengthens the positive relationship between carbon risk and audit fees. Insights from additional tests indicate that auditors price carbon risk in line with fee premiums rather than additional audit effort and in doing so place greater emphasis on larger companies’ carbon risk. Hence, we conclude that auditors consider carbon risk and carbon regulation as a systematic business risk which results in higher audit fees. With interest in carbon risks and climate change developing rapidly across society, practice and research combined with the increasing importance of reducing carbon risk in future, our findings are timely and should thus appeal to a wide variety of recipients, such as regulators, auditors and fellow researchers.

Keywords: audit fees; audit risk; carbon risk; GHG emission; environmental regulation, EU emission trading systems

1 Introduction

According to the Financial Stability Board, climate change is "one of the most significant, and perhaps most misunderstood, risks that organizations face today" (FSB, 2017, p. 2). Hence, to tackle climate change, which *inter alia* is caused by Greenhouse Gas (GHG) emissions, various stakeholders such as governments, organisations, environmental activist groups, investors and lenders are increasing pressure to mitigate carbon risk, which relates to GHG emissions (Bebbington & Larrinaga-González, 2008; Sariannidis, Zafeiriou, Giannarakis, & Arabatzis, 2013). For instance, in 2005 the European Union (EU) established an Emission Trading System (ETS) to reduce carbon risk. However, it is important to note that increased pressure towards carbon mitigation affects not only companies in general, but also specifically the work of auditors. Whilst regulators and standard-setters are discussing possible carbon related considerations in reporting and auditing standards (Dinh, Husmann, & Melloni, 2021; Financial Reporting Council, 2020; IAASB, 2020), at the same time a large group of investors have submitted a public letter imploring the Big4-auditors to consider carbon related risks. Investors raise concerns that auditors do not pay appropriate attention to these issues, which could have even worse consequences than the financial crisis. A Deloitte spokesperson countered that they *have* understand the importance of these risks and hence have trained their staff accordingly.[1]

In this study, we respond to a recent call for further research into the effects of carbon risk on audit pricing (Eierle, Hartlieb, Hay, Niemi, & Ojala, 2021a) and aim to shed further light on the economic consequences of the EU ETS, which to date has been subjected to comparatively little analysis (e.g. Clarkson, Li, Pinnuck, & Richardson, 2015; Oestreich & Tsiakas, 2015; Patnaik, 2020).

Previous empirical studies provide evidence that carbon risk and carbon regulation affect the considerations of investors and lenders negatively (Chapple, Clarkson, & Gold, 2013; Clarkson et al., 2015; Herbohn, Gao, & Clarkson, 2019; Jaggi, Allini, Macchioni, & Zampella, 2017). Matsumura, Prakash, and Vera-Muñoz (2014) show that on average every additional thousand metric tons of GHG emission reduces the firm value by USD 212,000; furthermore, Jung, Herbohn, and Clarkson (2018) demonstrate that besides carbon risk itself, the respective carbon risk awareness is relevant in the context of lending decisions. While this suggests that carbon risk affects investment and lending decisions, we currently know little about the impact of

[1] For further information and reference see: https://www.reuters.com/article/us-climate change-accounts-exclusive/exclusive-big-four-auditors-face-investor-calls-for-tougher-climate-scrutiny-idUSKBN1Y21XK

carbon risk and carbon regulation on audit pricing, an issue which continues to gain in importance.

Accordingly, we first investigate whether or not carbon risk is associated with audit pricing as a relevant parameter of clients' business risk. Since the 1990s, auditors have been following a risk-based approach to enhance the effectiveness and efficiency of auditing, something which has become part of codified auditing standards (Bell, Doogar, & Solomon, 2008; De Martinis & Houghton, 2019; Niemi, Knechel, Ojala, & Collis, 2018). Thus, its evaluation is an important task during the audit process as clients' business risk is associated not only with their economic standing, but also a likelihood that they will not be able to attain business objectives in future, which is then reflected in audit costs. Hence, auditors respond to clients' increasing business risk with higher audit fees, either to extend audit work and/or charge a risk premium covering the additional risks (Bell, Landsman, & Shackelford, 2001; Pratt & Stice, 1994; Stanley, 2011). We argue that auditors value carbon risk, previously linked only with investors and lenders, as a relevant factor in auditors' business risk evaluations which affects audit pricing due to rising financial constraints and increasing reputational risks. We measure carbon risk as the total, direct and indirect GHG emissions of a company, which follows previous literature (e.g. Naranjo Tuesta, Crespo Soler, & Ripoll Feliu, 2021; Phan, Tran, Ming, & Le, 2021). In addition to evaluating the relationship of carbon risk and audit pricing directly, we secondly analyse the EU ETS' impact on this relationship, given that carbon regulation extends clients' business risk. Due to carbon regulation, existing literature indicates that it may change companies' behaviour (Bartram, Hou, & Kim, 2021; e.g. Cadez, Czerny, & Letmathe, 2019; Patnaik, 2020; Schiemann & Sakhel, 2019). This is then considered by capital markets, which in turn affects companies' firm values (Clarkson et al., 2015) and stock returns (Oestreich & Tsiakas, 2015), thus increasing clients' business risk which will be priced by auditors.

Employing a sample of the European Union's (EU) companies provides a relatively homogeneous regulatory environment (Schiemann & Sakhel, 2019), which enables us to investigate the effects of carbon risk and carbon regulation. Companies with high carbon risks are regulated under the EU ETS and hence receive special political attention (Pinkse & Kolk, 2007). Our sample includes 1,612 firm-year observations from 438 companies in the EU. Of these, 133 firm-year observations are participating in the EU ETS and 1,479 are not. We start our investigation by applying a multivariate regression model using the full sample to investigate the effects of carbon risk on audit pricing. We then conduct our analysis including an interaction term for ETS-participants and carbon risk to measure the influence of carbon regulation.

Our results suggest that auditors take into account only direct GHG emissions. Furthermore, it is indicated that a growth of one standard deviation in Scope 1 GHG emission, leads to an increase in audit fees averaging around 9.3%. Moreover, the positive relationship between carbon risk and audit fees is indeed strengthened by the EU ETS, with participants, particularly larger companies, paying higher audit fees for each additonal unit of GHG emission compared with non-participants. Further analyses suggest that additional audit fees are related to fee premiums rather than additional audit effort. Thus, we conclude that carbon risk and regulatory factors are important determinants for audit pricing. Moreover, our results are robust across different sensitivity tests and sample adjustments.

Accordingly, our study contributes to the current debate in two ways. Firstly, we add to the emerging body of literature covering climate-related consequences on auditing by showing that carbon risk is an important factor within clients' overall business risk. We show that auditors' risk considerations depend not only on physical risks such as drought (Truong, Garg, & Adrian, 2020), but also on carbon risk, for which companies themselves are responsible. In particular, only direct GHG emissions are valued as a critical risk parameter, which should continue to be considered into the future. Secondly, our paper contributes to the understanding of EU ETS consequences (e.g. Clarkson et al., 2015; Oestreich & Tsiakas, 2015; Patnaik, 2020) and also changes how we view carbon prices. We add an in-depth appraisal of more general studies focusing on climate-change related regulation and its impact on auditors in various environments (Li, Simunic, & Ye, 2014; Rabarison, Siraj, & Wang, 2020). Our findings confirm that carbon risk is indeed an important factor for auditors' business risk evaluation and that carbon regulation strengthens the effect, in other words that the contextual setting is relevant for auditors' risk considerations. Thus, our analyses should be of interest to a wide range of recipients.

This paper is organised as follows. In Section 2 we discuss the literature, provide background information on the regulatory setting and develop our hypotheses. Section 3 describes the sample, its selection and explains the study's econometric model. A discussion of our results follows in Section 4 and Sections 5 then concludes.

2 Background and Hypothesis Development

2.1 Carbon Risk and its Regulatory Environment

Jung et al. (2018) see in carbon risk a set of sub-divisions of environmental risks which "describe any corporate risk related to climate change or the use of fossil fuels" (Hoffmann & Busch, 2008, p. 514) and are complex, interdependent and varying across different sectors (Subramaniam, Wahyuni, Cooper, Leung, & Wines, 2015). Any associated stakeholder pressure forms an important determinant of companies' awareness to climate change and efforts to bring about emission reductions (Cadez et al., 2019; Haddock-Fraser & Tourelle, 2010; Lee, 2012; Martin & Rice, 2009). Following Hoffmann and Busch (2008), these risks relate to uncertainties about carbon constraints, which affect the input and output side of a company's value chain, thereby limiting managers' ability to conduct business. The input dimension concerns companies' dependency on fossil fuels, namely their natural scarcity and related socio-political factors such as the change in consumer preferences. Regarding the output dimension, in the first sub-division companies face direct effects induced through physical risks of climate change, such as water shortages. The second sub-division includes indirect effects, which comprise implications from any global climate change regulation, such as the EU ETS or changes to insurance contracts. The resulting carbon constraints arise in the company itself or in its value chain. (Busch & Hoffmann, 2007). Thus, carbon risk, which we define as a subset of climate-related risks, affects various dimensions that can be separated into physical and transition risks (FSB, 2017).

On the one hand, physical risks occur through the consequences of climate change such as droughts, floods, storms and rising sea levels (Jung et al., 2018; Labatt & White, 2007), which potentially affect not just companies, but also complete sectors. Companies not directly affected do nevertheless face physical risks due to production shortages amongst those that are and with which they have trading relationships (Truong et al., 2020). On the other hand, transition risks not directly impacted or motivated by natural disasters contain policy, legal, technological, market and reputation threats, which relate to higher carbon risk awareness amongst society in general, but stakeholders and policymakers specifically. Any resulting transformation towards a low-carbon economy, though, affects companies' financial and reputational risks in terms of technological, regulatory and market changes (FSB, 2017).

However, regardless of the circumstances, these risks influence companies and more widely sectors in different ways. For instance, they are associated with business risks, which occur at company level and refer to competitive, reputational, or legal concerns (Labatt & White, 2007).

Competitive risks refer to the increased likelihood that carbon-intensive products will be superseded by low-carbon equivalents (Allini, Giner, & Caldarelli, 2018; Bebbington & Larrinaga-González, 2008). Reputational risks occur through general market uncertainties, which arise due to a growing carbon risk awareness amongst customers and the different demands of specific products. Moreover, the as yet unfulfilled requirements for a low carbon economy combine to strengthen these market uncertainties (FSB, 2017). Furthermore, reputational risks also originate from losses in brand image, resulting from disregard for the effects of climate change. Hence, these risks could influence future cash flows through damages in operation and competitive market positions (Jung et al., 2018; Labatt & White, 2007). Moreover, the failure to reduce carbon risk or mitigate weaknesses in related disclosures affects legal risks. Studies reveal a recent growth in climate-related litigation claims by property owners, municipalities, states, insurers, environmental organisations and shareholders, which are likely to increase still further over the coming years (FSB, 2017). Regulatory risks also include those related to current and future carbon-regulation and policies, which influence companies' financial performance, for instance through additional compliance costs (Labatt & White, 2007), which affect all companies within a given sector.

In particular, due to its emission trading system the European setting calls for special regulatory requirements from high-emitting companies and hence further carbon-related regulatory risks. To meet requirements set by the Kyoto Protocol in 1997, the EU implemented EU ETS in 2005 to reduce its GHG output (Directive 2003/87/EC; European Commission, 2021d). To date, EU ETS is the world's largest carbon market, covering around 38% the EU's GHG emissions,[2] by minimising the output of more than 11,000 installations and around 600 airlines within the EU[3] (Brouwers, Schoubben, & van Hulle, 2018; European Commission, 2020a; Zhang & Liu, 2020).

In general, any ETS uses a 'cap and trade' system and market mechanism to reduce greenhouse gases by "[c]reating markets on which carbon could be traded (…) this is a process of translating ecological concerns into economic phenomena" (Bebbington & Larrinaga-González, 2008, p. 698). Hence, the regulator does not set restrictions for emissions per company, but instead sets a cap on the maximum GHG emissions permitted within the system. Hence, participants

[2] Meanwhile, it is one of the main mechanisms to attain the goals of the European Commission becoming climate neutral by 2050 (European Commission (2021a)).
[3] It includes installations, which are heavy energy using e.g. power and heat generation, oil refineries, steel works and production of iron, aluminum, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids and bulk organic chemicals and civil aviation (European Commission (2016)).

need to seek allowances for levels of GHG emissions. This they must do by arriving at a balance between reducing GHG emissions and purchasing sufficient allowances to continue their business by complying with regulatory requirements. Moreover, they are able to trade any unused allowances. (Bebbington & Larrinaga-González, 2008; Czerny & Letmathe, 2017; MacKenzie, 2009). Under the EU ETS, one allowance enables one ton of GHG output (European Commission, 2015; Schiemann & Sakhel, 2019).

Since implementation of the EU ETS in 2005, it has passed through different trading phases, characterised by various adjustments. In Phase 1 between 2005 and 2007, system piloting was instigated, which included infrastructure and market price settings. Next, in Phase 2 from 2008 to 2012 the EU ETS was extended to cover the aviation sector (European Commission, 2021b). During the first and second periods, most allowances freely allocated to participants (Clarkson et al., 2015). Phases 3 & 4 (2013 – 2020) were then shaped through changes based on the procedure's further regulatory climate targets and adjustments (European Commission, 2021c). Remarkable changes took place in Phase 3, namely the implementation of an EU-wide cap,[4] despite a prior national setting and shift towards auctioning as a standard allocation procedure for allowances to replace free allocation[5] (European Commission, 2015). For each ton of uncovered emissions from Phase 3 onwards, a penalty of EUR 100 became payable, with the appropriate number of uncovered allowances also needing to be surrendered. Moreover, since the beginning of this third period, reporting and monitoring has been harmonised. Operators of installations and airlines must provide information about their annual emissions, with such reports fulfilling the EU's various requirements, including verification by an independent, accredited auditor (European Commission, 2015, 2020b).[6] Data on freely allocated allowances, verified emissions and surrendered allowances is provided in an publicly available EU Registry[7], which improves the system's transparency due to compliance information (European Commission, 2020b). Phase 4 of the ETS began in 2021 and is planned to run until 2030.[8]

Due to increasing criticism about the system, the EU implemented further stability mechanisms to improve effectiveness. Concerns were to do with the emission cap and the decrease in

[4] In 2013 the cap of stationary installations is 2,084,301,856 allowances and in the aviation sector it is 210,349,264 (European Commission (2020a)).
[5] For further information on the impacts and consequences of free allocation of allowances see in Ellerman et al. (2011).
[6] For further information see European Commission (2015).
[7] The registry is called European Union Transaction Log (EUTL) (European Commission (2020b)).
[8] Further adjustments focusing on the fourth phase include adjustments due to the commitment of the Paris Agreement signed in 2015 i.e. the reduction of emissions of about 40% compared to the 1990 level (European Commission (2015, 2021d)).

allowance prices, particularly during 2008/2009 (covering the financial crisis) (European Environment Agency, 2010; Schiemann & Sakhel, 2019). These developments made the imposition of trading conditions for most companies unnecessary (Pinkse and Kolk 2007), which led to a simplification of compliance with the system. Hence, to counter this the EC implemented a market stability reserve to reduce the number of available allowances. Moreover, the cap continued to decline from 2013 to 2020 at an average annual rate of 1.74% and from 2020 onwards a reduction of 2.2% is recorded.[9] Beyond that, these adjustments and the accompanying increases in allowance prices is affecting management behaviour within companies involved in the system (Naranjo Tuesta et al., 2021).

In summary, carbon risk covers those constraints that affect companies due to physical risks and changes in the technological, legal and market environment. Moreover, political and hence regulatory requirements are continuing to be adjusted and will be further risk factors for affected companies. We conclude, therefore, that carbon risk and the EU's regulatory environment is suitable for evaluating the consequences of a key climate change driver, namely carbon risk.

2.2 How carbon risk affects auditors?

To date, the role of carbon risk in audit risk assessment is limited (Eierle et al., 2021a). On the one hand, certain studies seek to understand the effects of reputational risk within ESG reporting, CSR awareness and CSR performance from an audit perspective. Negative environmental factors, measured as the media coverage of ESG problems and damaged ESG reputation, lead to higher audit effort and audit fees (Asante-Appiah, 2020; Burke, Hoitash, & Hoitash, 2019), as well as environmental initiatives, which are also positively associated with audit effort (Sharma, Sharma, & Litt, 2018). LópezPuertas-Lamy, Desender, and Epure (2017) evaluate the association between a risk of material misstatement assessed by the auditor and a company's related CSR performance. They show a u-shape relationship between audit fees and CSR-performance, arguing that at a certain point the increase in CSR performance raises auditors' suspicions about the possible opportunistic use of CSR, which is then reflected in higher audit fees.

On the other hand, research also focuses on the effects of physical risks. Truong et al. (2020) examine whether or not external risks extend a client's overall audit risk. Based on a sample of U.S. companies, they find that drought, which is defined as a physical external risk, leads to higher audit fees. In sum, extant literature documents a largely positive relationship between

[9] The yearly reduction of the cap affects in phase 3 only EAUs (allowances for stationary installations) and from 2021 onwards stationary and aviation allowances (European Commission (2021c)).

reputational risks due to overall ESG and physical risk and audit pricing. By contrast, in this study we focus narrowly on carbon risk and its consequences in regard to auditors' behaviour. As previously described, carbon risk has become one of the central interests for governments and regulators, as well as other stakeholder groups (Jung et al., 2018).

We conjecture that carbon risk has become a relevant business risk factor, which consequently is now being considered by auditors. Companies with higher carbon risk are under increased pressure to eliminate outdated production systems and invest in new technologies with more energy efficient production capabilities (Henriques & Sadorsky, 2007; Sprengel & Busch, 2011; Weinhofer & Hoffmann, 2008). This in turn increases production costs and possibly leads to losses in market share. Moreover, any change towards low carbon production facilities is slow and complex (Nguyen, Truong, & Zhang, 2020). Hence, the transformation process to climate-friendly products generates risks, for example end-users questioning the quality of products, price increases or accompanying marketing activities, which could lead to sales decreases (Sharma et al., 2018). Furthermore, there is an increased likelihood that products with a carbon intensive production will become outdated or obsolete more quickly than climate friendly products (Bebbington & Larrinaga-González, 2008; Kolk & Levy, 2001; Kolk, Levy, & Pinkse, 2008). Hence, the displacement of products mitigates against former competitive positions and the associated cash flows of affected companies (Krueger, Sautner, & Starks, 2020). Besides the rise of abatement and innovation costs, the expected expenses for research and development increase for companies with high carbon risks (Sharma et al., 2018). Previous literature shows that carbon risk also affects the cost of debt and equity negatively (Jung et al., 2018; Matsumura et al., 2014). Similarly, with regard to legal risks some studies provide evidence that the level of carbon risk adversely impacts company cashflows, with possible legal costs and reputational damages also following (Nguyen et al., 2020; Thompson, 1998; Weber, 2012). For example, Karpoff, Lott and Wehrly (2005) show that it is more likely for companies with high carbon risks to harm environmental regulations, because their actions towards carbon emission reduction activities are small. This leads to consumer boycotts or lawsuits and hence lower current or future cash flows companies affected (Jung et al., 2018; Nguyen et al., 2020). In short, carbon risk negatively affects cash flows and thus enlarges financial constraints.

A number of studies suggest that the financial condition of the client affect the auditors risk assessment and audit fees (Bell et al., 2008; e.g. Pratt & Stice, 1994; Stanley, 2011). Simunic (1980) shows in his seminal paper that audit fees are the total expected costs of performing an audit, including the auditing hours expended and allowances made for future losses, for instance litigation risks. Due to the risk-based audit approach, it is important to evaluate clients' business risk, which is a relevant determinant in overall audit risk and determines audit costs (LópezPuertas-Lamy et al., 2017). Clients' business risk is defined as the risk that companies' economic condition will be impaired to the extent that business objectives in future will not be attained (De Martinis & Houghton, 2019; Johnstone, 2000). Thus, this assessment requires a deep and wide understanding of clients' business environments to evaluate risks relating to industry conditions, regulatory environment, business model, technological change, strategies and further external factors which can impact business objectives (Bell et al., 2008; De Martinis & Houghton, 2019). An increase in clients' business risk could result either in additional audit work, greater audit effort and/or a risk premium[10] covering the additional risks of expected future losses (e.g. through litigation risks) (Bell et al., 2001; Pratt & Stice, 1994; Stanley, 2011). Moreover, the audit procedure could affect auditors' own business risk, depending on whether auditors generate a loss resulting from the engagement (Johnstone, 2000) or the financial statement includes a material misstatement, which leads to litigation risks through threatening suits that are induced through investors. Both results in defence or settlement costs and reputational losses in regard to maintained misconduct, regardless of any law suits' ultimate findings (Eierle et al., 2021a; Palmrose, 1991; Stanley, 2011).

We argue that the components of carbon risk – policy and legal, technology, market and reputation issues – create uncertainty for clients' not only in terms of current and future cash flows, but also ultimately because of increasing business risks. In light of higher business risks, auditors will extend their audit work and/or charge a fee premium to compensate for the additional risks. Prior research provides support for this argument in the case of drought (Truong et al., 2020). Hence, we present the following first hypothesis:

H1: Companies with higher carbon risk paying higher audit fees.

While little literature exists on the effects of carbon risk and audit fees, some initial evidence has been presented that evaluates the impact of carbon regulation on auditors' behaviour. Li et al. (2014) argue that the company's environmental risk represents a key factor within its overall business risk and hence audit fees are higher for companies with greater environmental risk exposure. Thus, they take into account the different environmental regulations which a client faces and any related toxic emissions. They additionally investigate the impact of environmental regulation from the perspective that environmental exposure is higher in

[10] The risk premium presents an additional fee, which is charged from the auditor to compensate higher risks referring higher litigation risks or higher likelihood of audit failure of the audit assignment e.g. Niemi (2002); Bell et al. (2008); Niemi et al. (2018).

countries with stricter environmental regulation (Li et al., 2014). Rabarison et al. (2020) show that companies which act in environments with stricter environmental regulations are able to mitigate their business risks through better and more effective risk management as well as innovations. Accordingly, they pay lower audit fees than companies acting in a less regulated environment (Rabarison et al., 2020). Furthermore, clients operating in high polluting industries, albeit with low media attention, pay higher audit fees if they do not comply with reporting requirements (Yao, Pan, & Zhang, 2019). You, Wu, Le Luo, Shen and Tan (2021) show that the implementation of an ETS in China has provided a bargaining factor for auditors.

We contend that for all companies carbon risk is a business risk factor, which will be considered in audit pricing. In addition, recent literature provides evidence that regulatory concerns affect clients' business risk considerations. Hence, we argue that companies under the EU ETS face greater risks, more complex accounting behaviour and extended public pressure, which will increase with greater carbon risk and thus result in higher related audit fees.

For companies with high carbon risks, the risk of growing regulatory stringency from existing regulation and exposed climate policies in future increases (Schiemann & Sakhel, 2019), which in turn extend mandatory ETS participants' compliance costs. For instance, compliance requirements for ETS participants reflect: the change towards auctions and thus the reduction of free allocated allowances; the implementation of additional reporting requirements; and the reduction of available allowances due to the market stability reserve. Companies are forced to establish internal control mechanisms, deal with ETS transaction costs and handle market weaknesses, such as volatilities and interrupted supply as well as demand for allowances (Li et al., 2014; Matisoff, 2010; Patnaik, 2020). The increase of allowance prices is then reflected in related costs (Sprengel & Busch, 2011). Furthermore, the EU ETS regulation includes explicit fines for participants that do not comply with the system. These penalties increase in accordance with rising amounts of allowances that have not been surrendered. We expect in particular, that companies with higher carbon risk face extended compliance costs and greater pressure to invest in low carbon technologies, which is supported by prior literature (Chapple et al., 2013; Clarkson et al., 2015; Naranjo Tuesta et al., 2021). Any risks related to disregard for compliance and market uncertainties increase with higher carbon risks and thus financial constraints are extended.

In any event, accounting for allowances coupled with the possibilities of banking and trading allowances can create a complex process. The study of Schaltegger and Csutora (2012) suggests that carbon accounting becomes a challenge for various groups such as professionals, departments and organisations, because it affects *inter alia* accounting behaviour and participants' financial terms (Schaltegger & Csutora, 2012). Black (2013) and Allini et al. (2018) demonstrate that accounting under an ETS environment is especially challenging. They find key differences in regulation and accounting behaviour between the various EU ETS participants. Mismatches in accounting regulation are caused by a lack of comparable accounting rules, for example as provided by the International Accounting Standards Board (Allini et al., 2018; Giner, 2014), for which it follows the implementation of national standards. Furthermore, companies apply their own accounting solutions, an aspect which also reduces accounting comparability (Allini et al., 2018). In short, studies suggest that accounting for carbon allowances is challenging due to various accounting choices, which increases the complexity of reporting and accounting requirements.

Following previous literature, auditing tasks which are more complex require additional audit resources and audit hours to safeguard audit quality. (Beattie, Goodacre, Pratt, & Stevenson, 2001; Bonner, 1994; Garcia, Villiers, & Li, 2021). Based on the assumptions of Simunic (1980), an increase in audit hours and additional audit resources will increase audit fees due to ambiguities in carbon allowances' accounting and reporting. With higher carbon risks and the context of a risk-based auditing approach, the relevance of these accounting and hence auditing tasks increases, which in turn elevates risks both for clients and auditors. To tackle this extended risk of significant errors or fraud in financial statements, auditors will be forced to expend greater audit effort, which may result in additional audit fees and/or pricing a risk premium for additional risks.

An additional consideration for auditors is that ETS participants face greater pressure to legitimise their actions. Based on socio-political theories, those companies affected are viewed more closely by various stakeholders, for instance governments, customers, organisations and employees. If they do not comply with the ETS and show no progress in reducing carbon emissions, reputational damage could follow, especially in light of increasing public awareness regarding carbon issues as well as pressures from a variety of stakeholder groups (Kolk et al., 2008; Schiemann & Sakhel, 2019; Sprengel & Busch, 2011). Sprengel and Busch (2011) argue that large companies with high carbon risks are greatly influenced by any future carbon regulation, which increases their actions towards stakeholder pressure. Moreover, previous literature shows that in general terms investors are now more likely to factor into their investment decisions any carbon-related information, as documented for ETS participants. Hence, risks due to legitimacy and reputational concerns are seen as increasing (Griffin, Lont,

& Sun, 2017; Matsumura et al., 2014; Schiemann & Sakhel, 2019). However, based on assumptions within auditors' risk-based auditing approaches, we can expect that they are equally aware. Thus, we expect that ETS participants with higher carbon risks face greater pressure towards carbon awareness, which increases clients' business risks due to reputational concerns, as documented in previous literature (e.g. Burke et al., 2019).

Accordingly, we suggest that the EU ETS regulatory environment will strengthen the positive relationship between carbon risk and audit fees. Any regulatory burdens are enhanced in line with higher carbon risk due to greater financial constraints related to compliance costs and market uncertainties as well as rising reputational risks. Moreover, the complexity of carbon accounting extends the risk of material errors in financial statements. In sum, as referred to earlier, we expect that these factors will influence auditors' business risk considerations and bring about increases in audit fees to compensate for higher audit effort and/or fee premiums. Thus, we formulate our second hypothesis as follows:

H2: For companies participating in the EU ETS, higher carbon risk is associated with higher audit fees.

3 Research Design und Sample

3.1 Sample Selection and Data Collection

We use a sample of EU companies, distinguishing between EU ETS participants and non-participants to test our hypotheses. To mitigate the effects of regulatory changes between the various EU ETS trading phases, we select a time period from 2013 to 2019. Our sample includes all EU companies for which complete data is available in Audit Analytics Europe, Thomson Reuters Datastream and Thomson Reuters Eikon databases. We begin by retrieving data from the Audit Analytics Europe database which comprises complete audit details from 39,291 firm-year observations. From this data, we obtain financial information using company ISINs in Thomson Reuters Datastream database, removing those observations which lacked details of total assets. We rerun the procedure to gather GHG emission related data in Thomson Reuters Eikon database, removing observations for those companies without information about total, direct and indirect GHG emissions. From the residual sample of 13,846 observations, we then eliminated further details due to relevant missing data in the matched samples, which resulted in a total of 2,106 firm-year observations. Thereafter, we break down our sample into ETS and non-ETS participants, as verified by the EUTL, following which the registered names of installation holders were matched with company names.[11] Matches are identified as EU ETS participants and thus by deduction the remainder as non-ETS participants. Due to distinct corporate governance structures and divergent financial reporting requirements (Asante-Appiah, 2020), we exclude financial firms (sic codes beginning with 49*) and public utilities (sic = 6***). Moreover, we exclude non-EU firm-year observations to create a sample which is comparable and homogenous in terms of regulatory burdens. Accordingly, the final sample covers 438 organisations generating 1,612 firm-year observations. Table 1 summarises the composition of our sample as we use in this study.

[Insert Table 1 around here]

3.2 Model Description and Variables

Next, to evaluate the effects of carbon risk on audit fees, we apply the findings of previous audit literature (Burke et al., 2019; e.g. Hay, Knechel, & Wong, 2006; Truong et al., 2020) and related studies (Busch, Bassen, Lewandowski, & Sump, 2020; e.g. Clarkson et al., 2015; Oestreich & Tsiakas, 2015) by use of a multivariate analysis framework and derive control variables. It is highly likely that these well-known determinants of audit fees will have an impact on our model. Equation 1 here presents the regression model, with the variables being defined below.

$$l\_audfee_{i,t} = \beta_0 + \beta_1\, carbon\_risk_{i,t} + \sum_{j=16}^{16} \beta_{j+1}\, controls_{i,\,t} + Year\_FE + Industry\_FE + Country\_FE + \varepsilon \qquad (1)$$

The dependent variable is the natural logarithm of audit fees paid to the external auditor (*l_audfee*) and is constructed in line with prior auditing studies (Hay et al., 2006; Sharma et al., 2018). It is a commonly applied proxy to measure audit effort and the risk evaluation of the auditor.

Carbon risk is proxied as the GHG emissions, which follows previous literature. We apply the natural logarithm of GHG emissions to use normalised values (Bartram et al., 2021; Delmas, Nairn-Birch, & Lim, 2015; Naranjo Tuesta et al., 2021; Phan et al., 2021). Hence, we calculate the natural logarithm of total GHG emissions (*co2_ln*), of Scope 1 GHG emissions (*scope1_ln*) and indirect GHG emissions (*indirect_ln*) to come up with emission data's skewed distribution. Scope 1 emissions display the company's direct GHG emissions, in other words a consequence of direct operations or sources owned by the company responsible. These emissions are

[11] For matching procedure, we use the matching algorithm of the Amadeus database. The matched companies are completed with their ISIN.

regulated under the EU ETS for mandating participants. Whereas, the sum of Scopes 2 and 3 GHG emissions shows a company's indirect emissions, which are not regulated or monitored under the EU ETS (Busch et al., 2020), indirect emissions stem from acquired sources such as electricity and other sources of GHG emissions (Delmas et al., 2015). Moreover, we measure the total GHG emissions as the sum of reported Scopes 1, 2 and 3 GHG emissions output. Before applying the natural logarithm, each continuous variable is winsorised at the 1% level.

Next, we include a set of various control variables, which we adapt from previous literature (Barua, Hossain, & Rama, 2019; Burke et al., 2019; Eierle, Hartlieb, Hay, Niemi, & Ojala, 2021b; e.g. Hay et al., 2006; Truong et al., 2020) and are widely known as factors that affect the price setting of the audit procedure. We control for the following client-specific variables. They include firm size (*size*), together with proxies for business complexity (*segments*) and inherent client risk (*recInv*). Moreover, we capture profitability measurements (*roa, loss*), the companies' leverage (*lev*), quick ratio (*current*) and the ratio of market to book value (*mvbv*). The model also contains proxies for growth (*growth*) and foreign activities (*forSales*).

Aside from client specific attributes, we control for auditor and engagement specific attributes by including an auditor change variable (*change*) and measuring whether or not clients' year-ends terminate during their busy season or not (*busy*). In addition, we include auditor firm size (*big4*), a variable capturing whether or not a restatement has been reported in the past (*restatement*), and a proxy for non-audit services (*n_audfee*). Finally, we include audit reporting lag (*arlag)* to capture possible problems, which can arise during the audit process and whilst not relate to GHG emissions, do affect the value of audit fees (Hay et al., 2006).

In line with prior studies, we predict a positive relationship on audit fees for *size, segements, recInv, loss, busy, big4, forSales*, *n_audfee*, *mvbv*, *ratioAsset*s, *growth* and *restatement* (Asante-Appiah, 2020; e.g. Hay et al., 2006; Truong et al., 2020). In addition, we expect that the variables *roa, current* and *change* relate negatively to audit fees (e.g. Hay et al., 2006; LópezPuertas-Lamy et al., 2017). Moreover, we include year and industry fixed effects to control for unobservable temporal and industry specific variations within the sample. We cluster the relevant industries in accordance with their two-digit SIC codes. Finally, we control for country-specific effects. All regression models are estimated with firm clustering, continuous control variables being winsorised at the 1% level.

To test the second hypothesis, we adjust Equation 1 and add the indicator variable *ets_part* and interaction terms to evaluate the impact of the EU ETS on the relationship of carbon risk and audit fees. The control variables and fixed effects are unchanged. Thus, we apply the following regression model:

$$l\_audfee_{i,t} = \beta_0 + \beta_1\, carbon\_risk_{i,t} + \beta_2 ets\_part_{i,t} + \beta_3 carbon\_risk_{i,t} * ets\_part_{i,t} + \sum_{j=16}^{16} \beta_{j+1}\, controls_{i,\,t} + Year\_FE + Industry\_FE + Country\_FE + \varepsilon \quad (2)$$

The definitions of variables are identical to those in Equation 1, with the addition of variables *ets_part* and the interaction terms *carbon risk*ets_part. ets_part* is an indicator variable that equals 1 if a company is participating in the EU ETS and 0 otherwise. The interaction terms are calculated based on previously applied carbon risk variables (*co2_ln*, *scope1_ln*, and *indirect_ln*) multiplied by *ets_part*.

3.3 Descriptive Statistics

Table 2 Panel A shows that the final sample covers 16 out of the then 28 EU[12] member states, with Great Britain, Germany and France providing the most observations. Out of the 133 ETS participating firm-year observations, more than 50% stem from these three countries. Table 2 Panel B presents the sample distribution by industry sector. Manufacturing sectors comprise 45% of the full sample and constitute 72% of all ETS participating firm-year observations.

[Insert Table 2 about here]

Table 3 shows summary statistics for the variable of interest, plus dependent and control variables. Panel A presents the GHG emissions' descriptive statistics, which show that the total containing Scopes 1, 2 and 3 GHG emissions is on average 17.70 million tons. The mean of total GHG emissions for an ETS participant is 37.29 million tons and hence on average higher than the mean of a non-participating company (15.94 million tons). The mean (median) of *co2_ln* is 13.15 (12.81). The mean (median) of the natural logarithm of Scope 1 GHG emissions is 11.03 (10.94) and the mean (median) of *indirect_ln* is 12.71 (12.28). Table 2 Panel B presents the mean (median) of the dependent variable *l_audfee*, which is 14.64 (14.62) and generally consistent with prior literature (e.g. Burke et al., 2019). The mean (median) of *l_audfee* of the ETS participants is 15.27 (15.54) and therefore larger than for non-ETS participants, which provide on average a natural logarithm for audit fees of 14.59 (median 14.57). On a univariate

[12] At the end of 2019, the United Kingdom was a member of the EU. For further information, see https://ec.europa.eu/info/strategy/relations-non-eu-countries/relations-united-kingdom/eu-uk-withdrawal-agreement_en.

analysis, figures show that the audit fees of non-ETS participants are lower than those in the system. This implies that auditors evaluate the relevant business risk of ETS participants higher and hence charge higher audit fees compared to non-ETS participants. Moreover, the size of the average ETS participant is larger (mean of the natural logarithm of total assets is 16.69) compared to non-ETS participants with an average size of 15.44 and therefore it is important to control for these factors. The relevant results are presented in the next section.

[Insert Table 3 about here]

Table 4 presents correlation coefficients between the variable of interest *l_audfee*, the proxies of GHG emissions, ETS participation and the control variables of the regression models. Coefficients in bold are significant at the 5% level. The correlation between *l_audfee* and *co2_ln* is positive for Scope1 GHG emissions and indirect emissions respectively. It indicates that companies with a higher carbon risk pay higher audit fees. The results are on a univariate analysis and show only initial evidence. Aside from that, correlation coefficients between various GHG emission proxies are highly correlated, which do not have an impact on further analysis, because the various proxies are not applied in one model. Further correlation coefficients of our independent and control variables are under the critical threshold of 0.80 (Kennedy, 1998), except for the correlation between *l_audfee* and *size*, which extends the critical threshold. This is in line with previous literature that for company size reports a high relevance for audit pricing (Hay et al., 2006). Furthermore, we capture the variance inflation factors (VIF) of the model variables, which are all below the critical threshold of 10 (Wooldridge, 2020). Thus, results indicate that multicollinearity should not be a problem in our analysis.

[Insert Table 4 about here]

4 Empirical Results

4.1 Main Results

The results of estimating Equation 1 are presented in Table 5, which evaluates the effects of carbon risk on auditors' price setting. We predict a positive relationship. Each column (1) – (3) shows results relating to the various proxies of GHG emissions. The models have an explanatory power of about 86%. The second column, which presents the results of regressing Scope 1 GHG emissions on audit fees, shows a positive significant relationship (p-value < 0.01). These findings support H1 and are also economically significant. The coefficient of *scope1_ln* in Table 5, column 2, indicates that a growth of one standard deviation in Scope

1 emissions leads to an increase in audit fees of about 9.3% on average, while all other variables remain constant.[13] Assuming an average level of audit fees in our sample of EUR 5,043,677, an increase of 9.3% equates to an increase of EUR 469,062. Interestingly, the results of column (1) and column (3) show no significant GHG related coefficients. Thus, it suggests that auditors are more likely to value direct GHG emissions as a critical business risk parameter than the total or indirect GHG emissions. Concluding that only Scope 1 GHG emissions are regulated under the EU ETS, results support our expectation that environmental regulations affect clients' risk evaluations and hence the audit procedure's pricing, which we evaluate in more detail under H2. The outcome of our control variables is generally as expected.

[Insert Table 5 about here]

For companies participating in the EU ETS, H2 predicts that higher carbon risk is related to higher audit fees. Table 6 presents these results in estimating Equation 2. Coefficients of the interaction terms are positive and significant at the minimum 10% level for all models. Column (1) presents the interaction term of total GHG emissions and column (3) the indirect GHG emissions. The interpretation for Scope 1 GHG emissions (column (2)) is as follows. Results of the interaction term *scope1_ln*ets_part* show a positive significant relationship on audit fees (p-value < 0.05), which indicates a difference between ETS and non-ETS participants. As the interaction term's coefficient is positive and larger than the coefficient of *scope1_ln*, it implies that ETS participants pay higher audit fees per additional unit of Scope1 GHG emissions compared to non-ETS participants. Hence, a growth of one unit of Scope 1 GHG emissions from EU ETS participants leads to an increase of (+0.030 + 0.089=) 11.9% in audit fees. This interpretation could be applied to total GHG emissions and indirect GHG emissions. Thus, results support our assumptions, as discussed in the hypothesis development for H2: firstly, there are higher compliance costs; secondly a complex accounting procedure results; and thirdly increased stakeholder pressure on ETS participants significantly increases the business risk of clients under the EU ETS, to which auditors respond with higher audit fees. In short, auditors include risks related to carbon regulation in their risk evaluation as being systematic, which moderates the relationship of carbon risk and audit fees positively.

[Insert Table 6 about here]

[13] 0.093 = 2.917 * 0.032, in which 2.917 presents the standard deviation of *scope1_ln* and 0.032 is the estimated coefficient of *scope1_ln*.

4.2 *Additional analyses*

4.2.1 Does carbon risk lead to greater audit effort?

Next, we gather additional insights into the relationship between carbon risk and audit fees. Companies with higher carbon risk, especially those participating in the EU ETS, pay higher audit fees which, as argued earlier, result from additional audit work and/or a fee premium to cover further risks. Hence, we evaluate whether auditors value carbon risk and carbon regulation by pricing in their associated risks or performing additional audit effort. When auditors face clients' extended business risks or complex auditing environments, the audit procedure may expend more auditing hours. Alternatively, auditors will price the additional risk as a premium (Asante-Appiah, 2020; Knechel, Rouse, & Schelleman, 2009; Sharma et al., 2018). We posit that carbon risk is a business risks which may not directly have an impact on the audit procedure, so the increase in audit fees presents a fee premium rather than additional audit effort. Prior research provides evidence for this assumption (Sharma et al., 2018). Moreover, we expect that the strengthening effect of carbon regulation is mainly driven by increasing financial constraints and reputational risks and rather by complex accounting procedures, which as well implies that additional audit fees present a fee premium. Data on the actual number of audit hours is not publicly available. Thus, drawing on previous studies, we replace the dependent variable in Equations 1 and 2 with audit reporting lag (*arlag*), a widely accepted measure for calculating audit effort as the number of days between a client's fiscal year end and the audit opinion's date of signature (Asante-Appiah, 2020; Truong et al., 2020).

Our untabulated regression provides nothing of significance in regard to the variables of interest. *co2_ln*, *scope1_ln*, and *indirect_ln* are not significantly related to *arlag*. These findings do not provide evidence that either carbon risk or carbon regulation is positively related to greater audit effort ($p > 0.10$). Thus, we infer that auditors do not extend their audit work during the audit process. In fact, they tend to price the risk of carbon or rather the effects of carbon regulation as a fee premium.

4.2.2 Does company size affect carbon risk considerations?

Existing literature suggests that stakeholder pressure could influence clients' carbon risk awareness and thus their behaviour towards carbon reduction (e.g. Cadez et al., 2019; Patnaik, 2020). For instance, external stakeholder pressure, which is driven by regulators, community and environmental groups, customers and suppliers, increases the probability that facilities will use cleaner technologies (Henriques & Sadorsky, 2007). Moreover, Sprengel and Busch (2011) show that company size and its carbon risk affects actions resulting from stakeholder pressure.

Due to higher dependency on further carbon regulation, these companies are keen to be involved with discussions on future regulation and thereby demonstrate publicly their commitment to reducing GHG emissions. This indicates that these companies in particular face increased reputational risks, because they face greater stakeholder pressure, which will heighten their business risks. As argued above, we expect that increases in clients' business risks will be considered by auditors, which will result in higher audit fees to compensate for more audit work and/or pricing fee premiums for higher risks. In the following additional test, we explore whether or not client size affects auditors' carbon risk evaluations (H1) and whether or not it affects carbon regulation's strengthening impact (H2).

We divide our sample into two subgroups and use a median split on our size variable to differentiate between large and small companies. As shown in Table 7 Column (2) Panel A, we find that only the coefficient of direct GHG emission (*scope1_ln*) of large companies is significant (p-value = 0.058). In addition, Table 7 Column (2) Panel B demonstrates that direct GHG emissions (*scope1_ln*ets_part*) of large companies strengthen the effect of carbon regulation (p-value = 0.039). Hence, clients' size and the extent of carbon risk has a strong impact on audit pricing when the level of carbon risk increases. This suggests that auditors may adapt their actions in line with stakeholder and political pressures by charging these clients more by way of compensation, which is in line with the previous findings of Sprengel and Busch (2011).

[Insert Table 7 around here]

4.3 Robustness of Results

As a final step in this section, we perform a number of robustness tests to consider the sensitivity of our results and any inferences. In sum, the tests support our initial findings and conclusions.

4.3.1 Sensitivity to Special Industries

We analyse the effect of carbon risk associated with audit fees for specific industries, considering that carbon risks do not influence all clients in the same way. Some industries are more vulnerable to carbon constraints due to their business models, in particular those which major on manufacturing high emitting products, for instance cement. Hence, the EU has established special programmes within the EU ETS to mitigate the consequences of carbon risk and carbon regulation in the short-term and medium-term (European Commission, 2020a). For instance, Veith, Werner and Zimmermann (2009), show that companies in the energy sector under EU ETS can pass on their regulatory burdens and generate additional profits by overcompensating for the relevant costs. Hence, we argue that companies within the manufacturing sector, which includes the energy sector, may face lower financial constraints and market uncertainties related to carbon risk. It is shown that our results are indeed influenced if the sample includes a considerable number of firm-year observations with supported industries and if indeed carbon risks and associated regulatory risks are proprietary to a very low degree. However, to control for this we exclude manufacturing sector observations, which comprise more than 70% percent of all EU ETS participants, and then rerun our regressions. The results provided in Table 8 show that the sign remains unchanged, in line with our main analyses.

4.3.2 Subsample Analyses excluding large Countries

While in our main sample more than 30% of the firm-year observations stem from British companies, we perform further tests to ensure that our results are not driven by country specific effects. Accordingly, we examine our first and second hypotheses again after having removed observations related to the UK.

As shown in Table 8, Panel A Columns (4) – (6), using a subsample of 1,112 firm-year observations, the results of Equation 1 show a positive and significant association between *scope1_ln* and audit fees (p-value < 0.10). Additionally, we record in Table 8, Panel B Columns (4) – (6) positive and significant coefficient on the interaction terms *co2_ln*ets_part* (p-value < 0.1) and *scope1_ln*ets_part* (p-value < 0.05). In sum, all signs on the variables of interest remain the same.

[Insert Table 8 around here]

5 Conclusion

Various stakeholders such as investors, customers and employees are increasing pressure on companies to reduce carbon risk (Dinh et al., 2021; Downar, Ernstberger, Reichelstein, Schwenen, & Zaklan, 2021; Liesen, Hoepner, Patten, & Figge, 2015; Sprengel & Busch, 2011). Moreover, the number of regulatory mechanisms implemented globally have been increased to tackle carbon risk (World Bank, 2022).

In this study, we investigate how carbon risk affects auditors' risk considerations and whether or not the establishment of an ETS, which uses the carbon price to reduce GHG emissions, affects audit pricing. We reason that carbon risk extends clients' financial constraints due to changes in consumer behaviour, increasing legal risks as well as rising abatement and innovations costs, which will enhance clients' business risk to which auditors will reply with higher audit fees. Moreover, we argue that the EU ETS will enlarge clients' business risks due to additional compliance costs, complex accounting processes and increasing pressure on ETS participants to legitimise their actions. Using a sample of EU companies, we find a positively significant association between Scope 1 GHG emissions and audit fees, which indicates that auditors consider only direct GHG emissions as a relevant risk parameter. Furthermore, our results provide evidence that ETS participants for each additional unit of GHG emissions pay higher audit fees compared to non-ETS participants. Additional tests imply that the increase in audit fees is related to a fee premium rather than additional audit effort. The relevant risk evaluations of carbon and carbon regulation are more prominent for large companies. Accordingly, we conclude that auditors include carbon risks as a systematic factor in their risk assessment, which is important against a background of increasing carbon regulation implementation globally. Accordingly, calls for a worldwide carbon price are taking on greater importance as well as the pressure towards carbon reduction.

The results of our study should be considered with the following limitations in mind. Firstly, results are based on archival data, thus the findings do not necessarily show causal relationships. Moreover, the nature of data necessarily describes circumstances of the past (third trading period). Due to wide adjustments in the EU ETS[14] over recent years and the associated changes in the fourth trading period, beginning in 2021, future research could evaluate whether or not such adjustments affect these research topics. Secondly, we do not include details about the accounting and reporting behaviour of carbon risk and EU ETS allowances, which could be important for auditors' risk evaluation. Further research could investigate whether or not these factors influence the audit procedure and thus audit fees. Moreover, we do not investigate the audit process of carbon risk and thus its financial implications. Hence, field studies could be applied to gather additional insights into the audit procedure and in this way examine the effects of carbon risk and carbon regulations on audit work. Furthermore, our investigation is based on large, publicly listed companies. Hence, findings may not necessarily be generalisable across smaller companies.

Overall, despite these caveats, our results suggest that auditors consider carbon risk and carbon regulation in their risk assessment and thus in audit pricing. This is an issue which will gain in significance over the coming years. Moreover, the importance of carbon risk as a driver of climate-change will continue to strengthen in the years to come. Accordingly, we provide

[14] Examples are the implementation of a market stability reserve and shortages of overall and free allowance certificates (see Section 2.1).

highly relevant insights for a wide range of recipients such as regulators and standard-setters, who currently evaluate the need for Auditing Standards that include these risk evaluations in financial statement audits (Financial Reporting Council, 2020; IAASB, 2020). Moreover, the findings reveal further insights into auditors' risk evaluations, which will be in the interests of investors, who are currently expressing concerns about adequate consideration being given to carbon related risks during the audit process. Taking the increasing relevance of this topic into account, further research of these issues is clearly needed.

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Appendix

Appendix: Variable Definitions.

Variable	Definition	Source
l_audfee	Natural logarithm of audit fees paid to the external auditor.	Audit Analytics Europe
co2_ln	Natural logarithm of total GHG emissions containing Scopes 1, 2 and 3 emissions (TR.CO2EmissionTotal).	Eikon
scope1_ln	Natural logarithm of reported Scope 1 (direct) GHG emissions (TR.CO2DirectScope1).	Eikon
indirect_ln	Natural logarithm of indirect GHG emission (Scope 2 and 3 emissions) (TR.CO2IndirectScope2 and TR.CO2IndirectScope3).	Eikon
ets_part	Indicator variable which equals 1 if the company is participated in the EU ETS, and zero otherwise.	EUTL
size	Natural logarithm of total assets.	Datastream
segement	Natural logarithm of one plus the number of product segments for which sales are reported (following Kress et al. 2019).	Datastream
recInv	Ratio of receivables and inventories to total assets.	Datastream
roa	Ratio of total assets to net income before extraordinary items.	Datastream
current	Current ratio, which is calculated as ratio of current assets and current liabilities.	Datastream
loss	Indicator variable which equals 1 if income is negative, and zero otherwise.	Datastream
mvbv	Ratio of market value to book value.	Datastream
lev	Ratio of total debt to total assets.	Datastream
forSales	Percentage of foreign sales to total sales.	Datastream
growth	Growth in sales from previous to current year.	Datastream
busy	Indicator variable which equals 1 if fiscal year ends in December, and zero otherwise.	Audit Analytics Europe
change	Indicator variable which equals 1 if the auditor changed during the fiscal year, and zero otherwise.	Audit Analytics Europe
big4	Indicator variable which equals 1 if the auditor is a big4 auditor (PwC, EY, KPMG, Deloitte), and zero otherwise.	Audit Analytics Europe
restatement	Indicator variable which equals 1 if a restatement is reported between 2010 and 2020, and zero otherwise.	Audit Analytics Europe
n_audfee	Natural logarithm of non-audit fees.	Audit Analytics Europe
arlag	Days between fiscal year end and signature date of the audit opinion.	Audit Analytics Europe

Table 1. Sample composition.

Steps	N
Sample of complete Audit Analytics Europe data for the fiscal years 2013 – 2019	39,291
Merge with data of Datastream	36,105
(observations with non-missing total assets)	
Merge with data of Eikon	13,846
(observations with no missing in co2-data)	
Total sample	2,106
(after deleting companies without necessary control variable data)	
./. non-EU firm-year observations	258
./. financial firms (sic codes beginning with 49*)	182
./. public utilities (sic = 6***)	54
Final sample: Firm-year observations of EU companies with complete data reported 2013-2019	1,612
thereof firm-year observations of EU ETS participants	133
thereof firm-year observations of non-EU ETS participants	1,479

Note: In Table 1 the sample selection is described.

Table 2. Sample distribution.

Panel A: *distribution of observations by country and year*								
Country	2013	2014	2015	2016	2017	2018	2019	Total
AT	2	1	2	1	2	6	6	20
BE	5	6	6	6	8	10	11	52
DE	19	23	27	32	32	35	34	202
DK	6	5	5	5	6	7	9	43
ES	12	14	15	17	21	19	22	120
FI	16	13	11	13	17	21	20	111
FR	20	22	19	18	31	43	48	201
GB	63	61	74	79	79	75	69	500
GR	0	0	0	0	1	1	1	3
HU	0	0	0	1	2	1	2	6
IE	2	2	2	3	2	4	5	20
IT	6	6	7	6	7	13	13	58
LU	1	2	2	2	1	2	3	13
NL	8	8	9	12	12	13	20	82
PT	3	2	3	4	4	6	5	27
SE	17	12	15	18	23	30	39	154
Total	180	177	197	217	248	286	307	1,612

Panel B: *distribution of observations by industry sector (SIC-Codes)*		
Industry	N	Percentage
Agriculture, Forestry, Fishing	7	0.43
Mining	105	6.51
Construction	98	6.08
Manufacturing	731	45.35
Transportation & Public Utilities	269	16.69
Wholesale Trade	34	2.11
Retail Trade	111	6.89
Services	257	15.94
Total	**1,612**	**100**

Note: Table 2 presents information on the sample. Panel A (Panel B) shows the distribution of the sample by country (industry).

Table 3. Descriptive Statistics.

Panel A: Descriptive Statistics of GHG emissions

	full sample (N = 1,612)					ETS sample (N = 133)					Non-ETS sample (N = 1,479)				
Variables	mean	median	SD	5%	95%	mean	median	SD	5%	95%	mean	median	SD	5%	95%
co2_m	17.700	0.367	75.771	0.008	64.020	37.294	3.969	84.573	0.362	288.550	15.938	0.270	74.709	0.007	39.893
co2_ln	13.153	12.812	2.723	8.962	17.975	15.533	15.194	2.174	12.799	19.480	12.939	12.504	2.666	8.894	17.502
scope1_ln	11.031	10.935	2.917	6.358	16.213	13.497	13.179	2.376	10.001	17.534	10.810	10.719	2.859	6.260	16.041
indirect_ln	12.713	12.284	2.780	8.494	17.874	15.090	14.824	2.270	11.899	19.325	12.499	12.087	2.723	8.396	17.297

Panel B: Descriptive Statistics of dependent Variable and Controls

	full sample (N = 1,612)					ETS sample (N = 133)					Non-ETS sample (N = 1,479)				
Variables	mean	median	SD	5%	95%	mean	median	SD	5%	95%	mean	median	SD	5%	95%
audfee	5,043,677	2,231,425	7,667,317	300,000	18,900,000	9,158,876	5,600,000	11,100,000	317,115	31,000,000	4,673,615	2,116,600	7,173,040	300,000	17,500,000
l_audfee	14.644	14.618	1.259	12.612	16.755	15.267	15.538	1.354	12.667	17.250	14.587	14.565	1.235	12.612	16.677
size	15.545	15.480	1.520	13.238	18.273	16.686	16.900	1.409	14.582	18.953	15.442	15.384	1.488	13.178	18.069
segment	1.584	1.609	0.432	0.693	2.079	1.778	1.792	0.347	0.693	2.197	1.566	1.609	0.434	0.693	2.079
recInv	0.272	0.249	0.161	0.060	0.574	0.236	0.227	0.109	0.063	0.466	0.275	0.251	0.165	0.059	0.581
roa	0.053	0.046	0.078	-0.045	0.182	0.063	0.047	0.050	0.005	0.176	0.052	0.046	0.079	-0.051	0.186
current	1.425	1.239	0.844	0.563	2.770	1.410	1.258	0.647	0.662	2.342	1.426	1.238	0.860	0.554	2.800
loss	0.114	0.000	0.317	0.000	1.000	0.030	0.000	0.171	0.000	0.000	0.121	0.000	0.326	0.000	1.000
mvbv	3.350	2.278	3.739	0.528	10.712	2.972	1.905	3.038	0.868	8.661	3.384	2.318	3.794	0.490	10.870
lev	0.257	0.244	0.161	0.008	0.534	0.273	0.253	0.131	0.074	0.507	0.256	0.243	0.164	0.007	0.546
forSales	62.376	72.700	33.090	0.000	100.000	69.795	75.470	27.353	0.000	98.580	61.709	72.290	33.485	0.000	100.000
growth	0.041	0.030	0.179	-0.161	0.241	0.029	0.025	0.120	-0.163	0.170	0.042	0.030	0.183	-0.161	0.255
busy	0.808	1.000	0.394	0.000	1.000	0.797	1.000	0.404	0.000	1.000	0.809	1.000	0.393	0.000	1.000
change	0.078	0.000	0.269	0.000	1.000	0.090	0.000	0.288	0.000	1.000	0.077	0.000	0.267	0.000	1.000
big4	0.979	1.000	0.144	1.000	1.000	1.000	1.000	0.000	1.000	1.000	0.977	1.000	0.150	1.000	1.000
restatement	0.016	0.000	0.126	0.000	0.000	0.023	0.000	0.149	0.000	0.000	0.016	0.000	0.124	0.000	0.000
n_audfee	13.291	13.346	1.548	10.745	15.761	13.965	13.971	1.439	11.377	16.300	13.230	13.249	1.544	10.695	15.676
arlag	62.366	59.000	19.250	35.000	99.000	57.316	57.000	20.908	29.000	92.000	62.820	59.000	19.036	36.000	99.000

Note: Table 3 Panel A shows descriptive statistics of GHG emissions in total, of Scope 1 GHG emissions and indirect GHG emissions (Scopes 2 and 3). In Panel B the descriptive statistics of the dependent variable *l_audfee* and control variables are displayed. The definitions of all variables are provided in Appendix. *loss*, *change*, *busy*, *big4*, *restatement* are binary variables and hence, the mean value shows the proportion of companies that are affected of loss, restatement, and auditor change, having a fiscal yearend during the busy season or audited by a big4 auditor.

Table 4: Correlations Table.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
(1)	*l_audfee*	1.00																				
(2)	*co2_ln*	**0.65**	1.00																			
(3)	*scope1_ln*	**0.59**	**0.85**	1.00																		
(4)	*indirect_ln*	**0.64**	**0.97**	**0.74**	1.00																	
(5)	*ets_part*	**0.15**	**0.26**	**0.25**	**0.26**	1.00																
(6)	*size*	**0.84**	**0.77**	**0.68**	**0.76**	**0.23**	1.00															
(7)	*segment*	**0.27**	**0.24**	**0.26**	**0.24**	**0.14**	**0.27**	1.00														
(8)	*recInv*	**0.19**	**0.18**	**0.17**	**0.16**	**0.07**	**0.28**	**0.07**	1.00													
(9)	*roa*	**0.20**	**0.22**	**0.26**	**0.16**	0.04	**0.23**	**0.08**	**0.11**	1.00												
(10)	*current*	**0.24**	**0.15**	**0.14**	**0.15**	0.01	**0.24**	**0.16**	**0.29**	**0.19**	1.00											
(11)	*loss*	**0.05**	**0.09**	**0.13**	0.03	**0.08**	0.04	0.01	**-0.05**	**-0.56**	-0.04	1.00										
(12)	*mvbv*	**0.12**	**0.22**	**0.25**	**0.18**	0.03	**0.22**	**0.13**	**0.07**	**0.44**	0.00	**-0.14**	1.00									
(13)	*lev*	**0.17**	**0.17**	**0.17**	**0.14**	0.03	**0.22**	**0.14**	**-0.35**	**-0.26**	**-0.30**	**0.15**	**-0.07**	1.00								
(14)	*forSales*	**0.35**	**0.25**	**0.23**	**0.26**	**0.07**	**0.19**	0.02	0.01	0.02	0.05	-0.01	0.01	-0.03	1.00							
(15)	*growth*	**0.09**	**0.11**	**0.13**	**0.10**	0.02	**0.06**	**0.08**	-0.02	**0.09**	0.05	**-0.13**	**0.07**	-0.05	-0.01	1.00						
(16)	*busy*	**0.16**	**0.15**	**0.11**	**0.15**	0.01	**0.17**	**0.13**	-0.01	**-0.10**	**-0.09**	**0.05**	**-0.09**	**0.13**	**0.17**	0.00	1.00					
(17)	*change*	0.01	0.03	0.05	0.01	0.01	0.01	0.02	0.00	0.00	0.00	-0.02	0.01	0.04	-0.01	0.04	0.03	1.00				
(18)	*big4*	0.01	0.00	0.04	0.01	0.04	0.02	0.03	**-0.10**	0.04	0.01	0.00	**0.07**	**0.06**	**0.10**	-0.01	-0.04	-0.04	1.00			
(19)	*restatement*	0.01	0.05	0.04	**0.05**	0.02	0.05	0.01	-0.02	-0.01	0.02	0.00	0.02	0.00	0.00	0.01	**-0.09**	**0.05**	-0.02	1.00		
(20)	*n_audfee*	**0.76**	**0.52**	**0.43**	**0.52**	**0.13**	**0.69**	**0.17**	**-0.21**	**-0.15**	**-0.20**	0.04	**-0.06**	**0.17**	**0.26**	**-0.08**	**0.08**	-0.04	0.04	-0.03	1.00	
(21)	*arlag*	**0.08**	**0.11**	0.03	**0.14**	**0.08**	**0.10**	**0.06**	**-0.05**	**-0.19**	**0.11**	**0.18**	**-0.17**	**0.12**	-0.02	0.05	**0.13**	0.00	-0.03	**0.05**	**-0.15**	1.00

Note: Table 4 shows the pairwise correlations among audit fees, GHG emissions proxies, ETS participation, and control variables of the full sample (N = 1,612). Coefficients in bold are significant at $p < 0.05$. The definition of all variables are presented in appendix.

Table 5: Regression models – Carbon risk and audit fees.

	(1)	(2)	(3)
_cons	2.988***	3.068***	2.983***
	(7.971)	(8.054)	(7.954)
co2_ln	0.011		
	(0.767)		
scope1_ln		0.032***	
		(2.699)	
indirect_ln			0.007
			(0.502)
size	0.487***	0.463***	0.492***
	(17.324)	(16.440)	(17.791)
segment	0.186***	0.171***	0.188***
	(4.222)	(3.824)	(4.262)
recInv	0.629***	0.632***	0.629***
	(3.682)	(3.737)	(3.671)
roa	-0.528*	-0.483	-0.533*
	(-1.708)	(-1.573)	(-1.729)
current	-0.095***	-0.093***	-0.095***
	(-2.946)	(-2.915)	(-2.948)
loss	-0.017	-0.024	-0.013
	(-0.257)	(-0.355)	(-0.202)
mvbv	0.010*	0.011*	0.010*
	(1.724)	(1.897)	(1.695)
lev	-0.106	-0.123	-0.104
	(-0.636)	(-0.737)	(-0.621)
forSales	0.004***	0.004***	0.004***
	(5.845)	(5.730)	(5.893)
growth	-0.177*	-0.154	-0.180*
	(-1.756)	(-1.577)	(-1.785)
change	0.126**	0.126**	0.126**
	(2.089)	(2.122)	(2.085)
busy	-0.021	-0.014	-0.022
	(-0.458)	(-0.326)	(-0.490)
big4	-0.055	-0.053	-0.058
	(-0.354)	(-0.345)	(-0.372)
restatement	0.219**	0.224**	0.219**
	(2.503)	(2.512)	(2.504)
n_audfee	0.244***	0.249***	0.243***
	(13.803)	(14.013)	(13.743)
arlag	0.002	0.002	0.002
	(1.553)	(1.489)	(1.524)
Fixed Effects	*year, industry, country*	*year, industry, country*	*year, industry, country*
N	1,612	1,612	1,612
R^2	0.856	0.858	0.856
adj. R^2	0.852	0.854	0.852

Note: Table 5 Column (1) shows the results of regressing natural logarithm of audit fees on natural logarithm of total GHG emissions. Column (2) (3) shows the regression results of Scope 1 GHG emissions (indirect GHG emissions) on audit fees. We use heteroscedasticity-robust standard errors clustered by firm. In parenthesis, the t-statistics are reported. Variables are defined in Appendix. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Interaction models – Carbon regulation and audit fees.

	(1)	(2)	(3)
_cons	2.993***	3.033***	2.968***
	(7.789)	(7.768)	(7.717)
ets_part	-1.719***	-1.370***	-1.376**
	(-2.594)	(-2.903)	(-2.156)
co2_ln	0.009		
	(0.611)		
*co2_ln*ets_part*	0.101**		
	(2.356)		
scope1_ln		0.030***	
		(2.638)	
*scope1_ln*ets_part*		0.089**	
		(2.554)	
indirect_ln			0.004
			(0.318)
*indirect_ln*ets_part*			0.082*
			(1.915)
size	0.490***	0.466***	0.497***
	(17.056)	(16.325)	(17.437)
segment	0.193***	0.175***	0.194***
	(4.421)	(3.934)	(4.475)
recInv	0.608***	0.617***	0.607***
	(3.596)	(3.690)	(3.582)
roa	-0.497	-0.452	-0.503
	(-1.624)	(-1.495)	(-1.643)
current	-0.089***	-0.086***	-0.091***
	(-2.794)	(-2.724)	(-2.828)
loss	-0.018	-0.028	-0.016
	(-0.277)	(-0.430)	(-0.244)
mvbv	0.010*	0.011*	0.009
	(1.668)	(1.877)	(1.632)
lev	-0.096	-0.087	-0.101
	(-0.578)	(-0.520)	(-0.605)
forSales	0.004***	0.004***	0.005***
	(6.081)	(5.748)	(6.133)
growth	-0.178*	-0.153	-0.182*
	(-1.789)	(-1.590)	(-1.821)
change	0.109*	0.116*	0.110*
	(1.819)	(1.956)	(1.820)
busy	-0.013	-0.002	-0.017
	(-0.299)	(-0.047)	(-0.383)
big4	-0.049	-0.038	-0.052
	(-0.317)	(-0.252)	(-0.342)
restatement	0.247***	0.237***	0.258***
	(2.919)	(2.744)	(2.964)
n_audfee	0.241***	0.248***	0.240***
	(14.064)	(14.277)	(13.805)
arlag	0.002	0.002	0.002
	(1.421)	(1.312)	(1.432)
Fixed Effects	*year, industry, country*	*year, industry, country*	*year, industry, country*
N	1,612	1,612	1,612
R^2	0.859	0.862	0.859
adj. R^2	0.855	0.857	0.854

Note: Table 6 presents the results of H2 including the interaction terms *ets_part* multiplied with carbon risk proxies.

Column (1) shows the results measuring carbon risk as the natural logarithm of total GHG emissions (*co2_ln*). Column (2) presents the results using the natural logarithm of Scope1 GHG emissions and column (3) shows the results of indirect GHG emissions. We use heteroscedasticity-robust standard errors clustered by firm. In parenthesis, the t statistics are reported. Variables are defined in Appendix. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Company size – carbon risk, carbon regulation and audit fees.

Panel A: *Carbon risk and audit fees*

	(1)	(2)	(3)	(4)	(5)	(6)
		large companies			small companies	
_cons	2.963***	2.734***	3.017***	3.269***	3.412***	3.261***
	(3.651)	(3.456)	(3.649)	(5.835)	(6.045)	(5.822)
co2_ln	0.016			-0.005		
	(0.833)			(-0.280)		
scope1_ln		0.037*			0.018	
		(1.907)			(1.065)	
indirect_ln			0.012			-0.007
			(0.748)			(-0.346)
Control Variables	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Fixed Effects	*year, industry, country*	*year, industry, country*	*year, industry, country*	*year, industry, country*	*year, industry, country*	*year, industry, country*
N	806	806	806	806	806	806
R^2	0.789	0.793	0.789	0.701	0.702	0.701
adj. R^2	0.777	0.781	0.777	0.684	0.686	0.684

Panel B: *Interaction models – Carbon regulation and audit fees*

	(1)	(2)	(3)	(4)	(5)	(6)
		large companies			small companies	
_cons	3.002***	2.825***	3.005***	3.160***	3.307***	3.158***
	(3.528)	(3.444)	(3.463)	(5.699)	(5.929)	(5.706)
ets_part	-0.957	-1.117**	-0.463	-2.450*	0.151	-2.691**
	(-1.244)	(-2.312)	(-0.627)	(-1.722)	(0.139)	(-2.028)
co2_ln	0.012			0.002		
	(0.625)			(0.118)		
*co2_ln*ets_part*	0.056			0.145		
	(1.122)			(1.313)		
scope1_ln		0.029			0.031**	
		(1.563)			(2.051)	
*scope1_ln*ets_part*		0.076**			-0.061	
		(2.074)			(-0.655)	
indirect_ln			0.011			-0.002
			(0.638)			(-0.090)
*indirect_ln*ets_part*			0.026			0.168
Control Variables	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Fixed Effects	*year, industry, country*	*year, industry, country*	*year, industry, country*	*year, industry, country*	*year, industry, country*	*year, industry, country*
N	806	806	806	806	806	806
R^2	0.791	0.797	0.790	0.714	0.716	0.715
adj. R^2	0.778	0.784	0.777	0.697	0.699	0.698

Note: Table 7 Panel A reports results for tests where we investigate the role of company size and carbon risk on audit fees. In Panel B, the results are derived from Equation 2. We define large companies as companies, which are larger than the median company (*size*) of the sample, and small companies as companies which *size* is equal or smaller than the median of the sample. In parenthesis, the t statistics are reported and clustered at company level. Variables are defined in Appendix. * p < 0.10, ** p < 0.05, *** p < 0.01

Table 8: Sensitivity Tests – carbon risk, carbon regulation and audit fees.

Panel A: *Carbon risk and audit fees*

	(1)	(2)	(3)	(4)	(5)	(6)
		Industry			Country	
_cons	3.549***	3.594***	3.668***	2.217***	2.373***	2.186***
	(6.812)	(7.057)	(6.922)	(3.847)	(4.061)	(3.786)
co2_ln	0.025			-0.004		
	(1.252)			(-0.232)		
scope1_ln		0.039**			0.027*	
		(2.483)			(1.929)	
indirect_ln			0.031*			-0.008
			(1.667)			(-0.498)
Control Variables	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Fixed Effects	*year, industry, country*	*year, industry, country*	*year, industry, country*	*year, industry, country*	*year, industry, country*	*year, industry, country*
N	881	881	881	1,112	1,112	1,112
R^2	0.853	0.855	0.854	0.856	0.857	0.856
adj. R^2	0.845	0.848	0.846	0.850	0.851	0.850

Panel B: *Interaction models – Carbon regulation and audit fees.*

	(1)	(2)	(3)	(4)	(5)	(6)
		Industry			Country	
_cons	3.606***	3.624***	3.696***	2.245***	2.327***	2.202***
	(6.949)	(7.128)	(6.999)	(3.768)	(3.880)	(3.684)
ets_part	-1.726**	-0.600	-1.286	-1.645*	-1.397**	-1.445*
	(-1.974)	(-1.133)	(-1.313)	(-1.879)	(-2.591)	(-1.652)
co2_ln	0.021			-0.006		
	(1.039)			(-0.386)		
*co2_ln*ets_part*	0.110**			0.097*		
	(2.136)			(1.760)		
scope1_ln		0.035**			0.024*	
		(2.232)			(1.776)	
*scope1_ln*ets_part*		0.044			0.091**	
		(1.168)			(2.416)	
indirect_ln			0.027			-0.011
			(1.427)			(-0.664)
*indirect_ln*ets_part*			0.086			0.086
			(1.456)			(1.527)
Control Variables	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Fixed Effects	*year, industry, country*	*year, industry, country*	*year, industry, country*	*year, industry, country*	*year, industry, country*	*year, industry, country*
N	881	881	881	1,112	1,112	1,112
R^2	0.854	0.856	0.855	0.858	0.861	0.858
adj. R^2	0.846	0.848	0.847	0.852	0.855	0.852

Note: Table 8 Panel A reports results for sensitivity tests where we rerun Equation 1 to investigate the effects of special industries (columns (1) - (3)) and of large countries ((4) - (6)). In Panel B, the results are derived from Equation 2. To evaluate, whether the manufacturing sector drives the data, we exclude in columns (1) - (3) all observations of this sector. To consider the country-specific effects, we exclude all firm-year observations of Great Britain. In parenthesis, the t statistics are reported and clustered at company level. Variables are defined in Appendix. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$