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ESG risk exposure, management and firm risk: new evidence from a panel quantile regression approach

Libe Galdos Urbizu[a], Eduardo Ortas[b] and Igor Alvarez Etxeberria[c]

[a]Faculty of Economics and Business Sciences - Bizkaia, Department of Financial Economics I – Calle Elcano, University of the Basque Country UPV/EHU, Bilbao, Spain; [b]Faculty of Business and Public Administration- Plaza de la Constitución s/n, University of Zaragoza, Huesca, Spain; [c]Faculty of Economics and Business – Gipuzkoa, Department of Applied Economics I, University of the Basque Country UPV-EHU, Donostia-San Sebastian, Spain

ABSTRACT

This paper addresses how the environmental, social and governance (ESG) risk of a firm influences their global risk. Differentiated ESG risk measures are used to test for an excess risk effect derived from companies' effective management of ESG risk factors. With a panel quantile regression using the method of moments, we investigated a data set of 4,792 international firms over the 2018–2022 period, yielding a total of 23,960 firm-year observations. The results align with risk management theory, showing that firm risk increases with higher ESG risk. However, ESG risk exposure and unmanaged ESG risk have an asymmetrical effect on firm risk, with the latter being more positively influenced in the upper quantiles. Sensitivity analyses reveal that the findings are robust even during different market cycles, such as the recent COVID-19 pandemic. Managerial implications and insights for investors are useful regarding the riskiness of ESG issues and strategies for mitigating them.

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1. Introduction

Environmental, social and governance (ESG) risks are becoming highly relevant for managers of firms (Boiral et al., 2020; Li et al., 2024; Weber et al., 2010), partly due to the urgent need to make contributions to allow humanity to stay within planetary boundaries (Rockström et al., 2009; Steffen et al., 2015), and also due to the increasingly extensive media coverage of scandals related to ESG issues (Wong & Zhang, 2022; Zanatto et al., 2023). As shown by cases such as Volkswagen (Dieselgate) and Veolia (corruption lawsuits related to water supply and treatment contracts), scandals linked to environmental and social issues can significantly impact a company's reputation and overall value (Godfrey, 2005; Zhou et al., 2022). As a result, taking ESG into consideration plays an important role in boardrooms (Naciti et al., 2022; Taglialatela et al., 2024).

In parallel, ESG risks for firms are becoming of widespread importance in terms of investor decisions (Boiral et al., 2020; Weber et al., 2010). In this context, research into the links between ESG metrics and shareholder wealth has attracted wide attention over the last two decades (Bauer et al., 2005; Derwall et al., 2005; Lee & Koh, 2024). The main underlying hypothesis of this research revolves around doing well by doing good. While findings on the topic are often mixed and contradictory (Barnett & Salomon, 2006; Bauer et al., 2005), the general view is that going green enhances firms' profitability and, at the same time, allows investors to align their moral convictions with their investment strategies (Derwall et al., 2005; Friede et al., 2015). However, the literature is less evolved regarding the linkages between firm risk and companies' ESG risks. In this respect, Lööf et al. (2022) showed that long positions on companies with lower ESG risk levels allowed investors to reduce their portfolio risk exposure during the

CONTACT Libe Galdos Urbizu libe.galdos@ehu.eus University of the Basque Country UPV/EHU, Faculty of Economics and Business Sciences - Bizkaia, Department of Financial Economics I – Calle Elcano, 21, 48008 Bilbao, Spain

COVID-19 pandemic, while retaining the risk/return trade-off. Boucher et al. (2025) explored three investment universes (Europe, North America, and the Asia-Pacific), and they found a negative connection between ESG risk and idiosyncratic enterprise volatility. While Döttling and Kim (2024) reveal that the screening processes for ESG risk funds weakened the financial distress induced by COVID-19. However, Pástor and Vorsatz (2020) results were non-conclusive.

Nevertheless, the majority of these papers focus on often-criticized, first-generation ESG metrics, which are mainly based on performance measures (Christensen et al., 2022; Porter et al., 2019). Unlike conventional ESG scores (He et al., 2023; Liu & Song, 2025), which often fail to distinguish ESG risk exposure and ESG risk management quality, focusing on ESG risk exposure and unmanaged ESG risk allows both managers and investors to identify the areas that are most critical for effective risk-reduction strategies. Our findings reveal that it is not mere ESG risk exposure that drives risk, but rather the residual, unmanaged component. This insight is critical for resource allocation, corporate sustainability strategies and when building resilient investment portfolios. In this paper, we address this limitation and focus on a second-generation ESG scoring system (Gaussel & Le Saint, 2020), to assess whether firms with lower ESG risk represent a less risky investment strategy. To that end, we examined a panel of 4,792 international companies for the 2018–2022 period with a panel quantile regression model using the method of moments. This approach, which is robust in the presence of non-normality and non-linearity issues, will help to identify links between a company's ESG risk and overall firm risk. Interestingly, this work focuses on the differentiated enterprise ESG risk measures, namely: i) ESG risk exposure; and ii) unmanaged ESG risk. Lastly, we tested for robustness by including the economic upheaval caused by the COVID-19 pandemic.

Thus, this study aims to contribute to the existing literature in several ways. First, to the best of our knowledge, this is the first study analysing how ESG risk can affect enterprise risk. As noted by Christensen et al. (2022) and Porter et al. (2019), the limited research in this area is mainly focused on the relationship between ESG performance and enterprise risk (e.g. Lee & Koh, 2024), which are focused on measuring the ESG practice level rather than the ESG risk level. Secondly, we use a proxy of ESG risk that represents a second-generation measure that uses both inside-out and outside-in approaches, which is related to the concept of double materiality that comes from the new sustainability reporting rules. Third, the present study provides evidence of the impact of ESG risk on firm risk in the context of periods of market upheaval, such as the recent COVID-19 pandemic. Accordingly, this study has several notable implications for corporate managers, portfolio managers, and enterprise stakeholders, including investors, because they need to be aware that ESG risk should be a significant factor to take into account when evaluating enterprise risk.

The rest of the paper is organised as follows: Section 2 presents the theoretical background, including the literature review and sets forth the research hypotheses. Section 3 describes the data and method. Section 4 presents and discusses the main results and finally, Section 5 concludes the paper.

2. Theoretical notes, literature review and hypotheses

Incorporating ESG criteria into portfolio selection decisions is gathering momentum across stock markets (Daugaard, 2020; Meira et al., 2023). The number of firms publicly affirming their commitment to ESG investment principles continues to grow—as can be seen in the Principles for Responsible Investment (PRI) Annual Report by the United Nations Global Compact (2024), it increased from 2,000 in 2017 to over 5,000 in 2024. However, and despite the considerable research in the field, one fundamental question remains unsolved: do financial markets value enterprise commitment to ESG practices? And more interestingly, is firm risk influenced by company ESG risk?

The relationship between the variables under study has been analyzed through the lens of different theoretical models. However, some theoretical models have treated this relationship superficially, without offering deeper theoretical reasoning. Therefore, we will focus on the theoretical models that best support our hypotheses and allow to contextualize the results providing conceptual explanations for real business and portfolio management practices. In the subsequent subsections, we address the theoretical basis for formulating the research hypotheses.

2.1. Theoretical background

The theoretical model that explains how ESG risk exposure and unmanaged ESG risk affect firm risk builds on the risk management, stakeholder and signalling theories.

The risk management theory argues that risk management can reduce a firm's exposure to specific risks that investors are not able to diversify, leading to a risk reduction and protecting shareholders against deadweight costs (Godfrey, 2005; Orlitzky & Benjamin, 2001; Spicer, 1978). In other words, by being responsible for ESG issues, companies may avoid additional costs related to regulatory fines or legal sanctions that could damage their financial stability (Cohen, 2023; McGuire et al., 1988). Accordingly, ESG risk management can increase a company's value and, thus, add value for shareholders (Godfrey et al., 2009; Lu et al., 2023), which is also in line with the classic proposition of 'doing well by doing good' (Lu et al., 2023). In addition, several studies support the main idea of the risk management theory. For instance, Albuquerque et al. (2019) found that firms with a strong ESG commitment face a relatively low price elasticity of demand and, as a result, they have lower systematic risk. According to Gillan et al. (2021) mitigating ESG risks firms may reduce systematic risk, regulatory risk, supply chain risk, or reputational risk. Finally, Harjoto and Laksmana (2018) found that good corporate social responsibility (CSR) practices lead to lower unsystematic total risk. Consequently, based on this theory, commitment to ESG issues leads to lower firm risk (Kim et al., 2021) and, by contrast, the non-involvement of ESG leads to a major company's financial risk.

According to the stakeholder theory (Freeman, 1984), a firm's activity must satisfy the interests of all the actors that may be influenced by the company, not only those of its shareholders and managers. This ability to generate value for society is widely known as CSR, presently the term ESG is commonly used to refer to a company's commitment to environmental, social and governance issues. Therefore, in relation to the focus of this study, stakeholder theory argues that a firm, in order to reduce its overall risk, must satisfy the needs of stakeholders by taking on the appropriate risks, which are definitely ones associated with ESG issues (Jardine, 2008). Based on this theory, engaging in ESG initiatives, firms could generate reputation capital (El Ghoul & Karoui, 2017; Godfrey, 2005; Minor & Morgan, 2011), and they will be able to build trust among stakeholders (Mishra & Modi, 2013). Thanks to reputation capital, the theory maintains that firms will be able to cope with market fluctuations and risk exposure by safeguarding their equity value (Fombrun et al., 2000; Godfrey et al., 2009; Jo & Na, 2012). Therefore, in essence, based on stakeholder theory, by decreasing ESG risk, a firm will curb its market risk.

Another key factor that influences enterprise risk is investor sentiment, which is influenced by the signals received by the investor. According to the signalling theory, ESG indices serve as signalling mechanisms that could be interpreted as good signals by the market (Connelly et al., 2011), as this indicates that a firm has a long-term commitment to ESG issues and that it is focused on mitigating ESG risks (Doh et al., 2010; Sabbaghi, 2022). As confirmed by previous literature, negative events can cause a negative stock price reaction in the financial market. In fact, negative events have a greater impact than positive ones (Kölbel et al., 2017; Krüger, 2015; Sabbaghi, 2023). However, according to this theory, a low level of ESG risk could be seen as a positive signal by stakeholders that could be translated into moral capital, and such moral capital may serve as a shield against market sanctions that arise when a negative event occurs (Fombrun et al., 2000; Godfrey, 2005; Godfrey et al., 2009). In other words, firms engaged in ESG risk mitigation benefit from an insurance effect against negative events that impact their risk levels. Therefore, in line with this theory, firms that do not manage their ESG risks will experience more risk than firms that do mitigate their ESG risks when a negative event occurs, because the latter possesses moral capital that has an insurance effect that will temper market reactions that impact stock prices.

In conclusion, the engagement of a firm with ESG risk mitigation reflects that they consider society's general welfare when making decisions and are not entirely self-interested (Davis, 1973; Godfrey et al., 2009). When these signals are perceived and appreciated by the market, firms gain moral capital (El Ghoul & Karoui, 2017 Godfrey, 2005), also referred to as 'reputation insurance' (Minor & Morgan, 2011). This moral capital can influence investor sentiment and, in turn, market reaction. Therefore, the theoretical foundation of the present study argues that firms that involve in ESG activities can achieve success and improve their reputation in the market. This makes firms to build a good image in the eyes of

customers and investors and, as a result, they gain potential to increase their financial performance (Al Amosh et al., 2023) as well as decreasing the level of risk.

2.2. ESG risk exposure, unmanaged ESG risk and firm risk

There is little empirical evidence confirming that firms with higher ESG risk have reduced risk (Boucher et al., 2025; Lööf et al., 2022). The clearest arguments supporting that statement are based on risk management theory, emphasising that by managing ESG risk, a firm can lower risks and shield shareholders from deadweight expenses (Godfrey, 2005; Orlitzky & Benjamin, 2001; Spicer, 1978). In agreement with that, stakeholder theory (Freeman, 1984) also highlights that by addressing ESG responsibilities, firms build reputation capital (El Ghoul & Karoui, 2017; Godfrey, 2005; Minor & Morgan, 2011), which in turn protects their equity value, mitigating firm risk (Fombrun et al., 2000; Godfrey et al., 2009; Jo & Na, 2012). In addition, according to the literature, commitment to ESG risk management serves as a signalling mechanism that the market may interpret positively (Connelly et al., 2011; Doh et al., 2010; Sabbaghi, 2022), and it helps prevent expenses associated with fines or legal penalties (Cohen, 2023; McGuire et al., 1988). Not only that, there are studies that, in line with the risk management view, show that a firm could reduce several enterprise risks such as systematic risk (Albuquerque et al., 2019; Gillan et al., 2021), thus mitigating ESG risks. So, all in all, there is sufficient evidence in the literature to support that lower ESG risk is associated with lower firm risk (Kim et al., 2021). However, according to recent studies, the effect of ESG risk on enterprise risk is non-linear (Farah et al., 2021; Rouine et al., 2022) and, as seen in previous literature (Shiller, 1981), excess firm risk may emerge in this relationship. One reason for this non-linear pattern might be related to the reputational effect because, theoretically speaking, market reputation has a greater impact on well-known firms (Gardberg & Fombrun, 2002) and, thus, ESG controversies would have a greater impact on their market value (Krüger, 2015). There are also industry-specific effects—for example, Wang et al. (2023) find that carbon-intensive firms show stronger reactions to negative market news. Jo and Na (2012) also point out that controversial industry sectors manage to lower enterprise risk through involvement in ESG issues. Cai et al. (2016) show that environmentally responsible US public firms have lower risk, although only in the case of manufacturing firms, as they found an inverse relationship for service-providers. All these arguments suggest that investors' reactions are stronger to ESG risk shocks, showing higher risk compared to the market, and manifesting a significant increase in enterprise risk. Accordingly, we propose the following hypothesis to be tested:

H1: ESG risk exposure and unmanaged ESG risk asymmetrically increase firm risk.

2.3. Excess firm risk of unmanaged ESG risk

The connection between ESG risk and firm risk has been addressed by previous research (He et al., 2023; Hübel & Scholz, 2020; Sabbaghi, 2022). However, this leads us to question what might curb firm risk more successfully—less exposure to ESG risks, or taking further steps to mitigate ESG risks for the company? To the best of the authors' knowledge, this question remains unsolved. If we focus on risk management theory, the key to reducing firm risk is managing risks that investors are not able to diversify in order to maintain financial stability (Cohen, 2023; Godfrey, 2005; Orlitzky & Benjamin, 2001). Thus, rather than the initial level of risk, i.e. risk exposure, the level of managed ESG risk may be the most important factor in determining commitment to ESG issues (Connelly et al., 2011), and in reflecting the extent to which the company cares about the general welfare of society when making decisions (Godfrey et al., 2009). According to signalling theory, commitment to ESG issues could be interpreted by the market as a positive signal and it could function as a shield against market reactions to unfavourable circumstances (Fombrun et al., 2000; Godfrey, 2005; Godfrey et al., 2009). If we refer to previous studies that focus on ESG performance measures (i.e. 1st-generation ESG metrics), Kumar et al. (2016) show that companies facing greater ESG controversies have increased risk levels. Upon comparing the risk of enterprises not committed to ESG issues, they found a significant difference (approximately 47%) between firms that were most exposed to ESG risks (energy industry) and firms that were less exposed (insurance

industry). However, when considering the companies that were mitigating ESG issues and comparing the risk levels of those two industries, the difference decreased to around 11%. That indicates there is a gap between firm risk that arises from exposure due to ESG controversies as opposed to unmanaged ESG issues, noting that enterprise risk resulting from unmanaged ESG issues is greater. Consistently, when a firm becomes involved in ESG controversies, the market perceives it as riskier - particularly if it is a first-time offender or has current issues—and the magnitude of that effect depends on the sector in which it operates (Shakil et al., 2025). This means that while exposure to ESG factors may influence enterprise risk (Hübel & Scholz, 2020), the most significant factor influencing their risk is how these issues are managed. As shown by Jin (2022), passive investment strategies in ESG could help to improve the value of a firm. However, maximising returns may require the use of more complex ESG indices, which could be identified as ESG risk. Similarly, several recent studies have found an asymmetric effect between ESG indicators and financial performance. Le (2024) found that ESG practices have insufficient and different influences among the financial outcomes of Southeast Asian companies. Lööf et al. (2022) show that stocks with higher ESG ratings exhibit lower downside risk but also reduced upside potential, suggesting that ESG investments can mitigate risk while limiting the chance of higher returns. Bax et al. (2024) found that the relationship between companies' ESG scores, systemic impact, and vulnerability is time-dependent, with substantial differences between stable periods and tail events. Along those lines, we argue that in comparison to ESG risk exposure, an increase in unmanaged ESG risk will have a stronger impact on firm risk. We define the term 'excess risk of unmanaged ESG risk' as the incremental risk experienced by a firm that arises from ESG-related vulnerabilities that remain unmanaged by corporate policies, governance practices, or risk-control mechanisms. This residual component connects directly to risk-management theory, since unmanaged risks represent exposure that cannot be fully diversified away. It also resonates with the literature on reputation channels, where ESG controversies or governance failures can trigger outsized market reactions, thereby amplifying firm risk. That might be because a lower unmanaged ESG risk level may alleviate uncertainty among investors who care about climate risks (Cepni et al., 2023), resulting in firm risk stabilisation. Conversely, it has been proven that irresponsible actions regarding ESG issues have a significantly stronger impact on firm risk (Kölbel et al., 2017; Sabbaghi, 2023; Umar et al., 2023), also resulting in reputational loss that leads to increased risk (Krüger, 2015). Consistent with that, companies that inadequately manage their ESG risks may incur additional costs through regulatory fines or legal sanctions that can adversely impact their financial stability (Cohen, 2023). Accordingly, we support the following hypothesis:

H2: There is an excess firm risk effect derived from unmanaged ESG risk factors.

2.4. The connection between ESG risk and firm risk under market distress: the case of the COVID-19 pandemic

The COVID-19 pandemic caused a significant market crash, leading to a major decline in market returns (Broadstock et al., 2021; Chowdhury et al., 2022) and increasing uncertainty in the financial market (Albulescu, 2021). Several studies suggest that market turmoil increased risk among firms with a riskier profile before the market distress period (Azimli, 2020; Ghosh, 2022; Ullah et al., 2023). Given that our sample period (2018–2022) encompasses the period of instability attributable to the coronavirus disease, it is appropriate to test the robustness of the connection between firm ESG risk and company risk. If we look at previous literature on past market downturns, we see that scholars proved that during the 2008 financial crisis, companies with better CSR had higher returns than those with lower CSR, thanks to the trust built by the CSR performance for stakeholders and investors (Lins et al., 2017; Mishra & Modi, 2013). This is in line with stakeholder theory, which supports that firms will generate reputation capital if they assume and mitigate their ESG risks (El Ghoul & Karoui, 2017; Godfrey, 2005; Minor & Morgan, 2011) and that reputation capital will act as a safeguard against market downturns (Fombrun et al., 2000; Godfrey et al., 2009; Jo & Na, 2012). For all those reasons, based on past events and theories mentioned, we hypothesize that a crisis such as COVID-19 would increase firm risk, without altering the previous ESG risk-profile of a firm. In other words, due to empirical evidence found in the literature, we believe that even during the COVID-19 pandemic, investors would clearly identify firms with higher ESG risk as riskier

assets. Firstly, this is because it was observed that the tendency to incorporate ESG stocks in the investment portfolio grew significantly during the pandemic, with recent studies (e.g. Rubbaniy et al., 2022) suggesting that investors perceive ESG stocks as a hedging investment. Secondly, based on the discussion by Pástor and Vorsatz (2020) and Pedersen et al. (2021), even in market crashes, ESG-minded investors hold on to green stocks, as the utility gained from maintaining a green portfolio offsets the utility loss resulting from adverse fluctuations in wealth. Finally, recent studies demonstrated that during the pandemic, stocks with a lower ESG risk level offered greater returns and had lower risk compared to their brown peers (Albuquerque et al., 2020; Broadstock et al., 2021). Therefore, we suggest that even in periods of market uncertainty, such as COVID-19, firms that mitigate their ESG risks will maintain a lower risk profile than those that do not manage their ESG risks, showing a more robust relationship between the two variables being studied. Accordingly, the following hypothesis is proposed to be tested:

H3: The connections between asset ESG risk exposure, unmanaged ESG risk and firm risk are robust to market distress.

3. Data and method

Firms' ESG risk exposure (EXP) and unmanaged ESG risk (UESGR) scores for assets from 4,792 companies in various countries and industries were retrieved from Morningstar Sustainalytics. ESG data were obtained from 2018 to 2022, and comprise firms listed in the 10 Thomson Reuters Business Classification (TRBC) sectors and in 63 countries. The reason for choosing stocks from a wide range of countries is that they operate in markets with different CSR engagement profiles and sizes. Whilst conventional ESG measures are built on a firm's performance in the environmental, social and governance dimensions, Sustainalytics' ESG risk metrics distinguish between EXP and UESGR. Figure 1 illustrates the stepwise methodology followed by Sustainalytics to obtain the UESGR score. In the first step, the EXP score reflects the company's exposure to material ESG issues, which are issues that influence both the company's economic value and its financial risk. With EXP as starting point, at the second stage, Sustainalytics distinguishes between manageable and unmanageable risk through the application of the MRF factor. At the third level, once the manageable and unmanageable risks are differentiated, the managed risk is obtained by multiplying the manageable risk by the management score. At this stage, the portion of manageable risk that remains unaddressed is termed as management gap. Finally, the UESGR score risk is calculated by subtracting the managed risk from the risk exposure and reflects the portion of material ESG risk that has not been managed by the company how well the company manages such issues, as it is illustrated in Figure 1, it is calculated by subtracting the managed risk from the risk exposure.

This figure outlines the ESG Risk Ratings waterfall model. Company exposure, defined as subindustry exposure multiplied by issue beta, is partitioned into manageable and unmanageable risk. The beta score that is included in the first step is assessed at the individual company level to reflect the deviations from the subindustry exposure that has been identified. Manageable risk is derived using the Manageable Risk Factor (MRF), where MRF is calculated as: Overall manageable risk/Overall subindustry exposure. Managed risk is obtained by applying the management score. Finally, unmanaged risk results from subtracting the managed risk from the total risk exposure.

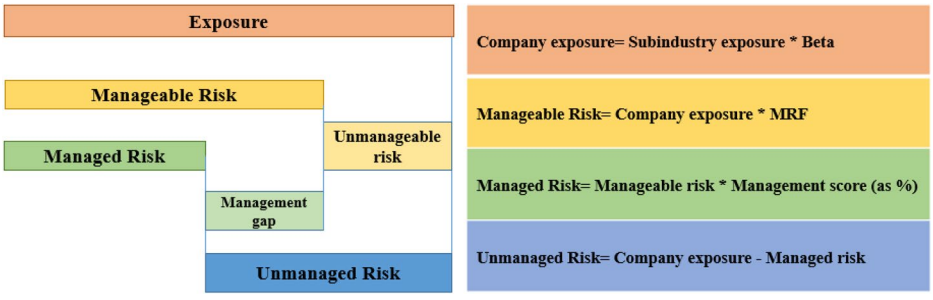

Figure 1. Composition of ESG risk score.

Consequently, while EXP measures a company's financial sensibility or vulnerability to ESG risks, UESGR is a signal reflecting how much a company's future financial performance is exposed to ESG risks that have not been managed properly. Accordingly, UESGR is designed to measure a company's unmanaged ESG risk.

The Sustainalytics dataset was developed to obtain the ESG Risk Ratings, including the components ESG risk exposure (EXP) and unmanaged ESG risk (UESGR), at the firm level on an annual basis. To build the panel, we mapped each Sustainalytics record to the corresponding firm and year in our dataset using the RIC code identifier as the primary matching key, cross-checked against company name and Refinitiv Eikon codes to ensure consistency. When multiple releases were available within the same year, we retained the rating closest to the fiscal year-end of the firm. Each firm-year observation therefore corresponds to one Sustainalytics ESG risk rating, combined and aligned with the financial data of the same year provided by Refinitiv Eikon.

The sector dummies listed in Table 1 are based on Thomson Reuters business Classification (TRBC) system. Each firm-year observation is mapped to one of the ten sectors, and corresponding binary indicators are included in all specifications as controls for industry-specific heterogeneity.

We obtained daily adjusted prices for stocks from January 2018 to December 2022 from Thomson Reuters Refinitiv database. Then, logarithmic returns were computed as $r_{it} = ln(p_{it} / p_{it-1})$. According to previous research (Adams et al., 2005; Bernile et al., 2018; He et al., 2023), the standard deviation of a firm's logarithmic returns was obtained as a proxy of firm risk. We followed the methodology by Rouine et al. (2022) to construct the variable firm risk, measured as the standard deviation of daily stock returns in the current year. Specifically, we compute the standard deviation of each firm's daily log returns over a 12-month rolling window. Missing returns due to non-trading days are excluded from the calculation. The resulting volatility measures are then matched to the corresponding year to construct an annual firm-level risk variable for the panel dataset. We also compiled the financial control variables from Refinitiv (see Table 2). Finally, the Sustainalytics and Refinitiv data sets were matched by using the firms' Reuters Instrument Codes (RIC). Table 2 shows the definition of the variables in the models.

Regarding the handling of possible outliers, to test for the robustness of results, we replicate the empirical analysis by controlling for the influence of extreme values. Specifically, all continuous variables were winsorized at the 1st and 99th percentiles. This process ensures that our results are not driven by outliers while preserving the underlying distribution of the data. After that, we confirmed that the main results remain consistent when using winsorized variables.

3.1. Econometric approach

A fixed-effects panel quantile regression model is applied by using the method of moments (MMQR) propounded by Machado and Silva (2019). Insofar as methodology, the model chosen to capture the influence

Table 1. Sample breakdown by sector and geographical area.

	N	%	% Cum		N	%	% Cum
Consumer discretionary	3,580	14.94	14.94	Africa/Middle East	675	2.82	2.82
Consumer staples	1,585	6.62	21.56	Asia/Pacific	9,205	38.42	41.24
Energy	990	4.13	25.69	Europe	4,675	19.51	60.75
Financials	3,420	14.27	39.96	Latin America and the Caribbean	660	2.75	63.50
Healthcare	1,960	8.18	48.14	United States and Canada	8,745	36.50	100.00
Industrials	4,455	18.59	66.74				
Information technology	2,925	12.21	78.94				
Materials	2,215	9.24	88.19				
Real estate	1,430	5.97	94.16				
Telecommunication services	410	1.71	95.87				
Utilities	990	4.13	100.00				
TOTAL	23,960			TOTAL	23,960		

This table shows the distribution of the sample by industry sector (left panel) and geographical area (right panel). Figures indicate the number of firm-year observations (N) and their percentage share of the total sample. The dataset covers 23,960 firm-year observations corresponding to 4,792 unique firms over the period 2018–2022. Sectoral and geographical classifications follow Sustainalytics' methodology.

Table 2. Definition of variables.

Label	Variable	N	Brief	Use
RISK	Firm risk	23,960	Computed by the standard deviation of firms' logarithmic returns	Measures the volatility of stock prices, a proxy of firm's risk
RETURN	Financial return	23,960	Measured by the equity return earned by stockholders on a yearly basis	Assesses companies' financial performance
EXP	ESG risk exposure	23,960	Quantifies the company's exposure to ESG risk factors	Evaluates the degree to which a company's economic value is at risk driven by environmental, social and governance factors
UESGR	Unmanaged ESG risk	23,960	Quantifies the company's unmanaged ESG risk	Evaluates the degree to which a company's economic value is at risk, driven by not managing its ESG controversies properly
SIZE	Total assets	23,960	Calculated by the natural logarithm of total assets	Represents the scale of a firm's operations and its financial resources
DEBT	Total debt percentage of equity	23,960	Quantifies the proportion of debt financing relative to equity	Evaluates a company's capital structure and financial leverage
CAPINT	Capital intensity	23,960	Measured through the ratio of net property, plant, and equipment to net sales	Measures a company's investments to produce goods and services
RDINT	R&D intensity	23,960	The ratio of research and development expenses to net sales	Assesses a company's commitment to develop innovative processes

This table provides a detailed overview of the variables used in the empirical analysis. N represents the total number of observations for panel data, which covers an annual frequency from 2018 to 2022 for 4,792 companies. For each variable, the table reports its label, definition, sample size, and the specific role it plays within the study, including a description of how it is calculated.

of ESG risk on firm risk was the MMQR model, because this approach is appropriate to evaluate the impact of the variables in different moments of the period analysed. This econometric approach was used with the objective of examining more complex effects and in order to assess the impact on firm risk across companies with different risk profiles. Using this approach, it will be possible to trace the heterogeneous and distributional variations across different quantiles between response variables (RISK) and their selected determinants. This method outperforms traditional QR approaches (Canay, 2011; Koenker & Bassett, 1982) because it allows for individual fixed effects, thus it can capture the conditional heterogeneous covariance influences of the exogenous variables and can modify the entire distribution. Accordingly, the MMQR approach accounts for the endogeneity issue, which avoids obtaining invalid estimations. Another advantage of the MMQR model is that it does not make any assumptions regarding the distribution of the error term, thus it is able to accommodate heteroscedasticity, while providing quantile-specific effects. Furthermore, the MMQR approach provides robust outcomes in the presence of non-normality and non-linearity issues. Under this approach, the conditional quantile of a random variable $Q_Y(\tau \mid X)$ is described as:

$$Y_{it} = \alpha_i + X'_{it}\beta + \left(\xi_i Z'_{it}\psi\right)U_{it} \tag{1}$$

where Y_{it} and X'_{it} are the dependent and independently and identically distributed variables; α, β, ξ, and ψ are the regression coefficients; Z refers to a k-vector of the X know components; i=1, ……, n, refers to the individual i fixed effects; and U_{it} is *iid* across i through t and perpendicular to X_{it}. Eq. (1) can be rewritten as:

$$Q_Y(\tau \mid X_{it}) = \left(\alpha_i + \xi_i q(\tau)\right) + X'_{it}\beta + Z'_{it}\psi q(\tau) \tag{2}$$

where $Q_Y(\tau \mid X_{it})$ is the quantile distribution of the dependent variable; X'_{it} is a regressor vector; $\alpha_i\tau = \alpha_i + \xi_i q(\tau)$ is the scalar coefficient that represents the individual i's quantile τ fixed effect. According to this notation, we rewrite the MMQR-version of the equation for the proposed hypotheses as:

$$QRISK(\tau_k \mid \alpha_i, x_{it}) = \alpha_i + \psi_{1\tau}\mathrm{EXP}_{it} + \psi_{2\tau}UESGR_{it} + \sum_{j=3}^{7}\psi_{j\tau}FCONTROLS_{it} + \sum_{j=8}^{16}\psi_{j\tau}SECTORS_{it} + \varepsilon_{it} \tag{3}$$

$$\begin{aligned} QRISK(\tau_k \mid \alpha_i, x_{it}) = {} & \alpha_i + \psi_{1\tau}\mathrm{EXP}_{it} + \psi_{2\tau}UESGR_{it} + \psi_{3\tau}COVID_{it} + \psi_{4\tau}\mathrm{EXP}_{it} * COVID_{it} + \psi_{5\tau}UESGR_{it} * COVID_{it} \\ & + \sum_{j=6}^{10}\psi_{j\tau}FCONTROLS_{it} + \sum_{j=11}^{19}\psi_{j\tau}SECTORS_{it} + \varepsilon_{it} \end{aligned} \tag{4}$$

where *COVID* is a binary variable that takes the value of 1 during the 2020 period and zero otherwise, *FCONTROLS* is a set of financial control variables (i.e. RETURN, SIZE, DEBT, CAPINT, RDINT); *SECTORS* is a set of non-financial controls that refer to the economic sector in which each company operates according to the TRBC system; and the remaining variables have been previously defined.

4. Results

4.1. Descriptive statistics, diagnostic tests and main MMQR estimates

Table 3 presents the descriptive statistics for the variables included in Eq. (3) and Eq. (4). It is clear from the statistics that all the variables are non-normally distributed. The mean value of RETURN indicates that the sample firms generally have profitable operations. The DEBT ratio is quite high, showing that firms typically have higher debt levels than their equity. The CAPINT and RDINT variables have the highest standard deviations, thus demonstrating more variation than the other financial controls. The relatively wide range of the remaining financial controls reveals that the sample comprises diverse firms with different financial profiles. Interestingly, due to that heterogeneity, the use of quantile regression seems to be appropriate.

Table 4 presents the diagnostic tests for the variables in the models. The slope heterogeneity test (Pesaran & Yamagata, 2008) rejects the null slope homogeneity at 1% significance level. In addition, the autocorrelation test reveals that the data are free from autocorrelation. Finally, results from the Pesaran CD tests (Pesaran, 2015) are significant for all variables in the models, thus the null variable cross-section independence is rejected. Accordingly, the model variables are cross-section-dependent.

Table 5 presents the regression coefficients of Eq. (3). Figure 2 depicts the graphical representation of the independent variables' coefficients in heterogeneous quantiles. The results of the MMQR model reveal that firm ESG risk exposure is positively associated with firm risk across all quantiles. This result agrees with previous studies such as Hübel & Scholz, 2020, that found that exposure to ESG issues can influence corporate risk. In addition, our results reveal the companies' ESG risk exposure location and scale parameters are positive, thus suggesting that the rise in that magnitude increases both the average and dispersion of firms' risk. Furthermore, in the middle to middle-high quantiles, a firm's ESG risk exposure imposes a more severe influence on firm risk than in the lower quantiles. Accordingly, firm ESG risk exposure raises firm risk at an increasing rate among the most volatile shares. This finding demonstrates that the relationship between the variables is non-linear which supports the evidence defended by Farah et al. (2021) and Rouine et al. (2022). The results also reveal that firm unmanaged ESG risk is positively associated with firm risk across all quantiles. Interestingly, the location and scale for this independent variable are positive, suggesting that increasing a company's unmanaged ESG risk agitates the average and dispersion of firm risk. In our model, the location parameter captures how ESG risk measures shift the conditional mean or central tendency of firm risk. It reflects whether higher ESG exposure or unmanaged ESG risk systematically increases or decreases the firms' volatility. By contrast, the scale parameter captures changes in the dispersion or heterogeneity of firm risk across firms and over time. Intuitively, a significant scale effect indicates that ESG factors not only affect the average level of risk but also amplify differences in risk intensity, making some firms disproportionately more volatile than others when unmanaged ESG vulnerabilities are present. In addition, a firm's unmanaged ESG risk imposes a more severe impact on firm risk in the higher quantiles. In other words, the results support the view that higher ESG exposure and unmanaged ESG risk leverage firm risk in terms of more volatile stocks to a greater extent. According to these results, **H1** cannot be rejected for all quantiles of the dependent variable. One explanation for this might be that riskier firms are in the spotlight and investors have a stronger reaction in the light of a negative event related to ESG issues (Sabbaghi, 2023; Umar et al., 2023), manifesting excess risk (Zarafat et al., 2022). Theoretically speaking, market reputation has a greater impact on well-known firms (Gardberg & Fombrun, 2002) and thus, ESG risk has a stronger effect on their market valuation (Krüger, 2015). Agreeing with previous literature, excess firm risk exists (Shiller, 1981) and although previous studies have attempted to explain it by attributing it to investor behaviour (Schmitt & Westerhoff, 2017) or external economic

Table 3. Descriptive statistics and correlations for the variables.

	Mean	SD	Min	Max	JB	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RISK(1)	0.023	0.011	0	0.261	428.102***	1							
RETURN(2)	0.0197	0.0277	−0.679	0.779	534.941***	0.061***	1						
UESGR(3)	27.035	9.842	4.670	72.465	1868.866***	0.033***	−0.114***	1					
EXP(4)	40.697	13.009	14.241	95.455	2001.745***	0.054***	−0.243***	0.8065***	1				
SIZE(5)	17.061	2.847	3.178	28.314	930.144***	−0.223***	0.307***	0.078***	0.104***	1			
DEBT(6)	5.345	3.245	−5.723	11.882	98.015***	0.014**	−0.006	0.009	0.010	0.005	1		
CAPINT(7)	6.896	18.380	0.000	150.231	3280.53***	0.0248***	−0.010	0.038***	0.042***	−0.18*	0.002	1	
RDINT(8)	7.528	23.456	0	2224.591	3772.357***	0.039***	0.027***	0.012	0.024	−0.045***	−0.001	0.065***	1

This table presents descriptive statistics and correlations for the variables: RISK (firm risk), RETURN (financial return), UESGR (unmanaged ESG risk), EXP (ESG risk exposure), SIZE (total assets), DEBT (total debt to equity), CAPINT (capital intensity), and RDINT (R&D intensity). For each variable, the table reports the mean, standard deviation, minimum, maximum, and the Jarque-Bera test for normality. Correlation significance is indicated by ***, **, * indicating significance for 1%, 5% and 10%, respectively.

Table 4. Diagnostic tests.

	Slope heterogeneity test			Autocorrelation test				
	Stat.	*p*-value		Stat.	*p*-value			
Delta	47.793***	0.000		89.731***	0.000			
Adj. Delta	75.567***	0.000						
	Cross-section dependence test †							
	RISK	RETURN	UESGR	EXP	SIZE	DEBT	CAPINT	RDINT
Perasan CD test	3736.279***	1392.599***	1172.69***	167.934***	3214.697***	1689.277***	1645.956***	975.801***
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

This table shows the results of the diagnosis test for the variables in the model, including slope heterogeneity, autocorrelation, and Pesaran's cross-section dependence tests that assumes cross-section independence. Significance is indicated by ***, ** indicating significance for 1%, 5%, and 10%, respectively. The test assumes null cross-section independence.

Table 5. Panel quantile regression estimates of the influence of ESG risk exposure and unmanaged ESG risk on firm risk.[1].

Quantile	EXP	UESGR	RETURN	SIZE	DEBT	CAPINT	RDINT
Location	0.0000413***	0.0001029***	0.0013156***	−0.0007249***	$2.72x10^{-8}$	$1.76x10^{-6}$	$-7.91x10^{-8***}$
	(0.0000107)	(0.0000109)	(0.00013347)	(0.0000341)	($4.20x10^{-8}$)	($4.83x10^{-6}$)	($1.93x10^{-8}$)
Scale	0.000021**	0.0000565***	0.000399*	−0.0003692***	$-6.12x10^{-8**}$	$5.30x10^{-6**}$	$-4.53x10^{-8*}$
	($9.23x10^{-6}$)	($8.46x10^{-6}$)	(0.0002232)	(0.0000282)	($2.93x10^{-8}$)	($2.27x10^{-6}$)	($2.33x10^{-8}$)
10th	0.0000127	0.0000257***	0.0007712***	−0.0002211***	$1.11x10^{-7***}$	$-5.47x10^{-6**}$	$-1.72x10^{-8}$
	($8.12x10^{-6}$)	($9.04x10^{-6}$)	(0.0002033)	(0.0000257)	($3.81x10^{-8}$)	($2.21x10^{-6}$)	($1.80x10^{-8}$)
20th	0.0000194***	0.0000441***	0.0008993***	−0.003396***	$9.10x10^{-8***}$	$-3.77x10^{-6}$	$-3.18x10^{-8**}$
	($6.97x10^{-6}$)	($8.13x10^{-6}$)	(0.0002031)	(0.0000225)	($3.52x10^{-8}$)	($2.73x10^{-6}$)	($1.24x10^{-8}$)
30th	0.0000249***	0.0000587***	0.0010036***	−0.0004362***	$7.5x10^{-8**}$	$-2.38x10^{-6}$	$-4.36x10^{-8***}$
	($6.9x10^{-6}$)	($8.06x10^{-6}$)	(0.0002209)	(0.0000227)	($3.46x10^{-8}$)	($3.22x10^{-6}$)	($9.84x10^{-9}$)
40th	0.0000302***	0.0000731***	0.0011051***	−0.0005301***	$5.94x10^{-8*}$	$-1.04x10^{-6}$	$-5.52x10^{-8***}$
	($7.61x10^{-6}$)	($8.55x10^{-6}$)	(0.0002503)	(0.0000249)	($3.56x10^{-8}$)	($3.73x10^{-6}$)	($1.07x10^{-8}$)
50th	0.0000358***	0.0000883***	0.0012112***	−0.0006283***	$4.32x10^{-8}$	$3.72x10^{-7}$	$-6.72x10^{-8***}$
	($8.98x10^{-6}$)	($9.6x10^{-6}$)	(0.0002899)	(0.0000291)	($3.82x10^{-8}$)	($4.28x10^{-6}$)	($1.44x10^{-8}$)
60th	0.0000420***	0.000105***	0.0013298***	−0.000738***	$2.50x10^{-8}$	$1.95x10^{-6}$	$-8.07x10^{-8***}$
	(0.000011)	(0.0000112)	(0.000341)	(0.0000352)	($4.26x10^{-8}$)	($4.9x10^{-6}$)	($2x10^{-8}$)
70th	0.0000497***	0.0001255***	0.0014754***	−0.0008728***	$2.68x10^{-9}$	$3.88x10^{-6}$	$-9.72x10^{-8***}$
	(0.0000138)	(0.0000135)	(0.0004099)	(0.0000438)	($4.96x10^{-8}$)	($5.69x10^{-6}$)	($2.77x10^{-8}$)
80th	0.0000592***	0.0001515***	0.0016564***	−0.0010403***	$-2.51x10^{-8}$	$6.29x10^{-6}$	$-1.18x10^{-7***}$
	(0.0000175)	(0.0000168)	(0.0005008)	(0.0000553)	($5.98x10^{-8}$)	($6.68x10^{-6}$)	($3.78x10^{-8}$)
90th	0.0000753***	0.0001944***	0.0019641***	−0.001325***	$-7.22x10^{-8}$	0.0000104	$-1.53x10^{-7***}$
	(0.0000243)	(0.0000228)	(0.0000243)	(0.0000763)	($7.94x10^{-8}$)	($8.38x10^{-6}$)	($5.54x10^{-8}$)

This table shows the panel quantile regression results of Eq. (3), showing the effects of EXP (ESG risk exposure), UESGR (unmanaged ESG risk), RETURN = Financial return, SIZE = total assets, DEBT (total debt to equity), CAPINT (capital intensity) and RDINT (R&D intensity) on firm risk. For each variable, the table reports estimated coefficients and standard errors across percentiles from the 10th to the 90th, as well as of the location and scale parameters. Significance is indicated by ***, **,* indicating significance for 1%, 5%, and 10%, respectively.

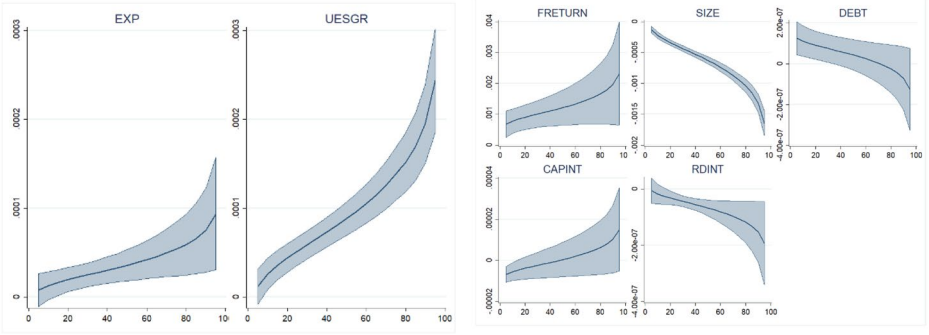

Figure 2. Quantile plots for the ESG risk exposure, unmanaged ESG risk and the financial controls.

factors (Kim & Nelson, 2014), our study demonstrates that it is also attributable to the inherent firm risk.

Further estimates from Table 5 and graphical representations in Figure 2 reveal a very interesting and novel finding. Although a firm's ESG risk exposure and unmanaged ESG risk both increase the average and dispersion of firm risk, the effect is more severe when focusing on a firm's unmanaged ESG risk. In

other words, although the market identifies companies with more ESG risk exposure as more volatile stocks, greater variability of share returns is associated with a firm exhibiting high levels of unmanaged ESG risk. This result is in line with previous studies that support that ESG indicators provoke an asymmetric effect (Le, 2024; Lööf et al., 2022; Bax et al., 2024). This finding is consistent across all quantiles of the dependent variable and could be called the excess risk of unmanaged ESG risk factors. For instance, if we calculate the effect size of the values reported in Table 5, we see that at the upper tail of the conditional risk distribution (Q90), an interquartile increase in ESG exposure (EXP) is associated with a 0.13% increase in firm risk. By contrast, the same interquartile change in unmanaged ESG risk (UESGR_) raises firm risk by 0.26%. This comparison illustrates that while ESG exposure has only a modest impact on firm volatility, the unmanaged component roughly doubles the effect, highlighting that risk stems primarily from insufficient mitigation rather than mere exposure.

Interestingly, this effect (i.e. the difference in the increase in a firm risk due to its ESG risk exposure and due to unmanaged ESG risk) is higher in the upper quantiles. Therefore, this 'risk penalty' cannot be generalized to all companies in the sample, being more pronounced in companies with higher initial risk profiles.

According to these results, **H2** cannot be rejected.

Given that the sample period includes an unprecedented period of instability (i.e. the financial distress caused by the COVID-19 pandemic) that might distort the conclusions, we did a robustness analysis, which is presented in Table 6 and Figure 3. The aim of the analysis is to examine whether the relationship between the variables studied (EXP, UESGR and RISK) and the proposed moderating effects change during periods of distress, such as the COVID-19 crisis (see Eq. (4)).

An initial overview of the results shows that the appearance of the COVID-19 pandemic had a positive influence on firm risk. This finding echoes recent research (Albulescu, 2021; Azimli, 2020; Ghosh, 2022; Ullah et al., 2023), which found an increase in firm risk during COVID-19. Interestingly, the location parameters of the COVID-19 variable are positive and significant. This means that the appearance of the financial distress derived from the COVID-19 pandemic increased average firm risk. However, the non-significance of the scale parameter reveals that the dispersion of firm risk across the sample remained stable. The estimates show that COVID-19 had a more severe influence on firm risk in the middle to middle-higher quantiles than in the lower quantiles. This result is in line with those obtained by previous studies that analysed the effect of CSR performance during the 2008 financial crisis (Lins et al., 2017; Mishra & Modi, 2013). Agreeing with Fombrun et al. (2000), Godfrey et al. (2009) and Jo and Na (2012) and in accordance with the stakeholder theory, our result supports that firms with a higher level of ESG commitment have a reputation capital that acts against the market downturns and permit them to maintain their risk profile. More interestingly, the results reveal that the findings discussed above (i.e. the influence of enterprise ESG risk exposure and unmanaged ESG risk on firm risk, and the appearance of excess risk of unmanaged ESG risk factors) remain stable after controlling for the appearance of the COVID-19 pandemic. This is due to the sign and significance of the firm ESG risk exposure and unmanaged ESG risk parameters. This result supports previous studies that found that even in market crashes, ESG-conscious investors rely on green stocks, as they prefer keeping a green portfolio than having negative fluctuations in wealth (Pástor et al., 2021; Pedersen et al., 2021).

In other words, the COVID-19 sensitivity analysis shows that the inclusion of interaction terms with the pandemic period does not significantly change our results. This suggests that unmanaged ESG risk remained a robust driver of firm-level volatility even under extreme market stress conditions. The intuition is that ESG vulnerabilities are structural rather than cyclical; firms with poor ESG risk management remained more exposed to downside risk during the pandemic. Although the interaction terms are not dominant, some sectorial heterogeneity emerges. Prior research suggests that carbon-intensive industries tend to display stronger ESG risk effects under downturns due to transition pressures, while sectors such as Health Care may show weaker associations, partly reflecting the positive ESG contributions highlighted during the pandemic.

To the best of our knowledge this finding has been proved for the first time and shows that the link between stocks' ESG risk and firms' risk is consistent even in market crashes, thus adding the robustness of the results from the previous section. Accordingly, **H3** cannot be rejected.

Table 6. Panel quantile regression estimates: the COVID 19 influence and moderating effects.[2].

T	EXP	UESGR	COVID	EXP*cOVID	UESGR*cOVID	RETURN	SIZE	DEBT	CAPINT	RDINT
Location	0.0000402***	0.0000898***	0.0069602***	0.0000271	0.0000289	0.0010769***	−0.0007277***	$1.13x10^{-8}$	$6.71x10^{-7}$	$-7.56x10^{-8***}$
	(0.0000104)	(0.0000108)	(0.0008744)	(0.00002)	(0.0000263)	(0.0003231)	(0.0000323)	($5.09x10^{-8}$)	($3.73x10^{-6}$)	($2.11x10^{-8}$)
Scale	0.0000153*	0.0000468***	0.0005884	0.0000197	0.0000389**	0.0003481	−0.0002901***	$-4.06x10^{-8}$	$4.5x10^{-6**}$	$-3.56x10^{-8}$
	(92.0x10-6)	($8.68x10^{-6}$)	(0.00071278)	(0.000016)	(0.0000198)	(0.000273)	(0.0000273)	($4.19x10^{-8}$)	($2.17x10^{-6}$)	($2.23x10^{-8}$)
10th	0.0000192***	0.0000256***	0.0061528***	4.79x10-8	−0.0000244	0.0005993***	−0.0003297***	$6.71x10^{-8}$	$-5.50x10^{-6***}$	$-2.68x10^{-8**}$
	($8.06x10^{-6}$)	($8.93x10^{-6}$)	(0.007118)	(0.0000164)	(0.000022)	(0.0001694)	(0.0000242)	($7.18x10^{-8}$)	($1.90x10^{-6}$)	($1.30x10^{-8}$)
20th	0.0000247***	0.0000423***	0.0063622***	$7.05x10^{-6}$	−0.0000105	0.0007231***	−0.0004329***	$5.26x10^{-8}$	$-3.90x10^{-6*}$	$-3.94x10^{-8***}$
	($6.74x10^{-6}$)	($7.88x10^{-6}$)	(0.0006245)	(0.0000145)	(0.0000199)	(0.0001744)	(0.0000209)	($6.21x10^{-8}$)	($2.14x10^{-6}$)	($7.77x10^{-9}$)
30th	0.0000285***	0.0000539***	0.0065107***	0.000012	$-9.21x10^{-7}$	0.000811***	−0.0005061***	$4.24x10^{-8}$	$-2.77x10^{-6}$	$-4.84x10^{-8***}$
	($6.69x10^{-6}$)	($7.82x10^{-6}$)	(0.0006205)	(0.0000144)	(0.0000198)	(0.000198)	(0.000021)	($5.66x10^{-8}$)	($2.44x10^{-6}$)	($7.70x10^{-9}$)
40th	0.0000321***	0.0000652***	0.0066492***	0.0000167	$8.48x10^{-6}$	0.0008929***	−0.0005744***	$3.28x10^{-8}$	$-1.71x10^{-6}$	$-5.68x10^{-8***}$
	($7.34x10^{-6}$)	($8.34x10^{-6}$)	(0.0006624)	(0.0000153)	(0.0000209)	(0.0002305)	(0.0000231)	($5.29x10^{-8}$)	($2.80x10^{-6}$)	($1.07x10^{-8}$)
50th	0.0000361***	0.0000773***	0.0068027***	0.0000218	0.0000185	0.0009838***	−0.0006501***	$2.22x10^{-8}$	$-5.33x10^{-7}$	$-6.61x10^{-8***}$
	($8.66x10^{-6}$)	($9.39x10^{-6}$)	(0.0007511)	(0.0000173)	(0.0000231)	(0.0002739)	(0.0000271)	($5.07x10^{-8}$)	($3.24x10^{-6}$)	($1.56x10^{-8}$)
60th	0.0000404***	0.0000907***	0.0069686***	0.0000273	0.0000297	0.0010819***	−0.0007319***	$1.08x10^{-8}$	$-7.36x10^{-7}$	$-7.61x10^{-8***}$
	(0.0000105)	(0.000011)	(0.0008816)	(0.0000201)	(0.0000265)	(0.0003259)	(0.0000327)	($5.10x10^{-8}$)	($3.76x10^{-6}$)	($2.14x10^{-8}$)
70th	0.0000459***	0.0001077***	0.0071793***	0.0000344	0.0000438	0.0012065***	−0.0008357***	$-3.79x10^{-9}$	$2.35x10^{-6}$	$-8.88x10^{-8***}$
	(0.0000133)	(0.0000134)	(0.0010789)	(0.0000245)	(0.0000318)	(0.0003965)	(0.0000409)	($5.51x10^{-8}$)	($4.45x10^{-6}$)	($2.90x10^{-8}$)
80th	0.0000538***	0.0001415***	0.0074829***	0.0000446	0.0000636	0.0013862***	−0.0009855***	$-2.47x10^{-8}$	$4.67x10^{-6}$	$-1.07x10^{-7***}$
	(0.0000175)	(0.0000172)	(0.0013967)	(0.0000316)	(0.0000402)	(0.0005031)	(0.0000536)	($6.68x10^{-8}$)	($5.49x10^{-6}$)	($4.03x10^{-8}$)
90th	0.0000651***	0.0002153***	0.0079176***	0.0000591	0.000916	0.0016434**	−0.0011998***	$-5.47x10^{-8}$	$7.99x10^{-6}$	$-1.34x10^{-7***}$
	(0.000024)	(0.000023)	(0.0018837)	(0.0000424)	(0.0000631)	(0.0006608)	(0.000073)	($9.02x10^{-8}$)	($7.02x10^{-6}$)	($5.66x10^{-8}$)

This table shows the results of the robustness test presented in Eq. (4). The table reports the effects of the studied variables EXP (ESG risk exposure) and UESGR (unmanaged ESG risk), on firm risk, including the COVID-19 variable as moderating effect. Notes: ***, **, * indicate significance at 1%, 5% and 10%. RETURN = Financial return, UESGR = Unmanaged ESG risk, EXP = ESG risk exposure, COVID = COVID period, EXP*COVID & UESGR*COVID = moderating effects, SIZE = total assets, DEBT = Total debt percentage of equity, CAPINT = Capital intensity, RDINT = R&D intensity.

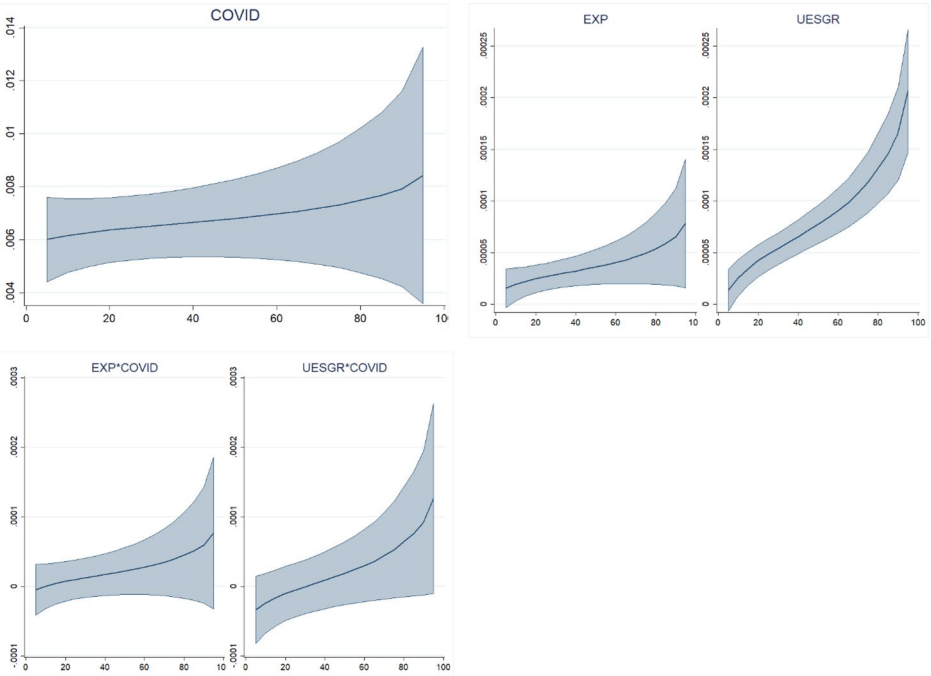

Figure 3. Quantile plots for the ESG risk exposure, unmanaged ESG, COVID19 and the moderating effects.

5. Conclusions

As the awareness of ESG issues grows in response to the ongoing climate emergency, the importance of ESG risk management is increasingly acknowledged in the business world (Boiral et al., 2020; Li et al., 2024; Weber et al., 2010). Proactive management to mitigate ESG risks is important for firms, not only to reduce their environmental impact but also to meet stakeholder demands. For example, ESG-related scandals can severely damage a firm's reputation and as a result, its overall value (Godfrey, 2005; Zhou et al., 2022). Furthermore, socially responsible investment is on the rise, and those investors require relevant and reliable ESG information to make their investment decisions (Boiral et al., 2020; Weber et al., 2010).

With the aim of understanding this highly relevant topic, this study provides empirical evidence that support stakeholder theory, signalling theory and risk management theory assessing how ESG risk influences firm risk. Using an MMQR approach with panel data from 4,792 international firms. The paper shows the heterogeneous shocks of firm ESG risk exposure and unmanaged ESG risk on firm risk. The analysis covers the period from 2018 to 2022, with particular reference to the COVID-19 pandemic period.

This study contributes to the environmental management literature by offering, to the best of our knowledge, the first effort to examine how ESG risk can affect a firm's financial risk. In addition, the variable that we use in the present study (the ESG risk score) measures the ESG risk level rather than the ESG practice level and this is considered the second-generation ESG measure that complies with the principle of double materiality. Lastly, it should be noted that the study provides significant insights related to periods of recession, such as the COVID-19 pandemic, as it is included in the period analysed.

Insofar as methodology, the model chosen to capture the influence of ESG risk on firm risk was the MMQR model, because thanks to this model, we could trace the distributional and heterogeneous differences between response variables (firm risk) and their chosen determinants across different quantiles, providing interesting insights that are essential to gaining a better understanding of the relationship.

The main findings draw the following conclusions. First, overall, firms with higher levels of ESG risk exposure and unmanaged ESG risk are associated with riskier investment alternatives. This finding extends stakeholder theory by highlighting that improper behaviour in the ESG field draws the attention of stakeholders, leading to a bad market reputation and, thus, increasing the overall risk of the firm. In addition, this evidence provide support for the stakeholder theory, by demonstrating that engagement in ESG issues improves the social image and public trust of the firm, which are crucial factors for

financial stability. By contrast, when the opposite happens and firms are not committed to ESG issues, stakeholders perceive it as an unsafe investment. Therefore, this explains that firms with higher ESG risk exposure and unmanaged risk tend to be riskier investment options.

Apart from that, the evidence that ESG risk raises the total firm risk has important implications for the signalling theory, as it is proven that higher ESG risk levels, perceived as negative signals by investors, lead to an increase in the firm's overall risk. As explained by signalling theory, market signals influence investor sentiment, thereby affecting their perception of risk. In addition, those signals originated from news events or diverse information sources that are perceived as negative, have a major effect in the stock price reaction (Kölbel et al., 2017; Krüger, 2015; Sabbaghi, 2023).

Second, the MMQR model results show that ESG risk exposure and unmanaged ESG risk enhance firm risk at an increasing rate among the most volatile shares. Using the MMQR approach, we were able to trace the heterogeneity across different quantiles and we found that volatile shares are more affected by alterations related with ESG issues. This finding supports the non-linearity of the relationship between ESG risk and firm risk that was also evidenced by Farah et al. (2021) and Rouine et al. (2022). In addition, thanks to the MMQR model we found that UESGR produces excess firm risk in those firms that are more volatile than the media.

Third, the positive impact of unmanaged ESG risk on firm risk is stronger than the influence of ESG risk exposure on firm risk. This finding reveals that firms that neglect to manage their ESG risks to a greater extent, are subject to greater firm risk, as markets tend to penalize them. This result provides empirical support for the risk management theory, confirming that the action of managing risk serves to reduce risks that investors can't diversify. In other words, what importantly contributes to the final risk of the firm is not the firm's ESG risk exposure but how that risk is managed. In other words, agreeing with signalling theory, a firm's risk is not only shaped by its ESG risk exposure but also by how investors interpret the signals from events or information emerging in the market. In addition, related to risk management theory, managing risk can help to reduce sanction costs and to enhance firm value.

Finally, the sensitivity analysis including the influence of COVID-19 on firm risk and moderating effects, draws the conclusion that COVID-19 did not fundamentally change the association between ESG risk levels and firm risk. Agreeing with Lööf et al. (2022) our finding has a significant implication, as it presumes that during an economic downturn, lower ESG risk levels would help to reduce the overall risk exposure of the portfolio maintaining the risk/return profile. In other words, ESG issues affect long-term structural influence on the market, rather than cyclical affect in an structural way rather than in a cyclical way.

The intuition is that ESG vulnerabilities are structural rather than cyclical; firms with poor ESG risk management remained more exposed to downside risk during the pandemic. Although the interaction terms are not dominant, some sectorial heterogeneity emerges.

These findings have threefold implications. First, the paper provides useful information to investors and portfolio managers about how to diversify their investment portfolio. Because, according to our findings, investing in companies that manage their ESG risks will lower portfolio risk. In addition, the findings show that with highly volatile stocks, elevated ESG risk correlates with increased firm risk to a greater extent. Thus, portfolio managers should re-balance their portfolios with long positions of assets that have lower levels of unmanaged ESG risk. In fact, some specific practices are shown with the aim of incorporating unmanaged ESG risk into risk-adjusted strategies. To begin with, portfolio screening can exclude firms with persistently high unmanaged ESG risk, thereby lowering the risk of ESG controversies. Then, unmanaged ESG risk should be included in factor-based asset pricing frameworks, thus adjusting expected returns for unmanaged ESG risk factors of firms. Finally, portfolio optimisation techniques may include unmanaged ESG risk as an input in conventional mean-variance allocations, thus ensuring that positions reflect not only financial but also ESG-adjusted risk. These practices can enhance the performance of investors' portfolios by accounting for the real economic consequences of ESG mismanagement. Second, regarding the implications for corporate managers, this study makes it clear that they should consider implementing a robust strategy to mitigate their ESG risks, recognising that companies failing to address their ESG controversies may face heightened firm risk, because they may lose public trust and market reputation. In practice, this involves developing several management practices such as integrating ESG risk management into the risk management frameworks of firms (Kuzmina et al., 2023),

establishing internal mechanism controls and monitoring systems for ESG controversies (Harasheh & Provasi, 2023), increasing the quality of ESG information disclosure to reduce information asymmetries (Silva et al., 2025) or engaging in sector-specific ESG factor mitigation plans. For example, companies in the utilities sector can invest in renewable energy capacity and grid modernisation that can mitigate transitional and regulatory risks (Khalid et al., 2021). Finally, the findings encompass pertinent insights regarding the trends associated with sustainable investments, encouraging further intervention by policymakers working towards an institutional environment that supports the development of ESG risk management.

Despite the findings, this study has limitations. First, the temporal scope is limited, covering the period from 2018 to 2022. Second, the study depends on Sustainalytics methodology as it is the only methodology used to measure ESG risk. Incorporating alternative metrics could improve robustness. Third, there may be sectoral biases affecting the results, which should be addressed in future research. Finally, the inclusion of the COVID-19 period could also influence the estimations. Future research should address these limitations by extending the temporal scope of the study, by using alternative metrics to measure ESG risk, and by exploring the sectoral or regional heterogeneity.

Notes

1. Quantile estimates associated with the non-financial controls (i.e., sectors) have been omitted for the purposes of brevity, however, they are available upon request to the corresponding author.
2. Quantile estimates associated with the non-financial controls (i.e., sectors) have been omitted for the purposes of brevity; however, they are available upon request to the corresponding author.

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Author contributions

CRediT: **Libe Galdos Urbizu**: Conceptualization, Data curation, Formal analysis, Investigation, Visualization, Writing – original draft; **Eduardo Ortas**: Conceptualization, Formal analysis, Funding acquisition, Methodology, Resources, Software, Supervision, Writing – review & editing; **Igor Alvarez Etxeberria**: Conceptualization, Funding acquisition, Project administration, Resources, Supervision, Validation, Writing – review & editing.

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About the authors

Libe Galdos Urbizu is a researcher at the University of the Basque Country. Her research focuses on ESG risk management, social, environmental and financial performance, green supply chain management and other topics related with environmental management.

Eduardo Ortas is Full Professor of finance in the Accounting and Finance Department at University of Zaragoza. His research focuses on corporate social, environmental and financial performance, sustainable supply chain management, ethical investment and other topics related with corporate sustainability.

Igor Alvarez Etxeberria is Full Professor of Accounting and Head of the Financial Economics Department at the University of the Basque Country. His research focuses on corporate social, environmental and financial performance, sustainable supply chain management, biodiversity accounting and other topics related with corporate sustainability.

ORCID

Libe Galdos Urbizu http://orcid.org/0000-0002-2980-5772
Eduardo Ortas http://orcid.org/0000-0001-5582-3694
Igor Alvarez Etxeberria http://orcid.org/0000-0002-3316-4875

Data availability statement

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

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