

ESG Uncertainty and Firm Market Value: The Moderating Role of Board Gender Diversity and ESG Controversies Score

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Abstract

ESG uncertainty highlights inconsistencies in ESG ratings, posing a risk that affects decision-making and research outcomes. This study examines the impact of ESG uncertainty on corporate market value, focusing on the role of board gender diversity. In ESG uncertainty research, this research tests a series of the most concerning aspects via Random-effects regression. By incorporating moderation variables, the analysis explores how the variability of ESG ratings influences the relationship between board gender diversity, ESG performance, and firm's market value. This approach provides a comprehensive understanding among different interaction terms, offering deeper insights into their interconnected dynamics.

KEYWORDS

board gender diversity, ESG Controversies Score, ESG uncertainty, ESG Score, token theory, sex-role stereotypes

1 Introduction

Environmental, Social, and Governance (ESG) ratings are widely used to evaluate firms' performance in sustainability, addressing environmental issues (e.g., carbon reduction, resource management), social factors (e.g., diversity, equity, community engagement), and governance practices (e.g., transparency, ethical leadership) (Tsang et al., 2023; Cesarone et al., 2024). Researchers stress the importance of ESG ratings for offering transparency and accountability, enabling stakeholders to assess a firm's long-term sustainability and ethical commitments (Heubeck, 2023; Haque et al., 2024).

However, disagreement among rating providers due to varying methodologies create uncertainty about ESG ratings' reliability and comparability (Dimson et al., 2020; Berg et al., 2022; Serafeim & Yoon, 2023). This lack of standardization complicates financial modeling and strategic planning, as outcomes often depend on individual providers' methods (Avramov et al., 2022). Reducing this uncertainty is crucial for clearer and more effective ESG assessments. Building on the methods used by Avramov et al. (2022) and Dimson et al. (2020), this paper will extract ESG ratings from different providers to compute a measure of ESG uncertainty. Avramov et al. (2022) analyzed ESG rating divergence by calculating the standard deviations of ratings from six distinct providers to assess sustainable investing. Following a similar approach, this study will calculate ESG Uncertainty. Aiming to enhance the understanding of the role ESG uncertainty plays in corporate governance, this paper addresses the first research question:

Research Question 1. How does ESG uncertainty affect firm performance?

ESG uncertainty, driven by inconsistencies in ratings across agencies, introduces significant ambiguity into firms' sustainability assessments and undermines the effectiveness of ESG initiatives (Avramov et al., 2022). This inconsistency, stemming from differences in measurement, scope, and weighting methodologies, complicates stakeholders' ability to evaluate a firm's ESG performance and make informed decisions (Berg et al., 2022). Meanwhile, board gender diversity has been widely recognized as

a critical factor in enhancing governance quality (Adams & Ferreira, 2009; Zaman et al., 2024; Tsang et al., 2023). It positions diverse boards as key mitigators of ESG uncertainty, enabling firms to navigate ambiguous ESG evaluations more effectively (Lawrence & Raithatha, 2023; Tampakoudis et al., 2022). Based on these considerations, the second research question is as follows:

Research Question 2. How does board gender diversity moderate the relationship between ESG uncertainty and firm performance?

Since 2017, studies have highlighted that companies employ Environmental, Social, and Governance (ESG) initiatives to meet societal expectations and maintain their legitimacy (Shakil, 2021; Heubeck, 2023; Haque et al., 2024). These ESG efforts not only enhance a company’s public image but also ensure its ability to operate under growing public and regulatory scrutiny (Giglio et al., 2025). However, companies often face challenges arising from ESG controversies, which can undermine their legitimacy and heighten financial risks (Brinette, Snomez, and Tournus, 2023). Such controversies disrupt a firm’s risk profile and raise questions about how ESG practices interact with financial risk.

Compounding this issue is the uncertainty surrounding ESG ratings. Divergences in ESG ratings across agencies create confusion about a firm’s true performance, reducing investor confidence and diminishing the effectiveness of ESG initiatives (Avramov et al., 2022; Serafeim & Yoon, 2023; Cesarone et al., 2024). As dual challenges, ESG controversies and ESG uncertainty may interact to further influence a firm’s financial outcomes. Despite their significance, limited research has explored how ESG controversies and ESG uncertainty jointly shape the relationship between ESG practices and firm market value. To address this gap, this study proposes the third research question as following:

Research Question 3. How do ESG controversies moderate the relationship between ESG uncertainty and firm performance?

Based on the above description, the paper is structured into the following main sections: (1) literature review and hypotheses, which examines relevant literature in greater detail and proposes the studies hypotheses; (2) Methodology and Data sources, outlining the methods and data used in the study; (3) Results of the Dynamic Panel data analysis; and (4) Limitations and Further Research. Each of these sections will be critically discussed using a diverse range of high-quality academic literature.

2 Literature Review and Hypothesis Development

2.1 Theoretical Literature Review

2.1.1 ESG Ratings and ESG Uncertainty

Agency Theory suggests that improving information transparency helps mitigate agency problems, with ESG ratings playing a key role in this regard. As sustainable investing gains global prominence, investors are increasingly focusing on ESG ratings as a measure of firms’ environmental and social responsibility (Giglio et al., 2025). However, ESG inconsistencies in ratings across agencies can create significant uncertainty, undermining investor confidence and leading to higher financial risks (Vu, 2025; Avramov et al., 2022).

Recent studies have highlighted that ESG rating uncertainty not only affects investor behavior but also raises the cost of capital for firms with strong ESG profiles, limiting their ability to fund socially responsible projects and achieve sustainability goals (Avramov et al., 2022). **This issue underscores the negative impact of ESG uncertainty on firms’ market value, particularly when inconsistent ESG ratings confuse a firm’s actual performance. This uncertainty negatively impacts firms’ market value, as inconsistent ratings obscure a firm’s actual performance.** In addition, firm-specific characteristics such as profitability (ROA), financial leverage (LEV), and ESG controversies are key determinants of market value, reflecting financial stability, operational efficiency, and reputational risks (Chen et al.,

2016; Rashid et al., 2020; Shakil, 2021).

Building on these insights, this study incorporates ESG uncertainty into its models while controlling for key firm-specific variables such as ROA, LEV, and ESG Controversies. Accordingly, the following hypothesis is proposed:

Hypothesis 1: ESG Uncertainty is negatively linked to firms’ market value.

2.1.2 Beyond Token Theory

Kanter (1977) introduced the concept of “tokens” to describe the under representation of women or minorities in top management, with “solos” referring to a sole representative of a demographic group. Female token managers are often linked more to femininity than leadership, reinforcing stereotypes that conflict with leadership roles. Kulich et al. (2007) extended this by attributing such stereotypes to the gender pay gap among executives. Critical Mass Theory builds on this, suggesting that the influence of women on boards becomes significant when their numbers reach a threshold, improving collaboration and decision-making (Kristie, 2011; Kramer et al., 2007).

While the presence of women on boards is growing (Gul et al., 2011; Adams and Ferreira, 2009), the qualitative impact remains debated. Robinson and Dechant (1997) argue women add unique value to boards, but this may oversimplify their contributions. Gender diversity’s impact on performance is complex, influenced by factors like “glass ceiling” effects. Empirical findings are mixed: some studies link female representation to better governance (Srinidhi et al., 2011; Allen et al., 2005), while others find no direct impact (Adams and Ferreira, 2009). This highlights the need for deeper research to understand how gender diversity affects board dynamics and firm value.

Empirical findings also vary: Liu et al. (2014) observe that female executive directors positively impact firm performance more than independent female directors, aligning with Critical Mass Theory. However, other studies report mixed results. For instance, Gul et al. (2011) and Carter et al. (2003) identify positive correlations, while Adams and Ferreira (2009) find no direct impact on performance. Further, the interplay between gender diversity and governance dynamics warrants examination. Srinidhi et al. (2011) and Allen et al. (2005) argue that female representation enhances governance effectiveness, while Miller and Triana (2009) suggest it fosters strategic risk-taking. However, traditional views of women as risk-averse (Eckel and Grossman, 2008; Niederle and Vesterlund, 2007) highlight conflicting perspectives. This underscores the need for nuanced research to decode the relationship between gender diversity, board dynamics, and firm value. While gender diversity is often the focus of governance studies, it represents only one dimension of board diversity. This paper aims to examine whether diverse boards serve as key mitigators of ESG uncertainty, enabling firms to navigate ambiguous ESG evaluations more effectively (Lawrence & Raithatha, 2023; Tampakoudis et al., 2022). Furthermore, firm-specific factors such as profitability (ROA), financial leverage (LEV), and ESG controversies play a crucial role in determining market value, as they indicate financial stability, operational efficiency, and reputational risk (Chen et al., 2016; Rashid et al., 2020; Shakil, 2021).

Hypothesis 2: Board gender diversity moderates the relationship between ESG uncertainty and firm performance by mitigating its negative impact.

2.1.3 The Moderating Role of ESG Controversies

ESG initiatives are often strategically implemented to enhance a company’s societal reputation and maintain its social license to operate in response to rising public expectations and stringent regulatory requirements (Kuo & Chen, 2013; Dong & Xu, 2016). However, ESG controversies frequently challenge a firm’s legitimacy, impacting its risk profile and financial stability. Such controversies can disrupt the relationship between ESG practices and the financial risks firms face, leading to fluctuations in their risk levels (Shakil, 2021). These dynamics suggest that ESG controversies may play a critical moderating role in shaping the effects of ESG practices on firm performance. Building on these insights, this study investigates the moderating role of ESG controversies in the relationship between ESG uncertainty and firm market value. Moreover, firm-specific factors such as profitability (ROA)

and financial leverage (LEV) play a pivotal role in shaping market value, as they reflect financial stability and operational efficiency (Chen et al., 2016; Rashid et al., 2020). Governance attributes, such as board gender diversity (BGD), contribute to improved decision-making and risk management, potentially reducing the negative impact of ESG uncertainty (Shakil, 2021). Accordingly, the following hypothesis is proposed:

Hypothesis 3: ESG controversies moderate the relationship between ESG uncertainty and firm market value, with gender diversity enhancing the effectiveness of ESG practices.

2.2 Empirical Literature Review

2.2.1 Research Gap and Contribution

A key research gap lies in the limited understanding of how board gender diversity interacts with ESG uncertainty to influence firm performance and strategic decision-making. While prior studies have explored ESG practices and gender diversity individually, their combined impact under conditions of ESG uncertainty remains under-examined. This lack of integration highlights the need for further research to determine whether gender-diverse boards can effectively mitigate the risks associated with ESG uncertainty.

While ESG performances are important for improving reputation, the role of ESG controversies in affecting firm legitimacy, risk, and financial stability is not well understood. Previous studies recognize that ESG controversies can disrupt the link between ESG practices and financial risks (Shakil, 2021), but their role in moderating the impact of ESG uncertainty on market value has been largely overlooked. Furthermore, the potential of board gender diversity (BGD) as a control variable to help mitigate the negative effects of ESG uncertainty remains unclear. This study addresses these gaps by examining how ESG controversies and governance factors together influence the relationship between ESG uncertainty and firm performance.

2.3 Cross-linkages

To provide a comprehensive understanding of the relationships explored in this study, **Figure 1** presents a diagram that visually illustrates the interconnections among the key variables. Hypothesis 1 addresses the direct impact of ESG uncertainty on firm market value, establishing the foundational link between uncertainty and performance. Hypothesis 2 expands on this by incorporating ESG Uncertainty and board gender diversity (BGD) as moderating factors, illustrating how governance structures can shape the effectiveness of ESG practices. Finally, Hypothesis 3 explores the combined moderating effects of ESG uncertainty and ESG Controversies uncovering the dynamics that influence firm outcomes. By presenting these elements within a single framework, **Figure 1** clarifies the theoretical and empirical structure of the study

Table 1

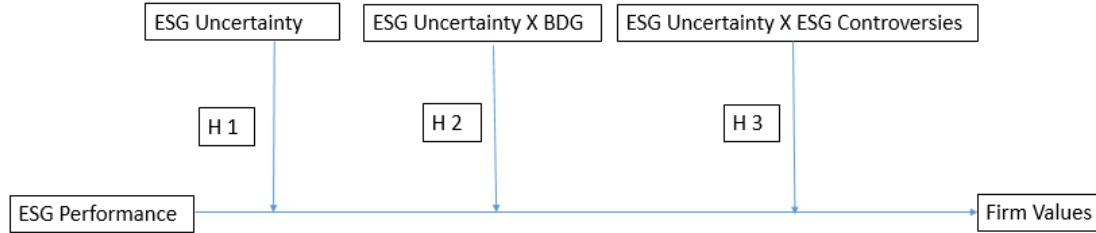
Sample Composition

This Table shows an unbalanced panel of 1424 observations. The final sample of S&P firms was obtained from Refinitiv database and Bloomberg database

Data Base	2018	2019	2020	2021	2022
Composition	201	303	301	297	322

Figure 1
Research model

Note: ESG Practice, ESG Uncertainty, Board Gender Diversity, ESG Controversies



3 Methods

3.1 Data Collection and Sampling Procedure

To effectively examine the hypotheses, this study utilizes ESG (Environmental, Social, and Governance) data sourced from the Refinitiv rating agency. Data from 2017 to 2022 was selected based on its frequent use in recent academic studies (Lee et al., 2022; Fafaliou et al., 2022; Patel et al., 2021; Husted et al., 2019; Aouadi and Marsat, 2018), highlighting its relevance and applicability to related research.

Despite efforts by the Refinitiv database to address missing data using models and tools, significant gaps remain, posing challenges to data quality. Relying solely on benchmark values to fill these gaps risks introducing statistical errors. This study seeks to improve data quality by exploring more robust methods for handling missing data. To address ESG uncertainty, this paper incorporates data sourced from the Bloomberg database. In subsequent sections, the methodology for computing ESG uncertainty will be introduced in detail. Table 1 shows a balanced panel, the final sample of S&P was collected, comprising 14 firm-year observations.

3.2 Summary of Variables and Definitions

A list of all variables with operational definitions is provided in Table 2. The **dependent variable** is Tobin's Q, which measures a firm's market value relative to its replacement cost of assets. The Tobin's Q serves as a robust indicator of market-based financial performance and is widely recognized in ESG-related research, as it offers valuable insights into how effectively the market values a company's assets (Coles et al., 2008; Marsat, 2018; Fafaliou et al., 2021; Brinette et al., 2023).

The main **independent variable** is ESG Uncertainty, defined as the variance in ESG ratings across multiple providers, highlights inconsistencies in evaluating a firm's ESG performance, which may influence financial outcomes. ESG uncertainty will be measured based on ESG rating divergence, calculated as the standard deviation of ratings provided by multiple agencies.

The study also examines **moderation variables**, focusing on ESG Uncertainty, Board Gender Diversity (BGD), and ESG Controversies. **ESG Uncertainty**, defined as the variance in ESG ratings across multiple providers, highlights inconsistencies in evaluating a firm’s ESG performance, which may influence financial outcomes. **Board Gender Diversity**, considers the proportion of female members on a firm’s board and their role in moderating ESG impacts. **ESG Controversies Score** measures a company’s exposure to environmental, social, and governance controversies and negative events reflected in global media.

3.2.1 Control Variables

Finally, to mitigate potential confounding factors, the study incorporates several control variables, such as ROA, Leverage Ratio, the natural logarithm of Market Capitalization, Board Size, and Board Independence. Table 2 presents detailed definitions and descriptions of these variables, which form the basis of the study’s empirical framework.

Table 2
Summary of Variables and Definitions

The key variables used in this study are summarized in Table 2, along with their definitions and data sources. These variables were selected to capture the complex relationships between ESG performances, board gender diversity, and firm financial performance. Each variable is derived from well-established databases, ensuring reliability and consistency in the analysis.

Variable	Definition	Data Source
Tobin’s Q (%)	A ratio of a firm’s market value to its assets’ replacement cost, serving as a crucial indicator in ESG-related studies.	Refinitiv
ESG Uncertainty Ranking (%)	Variance in ESG ratings across multiple rating agencies.	Refinitiv Bloomberg
Board Gender Diversity Score (%)	The percentage of female board members.	Refinitiv
Board Independence(%)	Percentage of strictly independent board members.	Refinitiv
ESG Score (%)	The Refinitiv ESG Score is an overall company score based on self-reported information in the environmental, social, and corporate governance pillars.	Refinitiv
Board Size	The total number of board members at the end of the fiscal year.	Refinitiv
ESG Controversies Score (%)	Measures a company’s exposure to environmental, social, and governance controversies and negative events as reflected in global media. The default value for all controversy measures is 0. Companies with no controversies receive a score of 100.	Refinitiv
ROA Total Assets (%)	A measure of profitability, calculated as net income divided by total assets.	Refinitiv
Leverage Ratio (%)	A financial metric used to assess a company’s level of debt relative to its assets, equity, or earnings.	Refinitiv
Market Capital (log)	The natural logarithm of the market value of the requested issue share type.	Refinitiv

The ESG Score evaluates a company’s long-term sustainability performance based on publicly reported data. It is calculated using weighted category scores across Environmental, Social, and Governance pillars, adjusted based on industry relevance. This score reflects a company’s proactive ESG strategies, policies, and commitments, such as carbon footprint reduction, workplace diversity, and corporate governance structures. A higher ESG Score means the company has well-established ESG policies and management practices. The ESG Controversies Score assesses negative ESG incidents

and controversies that a company has been involved in. It is calculated using 23 controversy topics and penalizes companies based on the severity, scale, and recency of controversies (e.g., regulatory violations, lawsuits, environmental accidents). Unlike the ESG Score, which reflects planned and disclosed policies, this score measures actual ESG-related risks and issues a company faces. A higher ESG Controversies Score means fewer or less severe controversies, whereas a lower score suggests significant ESG-related incidents. The ESG Score shows how well a company has structured its ESG strategy, but it may not reflect real-world ESG risks if issues arise after policies are implemented. The ESG Controversies Score captures actual ESG-related incidents, helping investors assess the risk exposure that is not visible in a company’s disclosed ESG policies.

Additionally, this study introduces **GIC Business Sectors**, derived from GIC industry classifications, as an improved measure of **firm-level** characteristics. Unlike traditional firm dummies, this classification accounts for industry-specific environmental impacts, based (Aswani et al., 2024; Bolton & Kacperczyk, 2021). **Table 3** shows the sample of 1,424 unique firms offers a broad view of the industry landscape over the period 2018-2022.

Table 3
Industry Representation by Number of Firms

The table reports the distribution of unique firms in the sample with respect to the GIC industry classification for the period 2018-2022.

	Industry	2018	2019	2020	2021	2022	Total
1	Consumer Discretionary	22	31	27	24	25	129
2	Consumer Staples	19	21	27	24	26	117
3	Energy	21	24	26	23	29	123
4	Financials	27	32	24	25	23	131
5	Health Care	17	19	21	15	25	97
6	Industrials	26	29	35	20	16	126
7	Information Technology	23	15	19	27	25	109
8	Materials	20	24	27	23	22	116
9	Real Estate	15	30	28	26	30	129
10	Unknown	22	22	30	21	17	112
11	Utilities	27	26	19	23	27	122
12	communication Service	20	19	26	18	30	113
	Total	259	292	309	269	295	1,424
	Observations: 1,424						

3.3 Statistical Procedure

The data were analysed with the R studio. This research employed the Random Effects (RE) model. Given that the model includes several variables that do not exhibit significant variation within firms over short time periods—such as ESG Score, Board Gender Diversity, and Leverage—the fixed effects (FE) approach may not be the most appropriate specification. Limited Within-Firm Variation and the Suitability of Random Effects FE models rely solely on within-firm variation over time to estimate coefficients. However, if key explanatory variables, such as ESG Score, Board Gender Diversity, and Leverage, remain relatively stable within firms over short periods (e.g., annual fluctuations are minimal), the FE estimator may struggle to extract meaningful variation. Consequently, this can lead to imprecise estimates and a loss of statistical significance. In contrast, random effects (RE) models leverage both within-firm and between-firm variation, increasing estimation efficiency and improving model fit. By utilizing cross-sectional variation, RE models provide more stable and interpretable results compared to FE.

An additional challenge with the FE specification in this context is the inclusion of time-invariant variables, such as the GIC Business Sector. Industry classification does not change over time for a given firm, meaning that a fixed effects model would automatically eliminate this variable from

the estimation. This exclusion prevents the model from accounting for industry-specific effects, potentially omitting an important source of heterogeneity across firms. In contrast, RE models retain time-invariant variables, allowing for a more comprehensive analysis of how industry characteristics impact firm value. Year fixed effects, on the other hand, are included in both FE and RE specifications to control for macroeconomic conditions and time-related shocks. However, while year fixed effects account for broad temporal trends, they do not substitute for firm- or industry-specific factors that FE models inadvertently remove.

Unobserved firm-specific characteristics, such as management quality, corporate culture, and long-term strategic decisions, can significantly influence firm value (proxied by Tobin’s Q). However, if these characteristics remain relatively stable over time, FE models may fail to capture their effects adequately. RE models, in contrast, assume that these unobserved firm-specific effects exist but are uncorrelated with the regressors, enabling them to be included in the estimation while still yielding valid coefficient estimates. This assumption allows RE models to provide a more holistic view of firm value determinants.

Since RE models preserve cross-sectional variation, key explanatory variables such as ESG Uncertainty and Board Gender Diversity remain statistically significant, whereas an FE specification may overly restrict variation, leading to weaker or statistically insignificant results. By incorporating both within-firm and between-firm differences, RE models enhance estimation efficiency and offer more robust insights into the relationship between ESG uncertainty, governance characteristics, and firm valuation.

4 Results

4.1 Regression Results

4.1.1 Calculation of ESG Uncertainty

In 2025, Zhou and Lei systematically quantifies ESG rating uncertainty by examining the discrepancies in percentile ranks assigned by multiple independent ESG rating agencies and compute the percentile rank of each firm’s ESG rating within its respective industry and year. This percentile ranking approach allows for a standardized comparison across different rating methodologies, thereby capturing the extent to which ESG assessments diverge across agencies.

To ensure robustness and reliability, the study employs the standard deviation of these percentile ranks as an alternative measure of ESG uncertainty. A higher standard deviation indicates greater inconsistency in how different rating agencies assess a firm’s ESG performance, leading to higher uncertainty for investors and stakeholders. This measure is particularly useful in capturing the ambiguity that arises from variations in rating methodologies, weight allocations, and data sources.

Inspired by their rigorous approach, this research adopted a similar methodology to quantify ESG rating uncertainty and analyze its effects. This research followed the same process of computing percentile ranks of ESG ratings for firms across multiple rating agencies and calculated the standard deviation of these rankings to capture divergence in ESG assessments.

4.1.2 The Divergence of ESG Ratings

Table 4 highlights significant disagreements in ESG ratings across Refinitiv, and Bloomberg Estimation, reflecting differences in assessment frameworks and data sources. The table provides descriptive statistics for the ESG scores from Refinitiv (ESGScore) and Bloomberg Estimation (ESG_SCORE) across a sample of 1,424 observations. The mean ESG score for Refinitiv is **64.43**, significantly higher than Bloomberg’s **40.56**, suggesting potential differences in scoring methodologies or data coverage between the two providers.

The standard deviation values of Refinitiv (**15.50**) showing slightly less dispersion compared to Bloomberg (**18.26**). The minimum values of Bloomberg scores include zero values, while Refinitiv's minimum score is **14.38**. The maximum scores indicate that Refinitiv's highest score (**93.72**) exceeds Bloomberg's (**86.30**).

Since 2020, researchers have underscored the need for transparency in ESG ratings, arguing they should not function as a “black box” (Dimson et al., 2020). By systematically analyzing discrepancies among providers, prior studies have revealed the methodological differences driving these variations, offering insights for sustainable investing and corporate governance research.

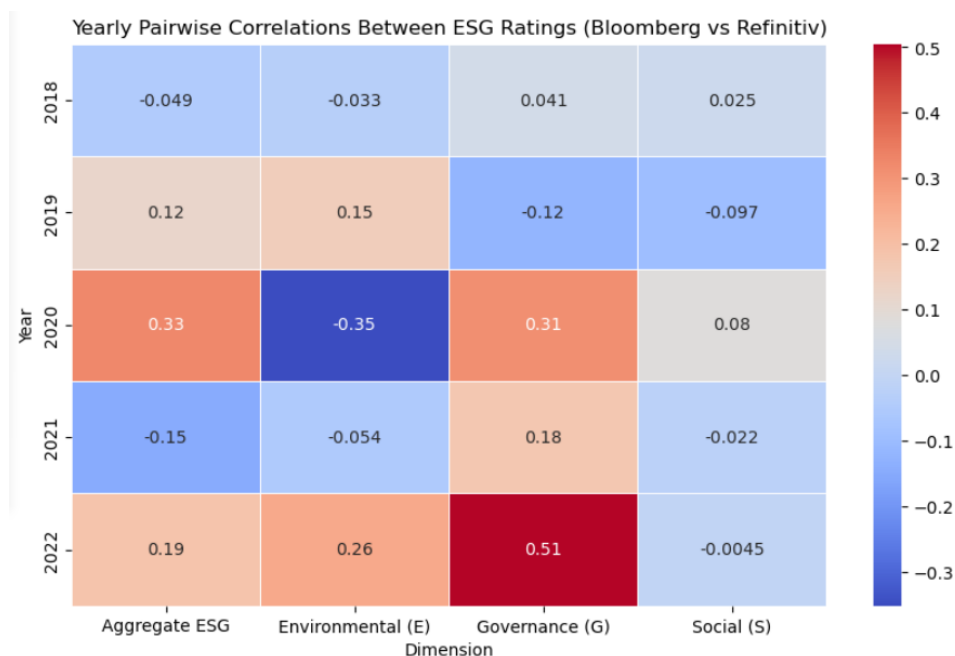
Table 4
Descriptive Statistics: Different ESG Rating Providers
 summarizes the descriptive statistics for aggregate ESG ratings from three key providers: Refinitiv, and Bloomberg Estimation. With 1,424 observations in each dataset.

	Refinitiv (ESGScore)	Bloomberg Estimation (ESG_SCORE)
Mean	64.43	40.56
Standard Dev.	15.50	18.26
Median	67.50	42.70
Min	14.38	0.00
Max	93.72	86.30

4.1.3 How to Treat the ESG Rating Divergences

Table 5 presents the yearly correlations between Bloomberg and Refinitiv ESG scores across four dimensions: Aggregate ESG, Environmental (E), Social (S), and Governance (G) for S&P 500 firms from 2018 to 2022. These correlations reveal variations across years and dimensions, reflecting differences in the methodologies employed by the two ESG rating providers. Such differences warrant a closer examination of specific dimensions and years to better understand the underlying divergence.

Table 5
Correlation between ESG Ratings: Different Providers
Correlation between ESG ratings at the aggregate rating level (ESG) and at the level of the environmental dimension (E), the social dimension (S), and the government dimension (G). **The Bloomberg ESG Estimation Score and the Refinitiv ESG Score are utilized to evaluate the performance of S&P 500 firms from 2018 to 2022.**



The Aggregate ESG scores in 2018 demonstrate a negative correlation of **-0.049**, indicating substantial alignment in overall ESG performance evaluations between the two providers. In contrast, the Social (S) scores in the same year exhibit a positive correlation of **0.025**, potentially due to differing interpretations or weightings of social factors such as labor practices or community engagement. Meanwhile, the Social (S) scores and Governance (G) scores in 2019 show negative correlations, suggesting disagreement on key Social (S) scores and Governance (G) indicators. However, the Environmental (E) scores in 2020 and 2021 reflect a weak negative correlation, highlighting potential divergences in the evaluation of environmental indicators.

The variability observed between Refinitiv and Bloomberg ESG scores aligns with the sources of divergence identified by Berg et al. (2022). Specifically, Berg et al. (2022) highlighted three primary sources of ESG rating divergence: measurement, scope, and weight differences. Measurement divergence (56%) results from the use of varying metrics to assess similar ESG attributes, while scope divergence (38%) reflects differences in the attributes prioritized by agencies, such as environmental versus social factors. Weight divergence (6%) arises from variations in the emphasis placed on specific ESG dimensions, such as governance versus environmental issues. These factors contribute to the inconsistencies observed in the yearly correlations, complicating direct comparisons across providers and emphasizing the need for greater standardization and transparency in ESG assessments.

4.2 Descriptive Statistics and Correlation

Table 6 presents the descriptive statistics and correlation matrix of the main variables used in this study. The mean value of **Tobin’s Q** is 19.03, with a standard deviation of 14.61, indicating substantial variation in firm market value within the sample. The first quartile (Q1) and third quartile (Q3) values of Tobin’s Q are 2.41 and 30.00, respectively, suggesting that the majority of firms in the sample have Tobin’s Q values within this range.

In the financial performance variables, the average **Return on Assets (ROA)** is 7.23%, with a standard deviation of 8.14%. There is a slight but significant positive correlation between ROA and Tobin’s Q ($\beta = 0.09$, $p < 0.001$), indicating that firms with higher profitability tend to have higher market valuations. The average **Leverage Ratio** is 4.20%, with a relatively high standard deviation of 18.56. A negative correlation exists between the leverage ratio and Tobin’s Q ($\beta = -0.02$), though this relationship is not statistically significant.

The average **ESG Uncertainty** is 18.82%, with a standard deviation of 14.49. It shows a positive but non-significant correlation with Tobin’s Q ($\beta = 0.04$), suggesting that the impact of ESG uncertainty on firm valuation may be nonlinear and contingent on interactions with other factors.

ESG Controversies Score reflects a firm’s ability to manage ESG-related risks and controversies. The average **ESG Controversies Score** is 75.10, with a standard deviation of 34.05. A higher score indicates a stronger capacity to handle ESG controversies. However, contrary to initial expectations, the ESG Controversies Score exhibits a significant negative correlation with Tobin’s Q ($\beta = -0.06$, $p < 0.05$), suggesting that firms with better controversy management capabilities may have lower market valuations. This relationship, however, is likely **nonlinear**, as firms that effectively manage ESG controversies may gradually transform the negative impact into strategic opportunities, thereby mitigating ESG-related risks over time. Additionally, there is a strong negative correlation between the ESG Controversies Score and the ESG Score ($\beta = -0.26$, $p < 0.001$). However, this relationship may also be influenced by the **nonlinear nature** of ESG controversies.

The average **Board Gender Diversity (BGD)** score is 67.08, with a standard deviation of 21.34. BGD exhibits a significant positive correlation with Tobin’s Q ($\beta = 0.25$, $p < 0.001$), indicating that firms with a higher proportion of female board members tend to have higher market valuations. This result supports the notion that gender-diverse boards contribute to improved corporate governance by enhancing oversight, strengthening decision-making processes, and boosting investor confidence.

ESG Score is a comprehensive indicator used to assess a company’s overall ESG performance. The average ESG score is 64.43%, with a standard deviation of 15.51. There is a significant positive correlation between ESG Score and Tobin’s Q ($\beta = 0.15$, $p < 0.001$), indicating that firms with stronger ESG performance tend to be valued more highly by the market. Additionally, ESG Score is significantly and positively correlated with **Board Gender Diversity** ($\beta = 0.23$, $p < 0.001$) and **Board Independence** ($\beta = 0.16$, $p < 0.001$), suggesting that stronger governance structures contribute to improved ESG performance.

The average **Board Independence** is 53.43%, with a standard deviation of 14.66. This variable is positively correlated with Tobin’s Q ($\beta = 0.07$, $p < 0.01$), supporting that independent board members enhance governance quality and firm valuation.

Board Size has a mean of 11 members, with a standard deviation of 2.18. It does not show a significant correlation with Tobin’s Q ($\beta = 0.00$). The negative correlation with ROA ($\beta = -0.18$, $p < 0.001$), suggesting that larger boards may be associated with lower profitability.

Market Capitalization (log-transformed) has a mean of 24.31 and a standard deviation of 1.11. It is positively correlated with Tobin’s Q ($\beta = 0.14$), but this relationship is not statistically significant. Market capitalization exhibits strong positive correlations with ESG Score ($\beta = 0.35$) and Board Size ($\beta = 0.21$).

Table 6
Descriptive Statistics and Correlation Matrix

	Mean	Std Dev	Q1	Q3	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) Tobin's Q	19.03	14.61	2.41	30.00	1.00									
(2) ROA	7.23	8.14	2.81	11.24	0.09***	1.00								
(3) Leverage Ratio	4.20	18.56	1.36	3.95	-0.02	0.01	1.00							
(4) ESG Uncertainty	18.82	14.49	7.07	28.28	0.04	-0.03	-0.00	1.00						
(5) ESG Controversies	75.10	34.05	50.00	100.00	-0.06*	0.07**	0.00	-0.04	1.00					
(6) BGDiversity Score	67.08	21.34	51.75	84.17	0.25***	-0.03	-0.00	0.01	-0.08**	1.00				
(7) ESG Score	64.43	15.51	55.29	76.12	0.15***	-0.05	0.01	0.04	-0.26***	0.23***	1.00			
(8) Board Independence	53.43	14.66	45.45	62.50	0.07**	-0.08**	0.00	0.06*	-0.09***	0.18***	0.16***	1.00		
(9) Board Size	11.00	2.18	10.00	12.00	0.00	-0.18***	-0.04	0.08**	-0.17***	0.04	0.18***	0.05	1.00	
(10) Market Cap (log)	24.31	1.11	23.47	24.95	0.14	0.01	0.05	-0.43	-0.02	0.12	0.35	-0.02	0.21	1.00
					(0.026)	(0.026)	(0.027)	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)	(-)

Note: Number of observations = 1,424. Standard errors are in parentheses.

Significance levels: * p < 0.05, ** p < 0.01, *** p < 0.001.

The column numbers (1)–(11) correspond to variables in the dataset:

(1) Tobin's Q, (2) ROA Total Assets(%), (3) Leverage Ratio(%), (4) ESG Uncertainty ranking (%), (5) ESG Controversies Score (%), (6) Board Gender Diversity Score (%), (7) ESG Score (%), (8) Board Independence, (9) Board Size, (10) Market Capital (log).

4.3 Model Results

4.3.1 Preliminary Visualization Analysis: ESG Uncertainty, ESG Controversies, and Board Gender Diversity in Relation to Firm Value

Figure 1 shows the Preliminary Visualization Analysis: ESG Uncertainty, ESG Controversies, and Board Gender Diversity in Relation to Firm Value. The first plot indicates a U-shaped relationship between ESG uncertainty and Tobin’s Q. Initially, as ESG uncertainty increases, firm value declines, reaching a minimum before rising again. This suggests that at low to moderate levels of uncertainty, the market perceives uncertainty negatively, likely due to increased risk perception and information asymmetry. However, at higher levels of ESG uncertainty, firms might have stronger governance mechanisms, proactive risk management, or market adaptation strategies that eventually lead to higher valuation. This U-shaped pattern justifies the inclusion of a quadratic ESG uncertainty term in the regression models to capture this nonlinear effect.

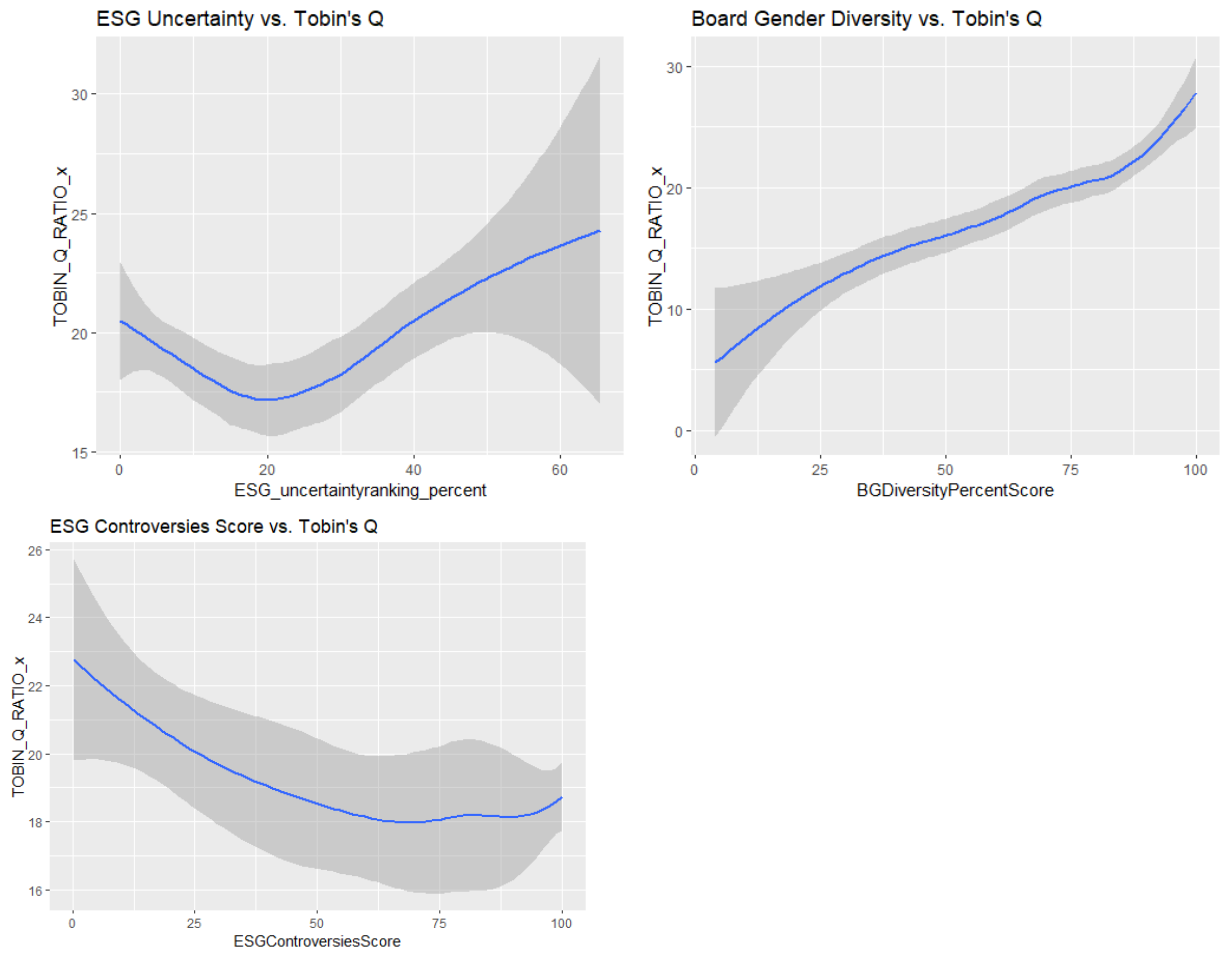
The ESG Controversies Score, ranging from 0 to 100, indicates the extent of ESG-related controversies, with higher scores representing fewer controversies and stronger ESG performance, while lower scores signify more controversies and higher ESG risks. The observed declining trend in Tobin’s Q as ESG Controversies Scores decrease suggests that firms with frequent ESG controversies tend to have lower valuations. This is consistent with agency theory and stakeholder theory, as persistent controversies can signal poor governance, weak risk management, or sustainability failures, increasing regulatory scrutiny, legal liabilities, and capital constraints. Investors may perceive such firms as riskier investments, leading to lower market valuations. However, the slight rebound at very high ESG Controversies Scores (indicating firms with strong ESG track records) may reflect market confidence in well-managed firms. Firms with proactive ESG risk management, transparency, and sustainable business practices may benefit from lower cost of capital, enhanced investor trust, and improved access to financing, resulting in higher Tobin’s Q. This aligns with the risk mitigation hypothesis, where firms with strong ESG credentials are perceived as less financially volatile and more resilient in the long term.

The third plot exhibits a clear positive relationship between board gender diversity and Tobin’s Q. As board gender diversity increases, firm value steadily rises, suggesting that more diverse boards contribute to better governance, improved decision-making, and enhanced firm reputation. The nearly linear pattern implies that board gender diversity should be included as a key explanatory variable in the regression models, and its potential moderating effects on ESG uncertainty could be explored.

The nonlinear nature of the relationship suggests that ESG controversies may not impact firm value in a strictly linear way. Firms with moderate controversy levels may still be able to maintain investor confidence through strong financial performance or industry dominance, whereas firms at the extremes—either highly controversial or with excellent ESG track records—may experience different valuation effects. This pattern underscores the importance of incorporating nonlinear terms and potential interaction effects with ESG uncertainty in further regression analyses to fully capture the financial implications of ESG risk exposure.

These visual patterns provide strong motivation for incorporating nonlinear terms and interaction effects in the regression models. The U-shaped trend in ESG uncertainty suggests that failing to include a quadratic term could lead to misleading conclusions. The impact of ESG controversies might also be nonlinear or interact with ESG uncertainty. Finally, the strong positive association between board gender diversity and Tobin’s Q supports its inclusion as a main predictor and potential moderator. The next steps in the analysis will focus on testing these relationships more rigorously through econometric modeling.

Figure 1
Preliminary Visualization Analysis: ESG Uncertainty, ESG Controversies, and Board Gender Diversity in Relation to Firm Value



4.3.2 Hypothesis 1: Whether and How the U shape relationship exists in ESG Rating Uncertainty and Firm Value

Table 7 presents the results of random effect regressions analyzing the impact of ESG uncertainty on firm value, measured using Tobin’s Q. Four models progressively incorporate additional controls and quadratic terms to capture potential nonlinear relationships. The regression Results of Table 7 tests Hypothesis 1, meaning a U shape relation exists in ESG Uncertainty and Firm Value.

In Model 1, ESG uncertainty is included as a linear predictor, along with key control variables such as board gender diversity, ESG score, return on assets (ROA), leverage, and firm size (log market capitalization). The coefficient on ESG uncertainty ($\beta = 0.032$, $p = 0.212$) is positive but not statistically significant, indicating no clear linear effect. Board gender diversity is positively associated with Tobin’s Q ($\beta = 0.156$, $p < 0.01$), suggesting that firms with more diverse boards tend to have higher valuations. ESG score and ROA are also positively significant ($p < 0.05$ and $p < 0.01$, respectively), reinforcing their role as key financial and governance indicators.

Model 2 introduces year fixed effects and industry dummies (GIC sector classifications) to control for time and industry-specific factors. ESG uncertainty remains statistically insignificant ($\beta = 0.026$, $p = 0.372$). However, industry effects show that firms in the energy sector ($\beta = -4.366$, $p < 0.01$) and industrials ($\beta = -2.986$, $p < 0.1$) exhibit significantly lower Tobin’s Q compared to the reference category.

In Model 3, a quadratic term for ESG uncertainty is introduced to test for nonlinear effects. The linear ESG uncertainty coefficient becomes significantly negative ($\beta = -0.229$, $p < 0.01$), while the quadratic term is positive and significant ($\beta = 0.005$, $p < 0.01$), confirming a U-shaped relationship between ESG uncertainty and firm value. This suggests that moderate ESG uncertainty negatively affects firm valuation, while extremely high levels may have a less severe or even positive effect.

Model 4, which incorporates year fixed effects along with the quadratic ESG uncertainty term, confirms this U-shaped effect. The linear term remains significantly negative ($\beta = -0.217$, $p < 0.05$), while the quadratic term remains positive ($\beta = 0.005$, $p < 0.01$). This suggests that ESG uncertainty is most detrimental at moderate levels but may trigger adaptive responses from firms at higher uncertainty levels, mitigating its impact on valuation.

Table 7

This table verifies Hypothesis 1: The U shape relationship exists in ESG Uncertainty and Firm Value

Random effect regression results under unbalanced panel data. This table presents the results of Random Effect estimations examining the relationship between a firm's market value and female board representation, along with control variables. For clarity, the independent variable Tobin's Q, a proxy for firm valuation.

*, ** and *** denote statistical significance at 10%, 5% and 1% respectively.

	Model 1	Model 2	Model 3	Model 4
Study Variables				
ESG Uncertainty	0.032 (0.026)	0.026 (0.027)	-0.229** (0.083)	-0.217* (0.049)
ESG Uncertainty ²			0.005** (0.002)	0.005*** (0.001)
Control Variables				
Board Gender Diversity	0.156*** (0.018)	0.157*** (0.014)	0.154*** (0.018)	0.155*** (0.013)
ESG Controversies	-0.001 (0.012)	0.014 (0.010)	-0.001 (0.012)	0.013 (0.010)
Board Independence	0.024 (0.026)	0.011 (0.022)	0.025 (0.026)	0.013 (0.024)
ESG Score	0.068** (0.027)	0.061** (0.013)	0.071** (0.027)	0.066** (0.014)
ROA	0.158** (0.048)	0.126* (0.039)	0.156** (0.048)	0.126* (0.040)
Leverage	-0.020 (0.020)	-0.015 (0.014)	-0.021 (0.020)	-0.016 (0.012)
Log Market Cap	0.838** (0.407)	0.630* (0.185)	0.867* (0.406)	0.655* (0.183)
Dummy Variables: GIC Business Sector				
GIC Consumer Discretionary		-0.889 (1.256)		-0.900 (1.270)
GIC Consumer Staples		-1.616 (1.063)		-2.039 (1.119)
GIC Energy		-4.366** (0.622)		-4.607** (0.544)
GIC Financials		-1.091* (0.529)		-1.310 (0.477)
GIC Health Care		0.672 (0.792)		0.406 (0.766)
GIC Industrials		-2.986* (0.713)		-3.023* (0.685)
GIC Information Technology		-0.782 (0.983)		-0.915 (0.996)
GIC Materials		-3.408* (1.047)		-3.714* (1.024)
GIC Real Estate		-3.938** (0.808)		-3.850** (0.786)
GIC Utilities		-2.092 (1.192)		-2.096 (1.190)
Constant	-19.136* (10.059)	-21.781** (9.951)	-17.975* (10.031)	-16.274 (10.412)
Year FE	No	Yes	No	Yes
Observations	1,424	1,424	1,424	1,424
Adjusted R ²	0.084	0.108	0.090	0.113
<i>Note:</i> *p<0.1; **p<0.05; ***p<0.01				

4.3.3 Hypothesis 2: Does Board Gender Diversity Moderate the Relationship Between ESG Uncertainty and Firm Value?

Table 8 examines the moderating role of board gender diversity (BGD) in the relationship between ESG uncertainty and firm value, proxied by Tobin's Q. The four models progressively introduce key controls and interaction terms to test whether diverse boards mitigate or amplify the negative effects of ESG uncertainty. The results indicate that rather than reducing ESG-related risks, board gender diversity appears to strengthen the negative relationship between ESG uncertainty and firm value at moderate levels. However, at extreme levels of ESG uncertainty, the interaction between BGD and ESG uncertainty squared suggests a stabilizing effect, reinforcing the non-linear dynamics in firm valuation.

In Model 1, the quadratic relationship between ESG uncertainty and firm value is established without interaction terms. The coefficient on ESG uncertainty is significantly negative ($\beta = -0.229$, $p < 0.01$), confirming that firms experiencing moderate ESG uncertainty tend to have lower valuations. However, the squared term of ESG uncertainty is positive and significant ($\beta = 0.005$, $p < 0.01$), supporting a U-shaped relationship where extreme levels of ESG uncertainty are associated with higher firm valuations. Board gender diversity exhibits a strong positive relationship with Tobin's Q ($\beta = 0.154$, $p < 0.01$), reinforcing prior findings that firms with more diverse boards tend to be valued higher. Other key controls, such as ESG score ($\beta = 0.07$, $p < 0.01$) and ROA ($\beta = 0.156$, $p < 0.1$), are also positively associated with firm value, suggesting that firms with strong ESG performance and profitability receive higher market valuations.

Model 2 introduces an interaction term between BGD and ESG uncertainty, revealing a significant negative coefficient ($\beta = -3.838$, $p < 0.1$). This suggests that board gender diversity amplifies the negative effects of ESG uncertainty rather than mitigating them. A possible explanation is that more diverse boards, while improving governance quality, may also lead to greater risk aversion, resulting in stronger negative market reactions to uncertainty. The linear ESG uncertainty term remains negative and significant ($\beta = -0.324$, $p < 0.01$), while its squared term continues to be positive and significant ($\beta = 0.005$, $p < 0.01$), reinforcing the U-shaped dynamic.

In Model 3, year fixed effects are incorporated to account for macroeconomic and time-related factors. The interaction term between BGD and ESG uncertainty remains negative and significant ($\beta = -3.847$, $p < 0.1$), indicating that this effect persists even after controlling for broader economic trends. The adjusted R^2 remains stable at 0.089, suggesting that the inclusion of fixed effects does not dramatically alter the explanatory power of the model. Industry fixed effects indicate that firms in the energy sector ($\beta = -4.607$, $p < 0.05$) and real estate ($\beta = -3.850$, $p < 0.05$) are particularly sensitive to ESG uncertainty, highlighting sector-specific vulnerabilities.

Model 4 refines the analysis further by introducing the interaction term between BGD and ESG uncertainty squared, yielding a positive and weakly significant coefficient ($\beta = 0.000$, $p < 0.1$). This suggests that while board gender diversity intensifies the negative effects of moderate ESG uncertainty, it may contribute to firm resilience at extreme levels of uncertainty. This finding aligns with the argument that diverse boards are more risk-averse in the face of uncertainty but may also foster adaptive strategies when uncertainty becomes unavoidable. The negative effect of ESG uncertainty ($\beta = -0.213$, $p < 0.1$) remains present, but its squared term ($\beta = 0.0024$) continues to suggest a U-shaped pattern, albeit with a slightly lower magnitude than in previous models.

Among the control variables, board gender diversity remains positively associated with firm value across all models ($\beta = 0.134$, $p < 0.01$ in Model 4), confirming its role in enhancing corporate governance and market confidence. ESG score remains positively significant ($\beta = 0.070$, $p < 0.05$), reinforcing the notion that firms with better ESG practices experience more favorable valuations. ROA continues to be positively linked to Tobin's Q ($\beta = 0.128$, $p < 0.1$), while leverage does not exhibit a statistically significant impact.

The adjusted R^2 improves slightly from 0.086 in Model 1 to 0.114 in Model 4, suggesting that incorporating interaction terms and fixed effects provides a more nuanced understanding of how BGD

interacts with ESG uncertainty. The presence of sectoral differences further highlights the complexity of ESG-related risks across industries.

4.3.4 Hypothesis 3: Whether ESG Controversies Moderate the Relationship Between ESG Uncertainty and Firm Value

Table 9 examines the moderating role of ESG controversies in the relationship between ESG uncertainty and firm value. This hypothesis tests whether firms with lower ESG controversies are better equipped to manage ESG-related uncertainties, potentially reducing their adverse effects on firm valuation. Six models progressively introduce interactions and fixed effects to capture these dynamics more comprehensively.

In Model 1, ESG uncertainty exhibits a significantly negative relationship with Tobin's Q ($\beta = -0.303$, $p < 0.05$), indicating that higher ESG uncertainty reduces firm valuation. However, the squared term of ESG uncertainty is positive and significant ($\beta = 0.005$, $p < 0.05$), confirming a U-shaped relationship, whereby firms experiencing extreme ESG uncertainty may eventually adapt and recover in market valuation. ESG controversies score is negative but not significant ($\beta = -0.020$, $p > 0.1$), suggesting that ESG controversies alone do not have an independent impact on firm value.

Model 2 introduces the interaction between ESG uncertainty and ESG controversies, but the coefficient remains small and statistically insignificant ($\beta = 0.001$, $p > 0.1$), indicating that ESG controversies do not strongly moderate the relationship between ESG uncertainty and firm value. The quadratic ESG uncertainty term remains highly significant ($\beta = 0.005$, $p < 0.05$), reinforcing the U-shaped effect.

Model 3 incorporates year fixed effects to control for time-related variations, and while the relationship between ESG uncertainty and firm value remains consistent ($\beta = -0.295$, $p < 0.1$), the interaction term between ESG uncertainty and ESG controversies remains statistically insignificant ($\beta = 0.001$, $p > 0.1$). This suggests that ESG controversies alone do not meaningfully alter the ESG uncertainty–firm value relationship.

Model 4 extends the analysis by including the squared term of ESG controversies, revealing that firms with fewer ESG controversies generally achieve higher firm valuations ($\beta = -0.124$, $p < 0.1$), but with diminishing returns at higher ESG controversies scores ($\beta = 0.001$, $p < 0.05$). However, the interaction term between ESG uncertainty and ESG controversies remains non-significant, suggesting that ESG controversies do not substantially mediate the uncertainty–firm value relationship.

Models 5 and 6 further explore non-linear moderating effects by introducing quadratic interaction terms between ESG uncertainty and ESG controversies squared. The results indicate that while ESG controversies have a marginally significant effect on firm valuation ($\beta = -0.133$, $p < 0.1$ in Model 5 and $\beta = -0.123$, $p < 0.1$ in Model 6), their interaction terms with ESG uncertainty remain statistically insignificant. The quadratic term of ESG uncertainty remains significant ($\beta = 0.004$, $p < 0.1$), suggesting that ESG uncertainty follows a U-shaped trajectory regardless of ESG controversies levels.

Control variables maintain expected relationships across all models. Board Gender Diversity (BGD) remains positively associated with firm valuation ($\beta = 0.154$, $p < 0.01$ in Model 1; $\beta = 0.148$, $p < 0.01$ in Model 2; $\beta = 0.155$, $p < 0.01$ in Model 3), confirming that more diverse boards enhance firm market value. ESG Score also exhibits a positive and significant effect on Tobin's Q ($\beta = 0.068$, $p < 0.1$ in Model 1; $\beta = 0.084$, $p < 0.05$ in Model 2; $\beta = 0.066$, $p < 0.05$ in Model 6), underscoring the value-enhancing role of ESG performance.

The presence of ESG controversies does not lead to substantial changes in the results. This indicates that while ESG uncertainty plays a crucial role in shaping firm value, ESG controversies do not significantly influence this relationship as a moderator.

Table 8

This table verifies Hypothesis 2: Board gender diversity moderates the relationship between ESG uncertainty and firm performance by mitigating its negative impact.

	Model 1	Model 2	Model 3	Model 4
Study Variables				
Board Gender Diversity	0.154*** (0.001)	0.124*** (0.029)	0.157*** (0.018)	0.134*** (0.016)
ESG Uncertainty	-0.229*** (0.006)	-0.324*** (0.117)	-0.298*** (0.102)	-0.213* (0.049)
ESG Uncertainty ²	0.005*** (0.001)	0.005*** (0.002)	0.005*** (0.002)	0.0024 (0.0014)
Interactions				
Board Gender Diversity × ESG Uncertainty		-3.838* (2.174)	-3.847* (2.172)	
Board Gender Diversity × ESG Uncertainty ²				0.000* (0.000)
Control Variables				
ESG Controversies	-0.001 (0.96)	-0.001 (0.013)	-0.024 (0.019)	0.014 (0.010)
Board Independence	0.034 (0.026)	0.043 (0.026)	0.039 (0.026)	0.015 (0.023)
ESG Score	0.07*** (0.008)	0.120** (0.050)	0.124** (0.050)	0.070** (0.013)
ROA	0.156 (0.001)	-0.015 (0.020)	-0.015 (0.020)	0.128* (0.041)
Leverage	-0.021 (0.301)	1.085*** (0.397)	1.047*** (0.397)	-0.016 (0.012)
Log Market Cap	0.867* (0.406)	-0.017 (0.033)	-0.085 (1.933)	0.643* (0.198)
Dummy Variables: GIC Business Sector				
GIC Consumer Discretionary		-0.440 (1.292)	-0.900 (1.270)	-1.207 (1.288)
GIC Consumer Staples		-0.637 (1.136)	-2.039 (1.119)	-2.330 (1.071)
GIC Energy		-3.589** (0.703)	-4.607** (0.544)	-5.098** (0.703)
GIC Financials		-0.756 (0.561)	-1.310 (0.477)	-1.447* (0.420)
GIC Health Care		1.406 (0.925)	0.406 (0.766)	0.122 (0.847)
GIC Industrials		-2.224* (0.812)	-3.023* (0.685)	-3.305* (0.774)
GIC Information Technology		0.000 (1.075)	-0.915 (0.996)	-1.246 (1.058)
GIC Materials		-2.420 (1.087)	-3.714* (1.024)	-4.012* (1.108)
GIC Real Estate		-2.975* (1.006)	-3.850** (0.786)	-4.206* (0.892)
GIC Utilities		-1.285 (1.154)	-2.096 (1.190)	-2.265 (1.121)
Constant	-17.975* (10.031)	-16.977 (10.362)		
Year FE	No	No	Yes	Yes
Observations	1,424	1,424	1,424	1,424
Adjusted R ²	0.086	0.089	0.089	0.114
<i>Note:</i>		*p<0.1; **p<0.05; ***p<0.01		

Table 9

This table tests Hypothesis 3: ESG controversies moderate the relationship between ESG uncertainty and firm market value, with gender diversity enhancing the effectiveness of ESG practices.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Study Variables						
ESG Controversies Score	-0.020 (0.019)	-0.016 (0.020)	-0.007 (0.014)	-0.124* (0.028)	-0.133* (0.037)	-0.123* (0.027)
ESG Uncertainty	-0.303** (0.101)	-0.300** (0.101)	-0.295* (0.086)	-0.277* (0.069)	-0.216* (0.048)	-0.216* (0.048)
ESG Uncertainty ²	0.005** (0.002)	0.005** (0.002)	0.005*** (0.001)	0.005*** (0.001)	0.004* (0.002)	0.004* (0.001)
ESG Controversies Score ²				0.001** (0.000)	0.001* (0.000)	0.001* (0.000)
Interactions						
ESG Uncertainty × ESG Controversies Score	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)			
ESG Uncertainty × ESG Controversies Score ²				0.000 (0.000)		
ESG Uncertainty ² × ESG Controversies Score					0.000 (0.000)	
ESG Uncertainty ² × ESG Controversies Score ²						0.000 (0.000)
Control Variables						
Board Gender Diversity	0.154*** (0.018)	0.148*** (0.018)	0.155*** (0.013)	0.155*** (0.014)	0.154*** (0.014)	0.154*** (0.014)
ESG Score	0.068* (0.027)	0.084** (0.028)	0.064** (0.014)	0.065** (0.012)	0.066** (0.012)	0.066** (0.012)
Board Independence	0.024 (0.026)	0.030 (0.026)	0.012 (0.024)	0.015 (0.023)	0.015 (0.023)	0.015 (0.023)
ROA	0.160*** (0.048)	0.140** (0.050)	0.130* (0.039)	0.120* (0.037)	0.119* (0.037)	0.119* (0.037)
Leverage	-0.021 (0.020)	-0.016 (0.020)	-0.016 (0.011)	-0.016 (0.012)	-0.016 (0.012)	-0.016 (0.012)
Log Market Cap	0.851* (0.406)	0.669 (0.415)	0.632* (0.172)	0.592* (0.152)	0.606* (0.162)	0.601* (0.157)
Dummy Variables: GIC Business Sector						
GIC Consumer Discretionary		-0.702	-1.190	-1.107	-1.040	-1.027
GIC Consumer Staples		-2.102	-2.218	-2.002	-1.903	-1.912
GIC Energy		-4.896*	-4.924**	-4.816**	-4.756**	-4.722**
GIC Financials		-1.257	-1.615	-1.464	-1.386	-1.374
GIC Health Care		0.473	0.119	0.392	0.471	0.485
GIC Industrials		-3.013	-3.283*	-3.254*	-3.200*	-3.183*
GIC Information Technology		-0.966	-1.176	-1.022	-0.969	-0.948
GIC Materials		-3.708*	-3.906*	-3.903*	-3.868*	-3.852*
GIC Real Estate		-3.472	-4.164*	-4.463*	-4.353*	-4.344*
GIC Utilities		-1.885	-2.330	-2.341	-2.237	-2.231
Constant	15.907 (10.149)	-10.955 (10.531)				
Year FE	No	No	Yes	Yes	Yes	Yes
Observations	1,424	1,424	1,424	1,424	1,424	1,424
Adjusted R ²	0.090	0.094	0.114	0.117	0.116	0.117
<i>Note:</i>				*p<0.1; **p<0.05; ***p<0.01		

4.3.5 Interpretation of Turning Points in ESG Uncertainty and Firm Value

Table 9 provides key insights into how **ESG uncertainty** affects **firm value**, measured by Tobin’s Q, and how this relationship shifts with different moderating variables, namely **Board Gender Diversity (BGD)**. The **turning point** represents the level of ESG uncertainty at which its previously negative impact on firm value begins to reverse, indicating firms’ adaptive strategies in response to ESG-related risks.

In tabel 7, which excludes interaction terms, the turning point occurs at **22.01%** ESG uncertainty. This result suggests that firms experiencing **low to moderate levels of ESG uncertainty** face an initial decline in firm value due to heightened risk perception and investor skepticism. However, beyond the **22.01%** threshold, firm valuation begins to recover, possibly due to firms adopting more transparent ESG practices, enhancing risk mitigation strategies, or implementing governance adjustments that restore market confidence. This finding is consistent with corporate finance theories suggesting that while moderate uncertainty deters investment, firms that manage extreme uncertainty effectively can develop **competitive advantages** in ESG-related domains.

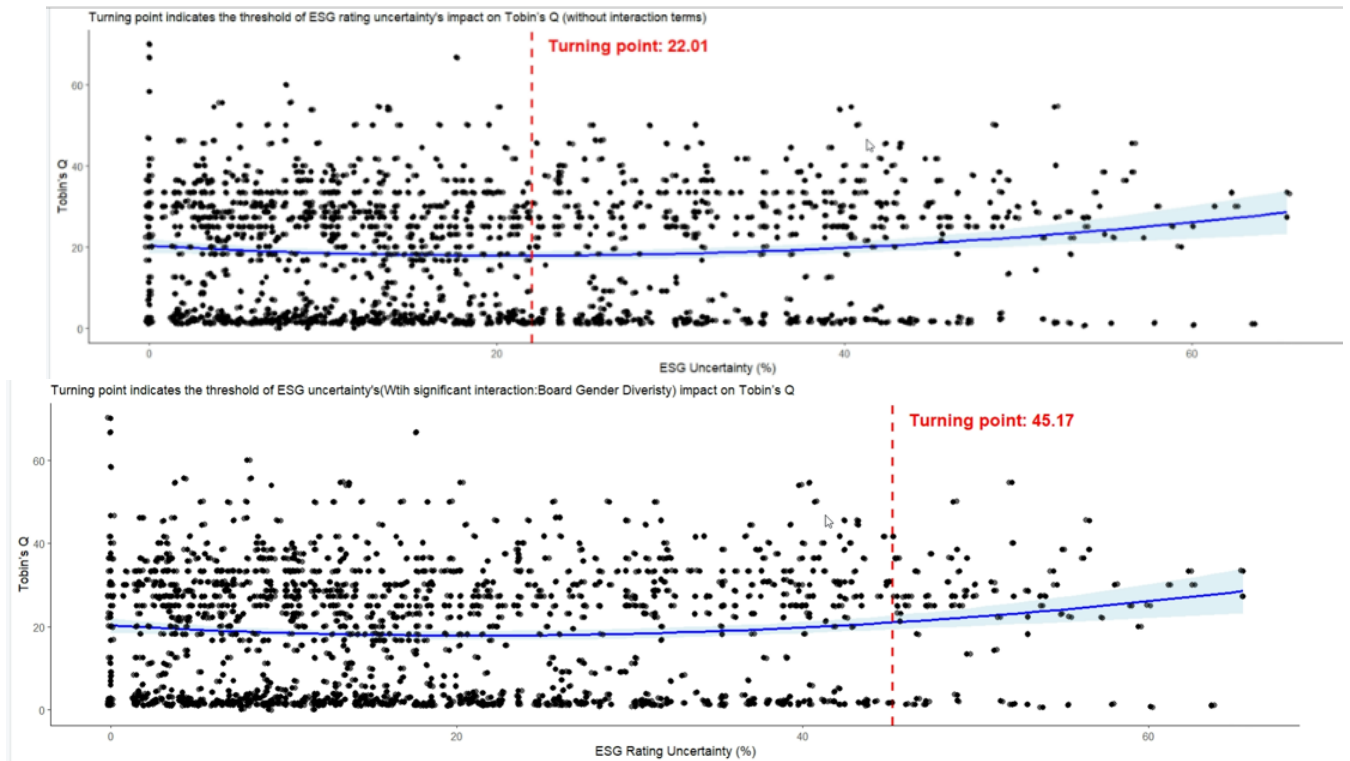
The table 8 introduces **Board Gender Diversity (BGD)** as a **moderating factor**, leading to a significant shift in the turning point to **45.17%** ESG uncertainty. This sharp increase implies that **firms with gender-diverse boards can tolerate a higher level of ESG uncertainty before experiencing a turnaround in firm value**. The significant interaction effect suggests that **diverse boards enhance risk oversight and strategic decision-making**, enabling firms to better manage ESG-related uncertainties. This finding aligns with **agency theory**, which argues that board diversity enhances governance quality, reduces information asymmetry, and promotes long-term risk mitigation. The dramatic increase in the turning point from **22.01% to 45.17%** underscores the critical role of board diversity in extending firms’ resilience to ESG uncertainty, delaying the point at which valuation rebounds.

A comparison of the two models underscores the importance of **corporate governance mechanisms** in determining how firms navigate ESG-related uncertainty. The turning point in the **BGD-interaction model (45.17%)** is significantly higher than in the baseline model (22.01%), reinforcing the idea that governance structures play a central role in sustaining firm value under uncertainty. While ESG uncertainty initially leads to a decline in Tobin’s Q, firms with strong governance—especially those with diverse boards—exhibit greater adaptability in mitigating ESG risks and prolonging their resilience before market perception shifts positively.

From a strategic perspective, these findings suggest that investors and firms should prioritize **board diversity and governance quality** as a critical tool for risk management in high-uncertainty environments. Firms operating in **high-uncertainty ESG contexts** should consider enhancing their board diversity to **extend the range at which ESG uncertainty remains a risk before firm value stabilizes**. Investors evaluating firms with high ESG uncertainty should **closely examine board composition**, as firms with greater diversity are likely to be more **resilient to ESG-related risks**.

Since the interaction term in Table 9 is not statistically significant, there is little reason to analyze its turning point graph in detail. In regression analysis, when an interaction term is insignificant, it means the moderating variable does not consistently affect the relationship between ESG Uncertainty and Tobin’s Q.

Figure 2
Turning Points in the U-Shaped Relationship Between ESG Rating Uncertainty and Tobin's Q



5 Discussion and Conclusion

The findings of this study focus on the growing body of literature on environmental, social, and governance (ESG) factors in corporate finance, particularly regarding the role of ESG uncertainty and firm valuation. Current research on ESG uncertainty primarily focuses on examining differences in ESG ratings and how firms respond to these variations (Berg et al., 2022). However, this study takes a more advanced approach by exploring the relationship between ESG uncertainty and key factors traditionally examined in ESG research, such as board gender diversity and ESG controversies. By moving beyond rating disparities, this paper provides a deeper understanding of how ESG uncertainty interacts with fundamental ESG governance and risk management mechanisms (Zhou & Lei, 2025). Moreover, this study identifies a U-shaped relationship between ESG uncertainty and firm value, further enriching the discourse on ESG-related financial impacts (Shakil, 2021; Lawrence & Raithatha, 2023; Tampakoudis et al., 2022).

5.1 Theoretical Contributions

Going beyond existing research, this study incorporates a more comprehensive approach to ESG analysis by explicitly considering ESG uncertainty (Zhou & Lei, 2020). While previous studies have primarily focused on traditional interaction effects, such as the moderating roles of board gender diversity (BGD) and ESG controversies, they have largely overlooked how these classic ESG factors interact with ESG uncertainty (Shakil, 2021; Heubeck, 2023). By integrating ESG uncertainty into the analysis, this research extends the scope of conventional ESG studies, offering a more holistic perspective on how firms navigate ESG-related risks and their impact on firm value (Gul et al., 2011; Adams and Ferreira, 2009; Lawrence & Raithatha, 2023; Tampakoudis et al., 2022).

5.2 Practical Implications

First contribution of this paper is on the U-shaped relationship. ESG uncertainty, which refers to the degree of inconsistency, ambiguity, and unpredictability in ESG-related disclosures and assessments, plays a crucial role in shaping market perceptions of firm risk (Berg et al., 2022; Zhou & Lei, 2025). In the baseline model without interaction terms, the turning point of 22.01% ESG uncertainty indicates that firms facing low-to-moderate ESG uncertainty tend to suffer from increased market skepticism and risk premiums, leading to lower Tobin's Q. This aligns with the theoretical perspective that markets penalize firms for unclear or unreliable ESG-related information due to concerns about regulatory risks, stakeholder pressures, and potential reputational damage. However, once firms surpass the 22.01% threshold, Tobin's Q begins to rise, suggesting that firms adapt by implementing more structured ESG reporting frameworks, risk mitigation strategies, and transparent governance mechanisms. This supports the strategic adaptation hypothesis, where firms that embrace ESG challenges proactively can transform uncertainty into long-term competitive advantages, particularly in attracting ESG-focused investors. Prior to this study, no research has explicitly identified a U-shaped relationship between ESG uncertainty and firm value. This study contributes to the literature by demonstrating that while moderate ESG uncertainty negatively impacts firm valuation, certain factors can buffer its effects at higher levels, eventually leading to a recovery in firm value.

The second contribution of this paper is on the moderation role of board gender diversity. The results show that when board gender diversity (BGD) is introduced as a moderator, the turning point for ESG uncertainty increases significantly to 45.17%, more than doubling the threshold observed in the baseline model. This finding provides compelling evidence against the notion of tokenism, which suggests that female board representation is merely symbolic and does not contribute to substantive corporate decision-making (Kanter, 1977; Kulich et al., 2007; Gul et al., 2011). Previous interaction models have demonstrated that BGD plays a moderating role in ESG-related relationships. This study further confirms that even in the presence of ESG uncertainty, the interaction between BGD and ESG uncertainty remains strong and significant, reinforcing the idea that gender-diverse boards continue to enhance corporate governance by improving oversight, risk management, and strategic ESG-related decision-making. (Srinidhi et al., 2011; Allen et al., 2005; Lawrence & Raithatha, 2023; Tampakoudis

et al., 2022).

The ability of gender-diverse boards to extend the range of ESG uncertainty before firm value begins to recover suggests that such boards adopt more cautious, well-informed, and proactive ESG strategies. This aligns with prior research indicating that gender-diverse boards enhance firm accountability, improve non-financial disclosures, and promote sustainable business practices. Additionally, from an investor perspective, firms with gender-diverse boards may be perceived as having stronger governance structures, thereby reducing investor concerns about ESG-related risks.

In this research, the regression results confirm that board gender diversity significantly and positively moderates the impact of ESG uncertainty. In 2021, Shakil identified a similar relationship in their study. However, their analysis did not account for ESG uncertainty. As a result, their findings may not provide a comprehensive understanding of how board gender diversity interacts with ESG uncertainty in influencing firm value (Shakil, 2021). This study adds to the existing literature by showing that while moderate ESG uncertainty has a negative impact on firm valuation, board gender diversity can mitigate its effects, ultimately facilitating a rebound in firm value.

The third contribution of this paper is on the ESG controversy score and its limited moderating effect. While ESG controversy Score represent negative incidents related to environmental, social, or governance issues, the results suggest that their impact on firm value is less pronounced compared to board diversity. The interaction term between ESG uncertainty and ESG controversy Score is not statistically significant, indicating that ESG controversy Score alone do not systematically alter the ESG uncertainty–firm value relationship (Shakil, 2021). In 2021, Shakil found that ESG controversy Score and board gender diversity significantly influenced the relationship between ESG factors and financial risk. However, this study finds no significant moderating effect when examining the interaction between ESG controversy Score and ESG uncertainty. This suggests that, unlike in the financial risk context, ESG controversy Score do not significantly change how ESG uncertainty impacts firm value. The results indicate that a firm’s ability to manage ESG controversies does not systematically alter the effects of ESG uncertainty on market valuation.

Our results document that even with the inclusion of ESG uncertainty, the positive and significant relationship between ESG score and firm value persists, reinforcing the idea that firms with higher ESG performance are rewarded by the market. ESG score captures the comprehensive quality of a firm’s ESG practices, including its transparency, sustainability efforts, and stakeholder engagement. The positive impact of ESG score in all models suggests that regardless of uncertainty and controversy levels, firms with strong ESG practices tend to command higher valuations. This is in line with prior research suggesting that ESG investments yield long-term financial benefits by reducing regulatory risks, improving operational efficiencies, and enhancing investor trust.

5.3 Limitations and Future Study

While the database is a valuable resource for financial and ESG data, researchers should be mindful of these limitations and consider complementing it with other data sources or methods to ensure a comprehensive and robust analysis.

Despite reputation for providing high-quality data, it is important to acknowledge that inaccuracies or errors may still exist within any database. Such discrepancies can arise from a variety of sources, including reporting errors, data entry mistakes, or delays in information updates. These factors can potentially compromise the precision of research findings. Additionally, Refinitiv amalgamates data from diverse sources, which may not always adhere to a uniform reporting standard. This variability in reporting can result in inconsistencies and challenges when attempting to compare data across different companies or industries. Furthermore, when utilizing ESG scores from Refinitiv, one must consider that these scores are the result of a proprietary methodology. Although this methodology is thorough, it may inherently carry certain biases or perspectives in the weighting and assessment of ESG factors.

In conclusion, while the Refinitiv database is a valuable resource for researchers, it is crucial to approach its use with a critical eye. Researchers should be aware of the potential limitations and biases inherent in the data, and where possible, corroborate findings with additional sources or methods to ensure a more comprehensive and accurate analysis.

6 Reference List

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