ESG trade-off with risk and return in Chinese energy companies

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Abstract

Purpose – This study aims to examine the relationship between environmental, social and governance (ESG) disclosure, firm risk and stock market returns within the Chinese energy sector. Using a variety of econometric techniques, the study seeks to uncover the impact of ESG disclosure on risk mitigation and its influence on stock market performance.

Design/methodology/approach – Benchmark regression models were used to explore the associations between ESG disclosure, firm risk and stock returns. To address potential endogeneity, a generalised method of moments estimator is used. Quantile regression was used for robustness analysis.

Findings – The study reveals a negative relationship between ESG disclosure and firm risk, indicating that companies with greater ESG disclosure tend to experience reduced risk exposure. In addition, a positive association is observed between ESG disclosure and stock market returns, suggesting that companies with more comprehensive ESG disclosure practices tend to perform better in the stock market.

Research limitations/implications – This study implies that investors appreciate sustainable investment and incorporate ESG practices and disclosure in decision-making. Policymakers can promote transparent ESG reporting through regulatory frameworks, fostering sustainable practices in the energy sector.

Originality/value – Despite the mounting concerns over carbon dioxide emissions and the energy industry's environmental footprint, this study pioneers a comprehensive analysis of ESG disclosure within this critical sector. Delving into the relationship of ESG practices, firm risk and market returns, this research uniquely examines both risk mitigation and return enhancement, shedding new light on sustainable strategies in the energy domain.

Keywords ESG, Disclosure, Risk, Volatility, Stock return, Energy industry

Paper type Research paper

1. Introduction

In recent years, the energy sector has witnessed a growing emphasis on environmental, social and governance (ESG) practices and emerged as a crucial consideration for investors, stakeholders and corporations alike. As the global community increasingly recognises the importance of sustainability, ethical practices and responsible governance, firms face mounting pressure to incorporate ESG principles into their business strategies. With the global drive towards sustainability and the need to address climate change, energy companies face unique challenges and opportunities in managing their ESG performance. As key contributors to greenhouse gas emissions and natural resource consumption, energy firms are under increasing pressure to demonstrate their commitment to sustainable practices, social responsibility and effective governance. Over the past 20 years, China has seen an extraordinary surge in energy requirements, primarily due to its rapid industrialisation and urban development. Since 2018, China has been the most prominent global crude oil, natural gas and coal importer. Consequently, it currently ranks as the world's foremost consumer of energy (BP, 2019). As stated by Bloomberg NEF, in 2021, the world invested a total of $755bn in transforming energy systems. Notably, China played a

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significant role in this global effort, contributing 35% of the total investment, making it the leader in investing in new energy (Yang *et al.*, 2021).

ESG disclosure has emerged as a critical tool for energy companies to communicate their efforts in managing ESG risks and integrating sustainable practices into their operations. The significance of ESG disclosure lies in its potential to enhance transparency and accountability and its impact on firm risk and stock volatility (Li *et al.*, 2022; Kumar *et al.*, 2016). Investors are increasingly considering ESG criteria as fundamental factors in their decision-making processes, aiming to align their portfolios with their ethical and sustainability preferences. By voluntarily disclosing ESG-related information, energy firms can address stakeholder concerns, enhance transparency and foster trust with investors, regulators and communities. However, the relationship between ESG disclosure and firm risk in the energy sector remains an area of considerable interest and debate.

Understanding the impact of ESG disclosure of firm risk and stock volatility is of particular significance for energy companies as they navigate a rapidly evolving landscape characterised by evolving regulatory frameworks, energy transition initiatives and shifting investor preferences. The intertwining of ESG factors and firm risk is a multifaceted subject that draws from various theoretical perspectives (He *et al.*, 2023; Orlitzky and Benjamin, 2001; Kumar *et al.*, 2016; Luo, 2022). Agency theory posits that ESG disclosure acts as a mechanism to align the interests of management and shareholders, potentially reducing information asymmetry and agency costs. Stakeholder theory emphasises the significance of ESG disclosure in maintaining positive relationships with diverse stakeholder groups, including employees, communities and regulators. Market-based theories suggest that ESG disclosure can positively influence a firm's reputation, attracting investors who incorporate ESG criteria into their decision-making processes. To date, empirical research has provided valuable insights into the ESG disclosure relationship with firm risk and stock volatility across industries. However, the energy sector remains relatively underexplored despite its unique challenges and opportunities in navigating the transition towards a sustainable future.

The energy sector, a vital driver of global economic growth, is facing a pivotal challenge in the form of its substantial contributions to environmental degradation. As international attention increasingly focuses on sustainability, ethical practices and responsible governance, the energy industry is grappling with the imperative to address these environmental concerns while maintaining financial viability. In this context, the lack of comprehensive understanding about how ESG disclosure impacts both firm risk and market returns poses a critical problem. While previous research has highlighted aspects of this relationship, a significant gap remains in examining these dynamics within the energy sector. Addressing this gap is essential for guiding sustainable practices and strategic decision-making within an industry that is not only subject to environmental scrutiny but also accountable to investors seeking returns. This study aims to bridge this gap by delving into the nuanced connection between ESG disclosure, firm risk and stock market returns in the energy sector, contributing vital insights to the intersection of sustainability and financial performance.

This study contributes to the capital market theories by examining the relationship between ESG disclosure, firm risk and stock market returns in the energy industry of China. China is the world's foremost consumer of energy (BP, 2019) and a leader in investing in new energy (Yang *et al.*, 2021). By analysing this relationship, we aim to provide insights into the potential benefits of ESG disclosure on risk management and stock performance in the energy sector. By analysing a comprehensive data set of Chinese energy companies over a period of 2014–2022, we aim to provide evidence on how ESG practices are associated with changes in firm risk and stock volatility within the energy industry. Furthermore, we also

use different estimation techniques in our analysis, ranging from ordinary least squares (OLS), fixed effect (FE), random effect (RE), feasible generalised least squares (FGLS) and generalised method of moments (GMM). The two-step system GMM, first proposed by Arellano and Bond (1991), is a valuable approach for mitigating the endogeneity problem. To ensure the robustness of our research, we use simultaneous quantile regression (SQR) estimates on the conditional explanatory variables at various levels. Irrespective of the estimation approaches, the conclusions of the study remain valid. The study will offer significant insights for energy businesses, investors, legislators and other relevant stakeholders, enhancing their decision-making processes, risk management techniques and sustainability initiatives. This research has the potential to facilitate positive transformations by promoting the adoption of sustainable business practices and promoting a more robust and responsible energy sector.

Section 2 will review relevant literature to explore the theories and frameworks that underpin ESG disclosure, firm risk and stock market return relationship. We will examine the theoretical linkages between agency theory, stakeholder theory, market-based theories and ESG disclosure practices. In addition, empirical studies will be reviewed to provide empirical support and validate these theoretical foundations. Section 3 discusses the methods used, including OLS, FE regression, REs regression, FGLS, two-step system GMM and SQR, to ensure the robustness and reliability of the results. The findings will be presented in Section 4, and conclusions will be followed with theoretical and practical implications.

2. Literature review and hypothesis development

2.1 Literature review

The energy sector is at a crucial stage where questions about its impact on the environment are gaining greater attention. Concerns about CO_2 emissions, greenhouse gases responsible for climate change, have particularly spotlighted the sector's role (Chandra Voumik *et al.*, 2022; Majumder *et al.*, 2023; Rahman and Majumder, 2022; Rahman *et al.*, 2022). As countries worldwide strive to make their way towards more sustainable paths, the energy industry is facing growing calls to rethink its strategies and adopt more environmentally friendly approaches (Nahrin *et al.*, 2023; Rahman *et al.*, 2021; Voumik *et al.*, 2023a; Voumik *et al.*, 2023b). In this section, we will explore how discussions about ESG – covering the environment, social responsibility and governance connect with the energy sector's specific environmental challenges. By examining the existing research, this review aims to shed light on how these concepts relate to the energy sector's complex dynamics, exploring how they could affect risk, returns and overall practices.

Numerous studies have investigated the relationship between ESG disclosure and various firm attributes. The information asymmetry between companies and stakeholders, including investors, can lead to increased risk and higher stock price volatility. ESG disclosure acts as a mechanism to reduce this information asymmetry by providing stakeholders with comprehensive and transparent information about a firm's ESG performance. The sustainable development theory highlights the importance of positive ESG performance for enterprises, as it signifies their commitment to business standardisation and long-term sustainable practices (He *et al.*, 2023). By prioritising sustainability, companies can attract prospective consumers, suppliers and dealers who align with the principles of sustainable development. This, in turn, helps mitigate shortsighted behaviour in enterprise development and effectively reduce potential risks (Bai *et al.*, 2022).

Eccles and Viviers (2011) examined the antecedents and consequences of titles characterising investment techniques that combine ESG problems by reviewing approximately 190 research studies published from 1975 to 2009. They claim that the primary goal of ESG investment

practice is to increase financial returns while adjusting for risk by considering ESG issues. A firm can allegedly lessen its exposure to different types of risks by incorporating ESG responsibilities (Dhaliwal *et al.*, 2014), leading to less unpredictability in cash flow and profitability (Kumar *et al.*, 2016). As a result, an ESG firm frequently outperforms a non-ESG company in terms of financial performance, which lowers the volatility of the stock of ESG companies relative to non-ESG companies (Liu *et al.*, 2023).

A sizable sample of European businesses is examined by Sassen *et al.* (2016); they concluded that ESG lowers both overall and idiosyncratic risks. In the existing literature, the studies of María del Carmen Valls *et al.* (2022), Sassen *et al.* (2016), Liu *et al.* (2023), Kumar *et al.* (2016) and He *et al.* (2023) provided negative ESG and risk relationship. Balcilar *et al.* (2017) also studied the ESG and risk relationship and concluded with a negative association. It is negative because providing comprehensive and transparent information about a firm's ESG performance has the potential to enhance transparency, improve governance and mitigate risk. This, in turn, can reduce firm risk and lower stock price volatility. The alignment of interests between managers and shareholders, as emphasised by agency theory, is facilitated through effective ESG disclosure practices. Stakeholder theory highlights the importance of addressing stakeholder concerns through transparent communication and engagement, which can lead to enhanced trust and reputation, potentially reducing risk. Lööf *et al.* (2022) demonstrated that equities with higher ESG ratings have a reduced tail risk and a lower potential upside return. Furthermore, market-based theories propose that investors consider ESG factors in their decision-making, leading to more accurate securities pricing and lower cost of capital for firms with strong ESG performance. This positive investor sentiment can lower firm risk and reduce stock price volatility. Overall, theory linkage, empirical studies and theoretical underpinnings suggest that ESG disclosure is associated with risk reduction, lower stock price volatility and increased return. By demonstrating a commitment to sustainable practices, responsible governance and transparent communication, firms can mitigate risks, enhance stakeholder relationships and improve market perceptions, ultimately leading to potential benefits in terms of risk management and stock market performance.

The other prospect of literature Revelli and Viviani (2015) concluded that conventional investments outperform socially conscious ones in terms of financial success. In a meta-analysis, Khan (2022) came up with similar results. In the context of the UK, Luo (2022) provided that negative ESG and return relationship. Bolton and Kacperczyk (2021) also support a negative relationship. Kumar *et al.* (2016) studied the relationship between ESG and risk across various industries, including the energy industry. Their findings suggest that implementing effective ESG procedures can help businesses reduce risk, although the degree of risk reduction may vary depending on industry characteristics. Notably, among the 12 industries examined, the energy industry emerged as the most volatile.

Despite this valuable contribution, a significant literature gap exists regarding the specific dynamics and nuances of the relationship between ESG disclosure, risk and volatility within the energy sector. Thus, further research is needed to delve deeper into this area and provide insights tailored to the unique context of the energy industry. Specifically, understanding how different aspects of ESG disclosure impact risk and volatility, considering industry-specific factors and dynamics, can contribute to developing targeted risk management strategies and fostering sustainable practices within the energy sector. This literature gap represents an important opportunity for researchers to expand our understanding of the ESG and risk-return relationship within the energy industry and its implications for long-term sustainable development. By addressing these gaps, this study aims to contribute to the existing literature by examining the relationship between ESG

disclosure and firm risk and return specifically within energy companies and provide valuable insights for practitioners, investors and policymakers operating in the energy industry. In the subsequent section, we establish the testable hypotheses.

2.2 Hypothesis development

Based on the theoretical underpinnings and empirical evidence presented in the literature review, we formulate the following hypotheses:

H1. ESG disclosure has a negative relationship with firm risk.

The comprehensive and transparent information provided through ESG disclosure enhances transparency, governance and stakeholder engagement, leading to effective risk mitigation and reduced stock price volatility (Lööf *et al.*, 2022; Sassen *et al.*, 2016; He *et al.*, 2023):

H2. ESG disclosure has a positive relationship with stock market returns.

By demonstrating a commitment to sustainable practices and responsible governance, firms can improve market perceptions, potentially leading to increased investor sentiment and improved stock market performance (Balcilar *et al.*, 2017; Liu *et al.*, 2023).

These hypotheses are guided by the theories of agency, stakeholder and market-based perspectives, which suggest that ESG disclosure positively influences firm behaviour, stakeholder relationships and investor sentiment, ultimately affecting risk and return outcomes. Furthermore, empirical studies within various industries, including the energy sector, provide support for these theoretical linkages (Kumar *et al.*, 2016; Luo, 2022; Revelli and Viviani, 2015).

By examining the unique context of the energy industry, this study aims to contribute to the existing literature and provide a deeper understanding of the relationship between ESG disclosure, risk and return. Addressing this gap will offer insights into how specific aspects of ESG disclosure impact risk and volatility within energy companies, allowing for the development of targeted risk management strategies that align with sustainable practices. Overall, this research seeks to shed light on the intricate interplay between ESG disclosure, firm risk and stock market returns within the energy sector, thereby offering valuable insights for industry practitioners, investors and policymakers.

3. Data and methodology

3.1 Data and sample

We create a sample based on annual financial data from Bloomberg. We create a panel data set with a sample size of 4,275 firms * years of observation from Chinese energy sector firms for the period from 2014 to 2022. There are several compelling reasons for considering the Chinese energy companies as the focus of our investigation. China has a crucial and influential position in the global energy markets, being recognised as one of the leading consumers of energy worldwide (BP, 2019). Its large impact on energy consumption and CO_2 emissions makes it an appropriate subject for studying ESG's impact on risk and return within a globally significant context.

3.2 Variables definition and description

Our dependent variables are firm risk and stock return. For publicly traded companies, the profitability of the stock market closely reflects investors' future earnings expectations (Gao *et al.*, 2022). This study uses stock price volatility as a measure of firm risk (Adams *et al.*, 2005; Bernile *et al.*, 2018; He *et al.*, 2023) and calculates firm risk based on stock price

volatility over the past three years. Stock return, which reflects the proportion of returns investors receive on their stock purchases (Yin *et al.*, 2023). We calculate the annual stock return by dividing the current year's price minus the prior year's price divided by the prior year's price.

ESG is the dependent variable. Our source for information on ESG reporting is Bloomberg. Every year, Bloomberg analyses companies based on how they disclose their ESG concerns in public sources like corporate annual reports, reports about sustainability, third-party analysis, direct interactions, press announcements and media news. Bloomberg tracks ESG disclosures on over 13,000 organisations. Each firm is assessed by Bloomberg using a range of quantitative and qualitative measures, and the result is a composite ESG score, which Bloomberg describes as a "proprietary Bloomberg score determined by the degree to which a company's Environmental, Social, and Governance (ESG) disclosure". The outcome is also customised for various businesses. The Bloomberg ESG score runs from 0.1 for companies that provide the "minimum amount of ESG data" to 100 for "those that disclose every data point collected by Bloomberg". The scores represent the level of disclosure or transparency for various ESG factors, including executive remuneration, independent directors, board size, employee turnover, diversity, involvement with the community, political donations, waste disposal, pollution, renewable energy and many others.

Control variables such as firm leverage, return on assets (ROA), return on equity (ROE), firm size and asset liquidity level account for important factors that could potentially influence the relationship between ESG disclosure, firm risk and stock return. Firm leverage helps consider the impact of capital structure on risk and return. ROA and ROE capture profitability and financial performance, respectively, ensuring the analysis accounts for these factors. Firm size helps control the scale of operations and potential differences in risk and return. Asset liquidity level captures the company's ability to manage short-term obligations and financial risk. By including these control variables, we can isolate the specific impact of ESG disclosure on firm risk and stock volatility while controlling for other relevant factors, resulting in more accurate and reliable conclusions regarding the effects of ESG disclosure within the energy sector.

3.3 Model setting

Multiple regression models are used as the primary analytical tool to examine the relationship between ESG disclosure, firm risk and stock return. OLS, FE regression and RE regression models are used as benchmark regressions to establish initial relationships. These models control for other variables such as firm leverage, ROAs, ROE, firm size and asset liquidity level. Using a multiple regression model, this paper constructs the following equations:

$$Firm\ \ Risk_{i,t} = \alpha_1 + \beta_1 ESG_{i,t} + \gamma_1 \sum Control_{i,t} + Year_t + Industry_i + \varepsilon_{i,t} \quad (1)$$

$$Stock\ \ Return_{i,t} = \alpha_1 + \beta_1 ESG_{i,t} + \gamma_1 \sum Control_{i,t} + Year_t + Industry_i + \varepsilon_{i,t} \quad (2)$$

where ESG is environmental, social and governance, control variables include firm leverage, ROAs, ROE, firm size and asset liquidity level, ε is the error term, i for firm and t for years.

The OLS, FE and RE rely on certain assumptions regarding the stochastic disturbance term, assuming homoscedasticity, no cross-sectional correlation and no autocorrelation within panels (Voumik *et al.*, 2023b). However, when these assumptions are violated, the

FGLS model becomes more appropriate for parameter estimation, and in the next step, FGLS is used. The FGLS framework is considered superior due to its incorporation of several important factors. Firstly, it takes into account the presence of serial or autocorrelation. Secondly, it addresses the issue of heteroskedasticity. Lastly, it also examines the presence of cross-sectional dependency (Shen *et al.*, 2020).

The endogeneity can introduce bias in the estimation results, potentially leading to unreliable findings. The GMM is a widely used econometric technique that effectively addresses the issue of endogeneity. It uses instrumental variables to automatically generate suitable instruments, hence mitigating the problem of endogeneity and reverse causation (Arellano and Bond, 1991; Arellano and Bover, 1995). The study hypothesis is tested by constructing a two-step GMM incorporating a finite sample adjustment to the covariance matrix as proposed by Windmeijer (2005), which allows for the estimation of dynamic panel models and accounts for potential simultaneity between variables. The instrumental variables used in the dynamic panel estimation conducted by Arellano and Bond (1991) consist of the lagged values of the first difference in the variables. According to Arellano and Bover (1995), lagged levels often prove to be insufficient instruments for initial differences. Therefore, it is recommended to use the "system GMM" estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998) as a means to mitigate this concern. In this enhanced version, the utilisation of lagged differences of the dependent variable is used as instruments for equations in levels, while lagged levels of the series are used as instruments for equations in the first differences. The instruments' validity is additionally assessed by examining the serial correlations of the error factors in the differences equation. GMM models, based on theoretical analysis and following previous empirical studies, e.g. He *et al.* (2023). Equations (3) and (4) are used for GMM estimations:

$$Firm\ Risk_{i,t} = \alpha_0 + \beta_1 firm\ risk_{i,t-1} + \beta_2 ESG_{i,t} + \delta \sum Control_{i,t} + V_I firm\ fixed\ effect + \eta_1 year\ fixed\ effect + \varepsilon_{i,t} \tag{3}$$

$$Stock\ Return_{i,t} = \alpha_0 + \beta_1 stock\ return_{i,t-1} + \beta_2 ESG_{i,t} + \delta \sum Control_{i,t} + V_I firm\ fixed\ effect + \eta_1 year\ fixed\ effect + \varepsilon_{i,t} \tag{4}$$

where ESG is environmental, social and governance, control variables include firm leverage, ROAs, ROE, firm size and asset liquidity level, ε is the error term, i for firm and t for years.

As a robustness analysis, SQR is used to assess the consistency of the findings across different quantiles of the data distribution. This technique provides insights into the relationship between ESG disclosure, risk and returns across various levels of risk and return, further strengthening the validity and generalisability of the results.

4. Empirical results and discussion

4.1 Descriptive statistics and correlation

Table 1 provides descriptive statistics, correlation and variance inflation factor (VIF) for study variables. Columns (1)–(6) show pairwise correlations, indicating the independent variable is not subject to multicollinearity issue further clarify Column (7) show VIF values

Variables	(1)	(2)	(3)	(4)	(5)	(6)	VIF	Mean	Std. dev.
(1) ESG Disclosure	1.000	–	–	–	–	–	1.31	35.311	13.775
(2) Financial Leverage	−0.039	1.000	–	–	–	–	1.12	0.772	0.654
(3) ROA	0.075	0.016	1.000	–	–	–	1.36	−4.769	57.757
(4) ROE	0.147	0.003	0.344	1.000	–	–	1.63	−3.506	47.297
(5) Firm Size	0.452	0.252	0.208	0.348	1.000	–	1.67	1.809	0.739
(6) Asset Liquidity	−0.092	0.091	−0.508	−0.071	−0.040	1.000	1.22	0.816	4.938
Firm Risk	–	–	–	–	–	–	–	4.032	11.515
Stock Return	–	–	–	–	–	–	–	0.45	3.685
Mean VIF	–	–	–	–	–	–	1.38	–	–

Notes: Study variables are presented in this table with correlation, VIF and descriptive statistics. Data from 2014 to 2022, totaling 4,275 firm-year observations, made up our sample. The dependent variables are firm risk and stock return. Environmental social governance (ESG) is our independent variable. The control variables include financial leverage, return on assets (ROA), return on equity (ROE), firm size and assets liquidity
Source: Compiled by authors from Stata 17.0 estimations

Table 1.
Pairwise correlations, VIF and descriptive statistics

within an acceptable range. Columns (8) and (9) show descriptive statistics, mean and standard deviation.

4.2 Benchmark regression results for risk and return

Table 2 presents regression results examining the relationship between ESG disclosure and firm risk, as well as the relationship between ESG disclosure and stock returns. The models used include OLS, FE and RE estimators. The coefficients represent the estimated effects of ESG disclosure on firm risk and stock returns while controlling for other variables. Similar to the majority of previous literature, María del Carmen Valls *et al.* (2022), Sassen *et al.* (2016), Liu *et al.* (2023), Kumar *et al.* (2016) and He *et al.* (2023) reported ESG is negatively correlated with firm risk. The negative coefficient suggests that higher levels of ESG disclosure are associated with lower firm risk. The result aligns with the theoretical expectation that transparent disclosure of ESG performance can reduce information asymmetry and mitigate risk. In the case of stock return, the coefficient for ESG disclosure is positive and statistically significant. This implies that higher levels of ESG disclosure are associated with higher stock returns. The result aligns with the theoretical argument that ESG-conscious investors may prefer companies with strong ESG performance, leading to positive market reactions and higher stock prices. The fixed effect model reinforces the finding from the OLS model, indicating that the positive relationship between ESG disclosure and stock returns persists even after controlling for time-invariant firm-specific factors.

The results of the regression models provide empirical evidence that supports theoretical arguments regarding the relationship between ESG disclosure and both firm risk and stock returns. The negative coefficient in the firm risk models indicates that greater ESG disclosure is associated with lower risk, consistent with agency, stakeholder and market-based theories. These theories propose that ESG disclosure can enhance transparency, improve governance and reduce risk.

Conversely, the positive coefficient in the stock return models supports the notion that ESG disclosure positively influences market perceptions and investor preferences, leading to higher stock returns. This aligns with market-based theories and the idea that investors consider ESG factors as part of their investment decision-making. Overall, the empirical

Table 2. Benchmark regression results for firm risk and stock return

Methods	OLS	OLS	FE	RE	OLS	OLS	FE	RE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	Firm risk	Firm risk	Firm risk	Firm risk	Stock return	Stock return	Stock return	Stock return
ESG	−0.0222** (0.0091)	−0.112*** (0.0428)	−0.1014** (0.0514)	−0.1971** (0.0973)	0.0231*** (0.0053)	0.0287*** (0.0097)	0.0431** (0.0203)	0.0287*** (0.0097)
Fin. Leverage		−2.930*** (1.019)	−0.122 (0.274)	−0.371* (0.205)		0.704*** (0.230)	0.378 (0.469)	0.704*** (0.230)
ROA		−0.0126 (0.0387)	−0.0078 (0.0056)	−0.0077 (0.0054)		0.0623*** (0.0087)	0.0718*** (0.0102)	0.0623*** (0.0087)
ROE		0.0160 (0.0244)	0.0001 (0.0037)	0.0014 (0.0036)		−0.0146*** (0.0055)	−0.0133* (0.0069)	−0.0146*** (0.0055)
Firm Size		6.697*** (1.489)	−0.851 (0.569)	1.057*** (0.295)		−3.577*** (0.335)	−9.695*** (0.982)	−3.577*** (0.335)
Asset Liquidity		0.1809*** (0.0501)	0.281*** (0.0733)	0.298*** (0.0732)		−0.141*** (0.0451)	−0.267*** (0.0483)	−0.141*** (0.0451)
Constant	1.164*** (0.344)	−0.905 (2.854)	1.955 (1.287)	−2.021*** (0.665)	−0.752*** (0.200)	6.652*** (0.644)	19.98*** (2.207)	6.652*** (0.644)
Industry Fixed	No	No	Yes	No	No	No	Yes	No
Year Fixed	No	No	Yes	No	No	No	Yes	No
R^2	0.006	0.027	0.063	0.071	0.187	0.1445	0.1316	0.0972
Observations	4,275	4,275	4,275	4,275	4,275	4,275	4,275	4,275

Notes: Table shows the benchmark regression results of ESG influence on firm risk and stock return. The dependent variables are firm risk and stock return. Environmental social governance (ESG) is our independent variable. The control variables include financial leverage, return on assets (ROA), return on equity (ROE), firm size and assets liquidity. Outcomes include OLS, FE and RE. Under the coefficients, the standard errors are presented in parentheses. Statistical significance denoted with asterisks at the 10% (*), 5% (**) and 1% (***)
Source: Compiled by authors from Stata 17.0 estimations

findings suggest that ESG disclosure can contribute to risk reduction and enhance stock market performance.

4.3 Feasible generalised least squares panel-specific Autoregressive (1) estimations

The previous section used the OLS approach, as well as fixed effect and random effect panel regression techniques to analyse the study variables. These methods rely on certain assumptions regarding the stochastic disturbance term, assuming homoscedasticity, no cross-sectional correlation and no autocorrelation within panels. However, when these assumptions are violated, the FGLS model becomes more appropriate for parameter estimation (Greene, 2018). The FGLS model allows for heteroscedasticity, cross-sectional correlation and autocorrelation within panels by modifying the stochastic disturbance term. Heteroscedasticity and autocorrelation within panels are tested using the Wald test proposed by Wooldridge (2010), while cross-sectional correlation is tested using the Breusch–Pagan Lagrange multiplier test suggested by Greene (2018). By using these statistical tests and the FGLS model, researchers can more accurately estimate parameters and address potential violations of the underlying assumptions in the data. Table 3 presents the FGLS estimation results.

The results suggest a negative relationship between ESG and firm risk. The coefficient for ESG disclosure is negative and statistically significant. This suggests that higher levels of ESG disclosure are associated with lower firm risk. In the case of stock return, the ESG coefficient is positive and statistically significant. This implies that higher levels of ESG disclosure are associated with higher stock returns.

4.4 Endogeneity

Baseline results are subject to endogeneity issues and, therefore, cause biased estimates. To deal with endogeneity, models like GMM provide better estimates. As Mehta (2001) stated:

> If the independent variable were regressed on the instrumental variable, the residual would contain all unobserved sources of variability that determine treatment assignment and also influence the outcome variable. As a result, the existence of an instrumental variable identifies or isolates the average direct of the treatment on the outcome independent of the unobserved sources of variability.

The application of models like GMM reduces the risk of biased results. We use a two-step system GMM with finite sample correction to the covariance matrix (Windmeijer, 2005). Instruments used in Arellano and Bond's (1991) dynamic panel estimate are lagged levels of the first difference in the variables. Lagged levels, however, frequently make inadequate instruments for first differences, as stated by Arellano and Bover (1995). They thus advise using a "system GMM" estimator created by Arellano and Bover (1995) and Blundell and Bond (1998) to lessen this issue. In this improved form, lagged differences of the dependent variable are used as instruments for equations in levels, and lagged levels of the series are used as instruments for equations in the first differences. The validity of the instruments is further tested using serial correlations for the differences in the equation's error terms.

4.5 System generalised method of moments estimations

Table 4 presents the GMM estimation results. The coefficients represent the estimated effects of the variables on firm risk and stock returns. The results suggest a negative relationship between ESG and firm risk. The coefficient for ESG disclosure is negative and statistically significant. This suggests that higher levels of ESG disclosure are associated with lower firm risk. The negative coefficient aligns with the theoretical expectation that ESG disclosure can enhance transparency, improve governance and mitigate risk.

	FGLS		FGLS panel-specific AR (1)	
	(1)	(2)	(3)	(4)
Variables	Firm risk	Stock returns	Firm risk	Stock returns
ESG	−0.112*** (0.0426)	0.0287*** (0.00963)	−0.231*** (0.0586)	0.0610*** (0.0128)
Financial Leverage	−2.930*** (1.015)	0.704*** (0.229)	−1.791 (1.494)	0.828*** (0.298)
ROA	−0.0126 (0.0386)	0.0623*** (0.00869)	−0.0422 (0.0272)	0.0791*** (0.00799)
ROE	0.0160 (0.0243)	−0.0146*** (0.00547)	0.0141 (0.0213)	−0.0134*** (0.00511)
Firm Size	6.697*** (1.484)	−3.577*** (0.334)	9.052*** (2.061)	−6.199*** (0.423)
Asset Liquidity	0.189 (0.200)	−0.141*** (0.0449)	0.0387 (0.157)	−0.137*** (0.0429)
Constant	−0.905 (2.844)	6.652*** (0.642)	0.512 (4.537)	11.14*** (0.830)
Observations	3,752	3,752	3,752	3,752
Number of ids	427	427	427	427
Wald chi2	27.76	167.10	29.64	342.68
Prob > chi2	0.000	0.000	0.000	0.000

Notes: Table shows the FGLS results of ESG influence on firm risk and stock return. The dependent variables are firm risk and stock return. Environmental social governance (ESG) is our independent variable. The control variables include financial leverage, return on assets (ROA), return on equity (ROE), firm size and assets liquidity. Under the coefficients, the standard errors are presented in parentheses. Statistical significance denoted with asterisks at the 10% (*), 5% (**) and 1% (***)
Source: Compiled by authors from Stata 17.0 estimations

Table 3.
FGLS and FGLS panel-specific AR (1) estimations

Method	1 step GMM		2 step system GMM	
	(1)	(2)	(3)	(4)
Variables	Firm risk	Stock returns	Firm risk	Stock returns
L. Firm Risk	0.291*** (0.0369)	–	−0.234*** (0.0202)	–
L. Stock Return	–	0.0236*** (0.0038)	–	−0.0206*** (0.00433)
ESG	−0.423*** (0.129)	0.0775** (0.0319)	−0.0328** (0.0157)	0.0355*** (0.0093)
Financial Leverage	−4.421 (3.328)	−0.360 (0.800)	−0.329 (0.234)	0.541 (0.452)
ROA	0.0235 (0.0507)	0.0174* (0.00971)	0.0102** (0.0494)	0.0427*** (0.0127)
ROE	0.0212 (0.0389)	0.00658 (0.00939)	0.0080 (0.0056)	−0.0105 (0.0068)
Firm Size	0.3311*** (0.0936)	−1.235 (0.972)	0.0664*** (0.0141)	−2.707* (1.435)
Asset Liquidity	0.2307** (0.1210)	−0.587*** (0.0546)	0.0111** (0.0053)	−0.436*** (0.0279)
Constant	1.47 (3.97)	0.978 (2.109)	1.145* (0.656)	5.555* (2.872)
Observations	3,752	3,752	3,752	3,752
No. of Firms	427	427	427	427
Arellano Bond 1st difference test				
AR 1 (*p*-value)	–	–	0.0000	0.0000
AR 2 (*p*-value)	–	–	0.126	0.169
Test for overidentification restrictions (Hansan)				
Hansan (*p*-value)	–	–	0.327	0.990

Notes: Table shows the one and two-step system GMM results of ESG influence on firm risk and stock return. The dependent variables are firm risk and stock return. Environmental social governance (ESG) is our independent variable. The control variables include financial leverage, return on assets (ROA), return on equity (ROE), firm size and assets liquidity. Under the coefficients, the standard errors are presented in parentheses. Statistical significance denoted with asterisks at the 10% (*), 5% (**) and 1% (***)
Source: Compiled by authors from Stata 17.0 estimations

Table 4.
System GMM estimations

The results of the analysis are consistent with our *H1*, suggesting that there is a negative association between ESG disclosure and firm risk. Several studies in the literature, Lööf *et al.* (2022), Sassen *et al.* (2016), He *et al.* (2023), María del Carmen Valls *et al.* (2022), Liu *et al.* (2023) and Kumar *et al.* (2016) have presented comparable results, suggesting that companies with greater ESG disclosure tend to exhibit reduced risk profiles. Theoretical frameworks, including agency theory, stakeholder theory and market-based perspectives, suggest that the disclosure of ESG information has a beneficial effect on the behaviour of firms, their interactions with stakeholders and investor confidence. Consequently, this disclosure has implications for both risk and return outcomes.

In the case of stock return, the ESG coefficient is positive and statistically significant. This implies that higher levels of ESG disclosure are associated with higher stock returns. The positive coefficient aligns with the theoretical argument that ESG-conscious investors may prefer companies with strong ESG performance, leading to positive market reactions and higher stock prices. The results of our study support *H2*, suggesting that there is a positive correlation between ESG disclosure and stock market returns. By demonstrating a commitment to sustainable practices and responsible governance, firms have the potential to improve their position in the market, perhaps leading to increased investor trust and improved performance in the stock market (Balcilar *et al.*, 2017; Liu *et al.*, 2023). According to market-based viewpoints, the disclosure of ESG information has a favourable impact on corporate behaviour, stakeholder relationships and investor confidence. This, in turn, leads to effects on stock returns.

The results of the GMM estimation provide some support for the theoretical expectations regarding the relationship between ESG disclosure and both firm risk and stock returns. The negative coefficient for ESG disclosure in the firm risk equation suggests that greater ESG disclosure is associated with lower risk, aligning with theoretical arguments on transparency, governance and risk mitigation. Moreover, the positive coefficient for ESG disclosure in the stock return equation supports the notion that higher levels of ESG disclosure can lead to positive market reactions and higher stock returns. This aligns with the theoretical argument that investors increasingly consider ESG factors in their investment decisions and value companies with strong ESG performance. In summary, the results of the GMM estimation provide some empirical evidence supporting the theoretical expectations of the relationship between ESG disclosure, firm risk and stock returns.

4.6 Robustness analysis with simultaneous quantile regression

To validate research outcomes with alternate methods, the SQR analysis with bootstrap standard errors was used. The analysis was performed using three quantile levels: 50th, 75th and 90th quantiles. Table 5 presents regression results for different quantiles of firm risk and stock returns. The coefficients represent the estimated effects of the variables on firm risk and stock returns at the 50th, 75th and 90th quantiles. SQR is an appropriate technique for robustness analysis due to its non-parametric approach, robustness to outliers, ability to analyse relationships across different quantiles and comprehensive validation of results (Majumder *et al.*, 2023). By considering the entire data distribution, it provides a flexible and reliable assessment of the relationship between ESG disclosure, risk and returns, strengthening the robustness of our findings.

The results of robustness analysis by using SQR are presented in Table 5. ESG has a negative relationship with firm risk. The coefficient for ESG is negative and statistically significant at different levels of significance across the quantiles. This indicates that higher levels of ESG disclosure are associated with lower firm risk, regardless of the position in the risk distribution. In the case of a stock return, this relationship is positive. The coefficient for

Table 5. Simultaneous quantiles regression estimations

Methods	Quantiles (50th)	Quantiles (75th)	Quantiles (90th)	Quantiles (50th)	Quantiles (75th)	Quantiles (90th)
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Firm risk	Firm risk	Firm risk	Stock return	Stock return	Stock return
ESG	−0.0208*** (0.00682)	−0.0183** (0.00795)	−0.0181* (0.0102)	0.00975 (0.0151)	0.188** (0.0856)	0.453*** (0.0256)
Financial Leverage	−0.824*** (0.188)	−0.686** (0.296)	−0.667** (0.284)	−0.00470 (0.0195)	0.0404 (0.0731)	0.250 (0.447)
ROA	0.0195 (0.0124)	0.0162 (0.0181)	−0.00582 (0.0157)	−0.00132 (0.00346)	−0.00899 (0.0102)	−0.00816 (0.0190)
ROE	−0.00746* (0.00452)	−0.00233 (0.00712)	0.00648 (0.00783)	−0.00173* (0.000912)	−0.00145 (0.00217)	−0.00628 (0.00837)
Firm Size	2.744*** (0.327)	1.721*** (0.547)	1.080*** (0.384)	−0.0245 (0.0363)	−0.519*** (0.181)	−1.437*** (0.413)
Asset Liquidity	0.0504 (0.213)	0.0168 (0.442)	0.00842 (0.602)	−0.00455 (0.0352)	−0.0165 (0.183)	−0.0565 (1.314)
Constant	−4.461*** (0.669)	−0.964 (0.975)	1.823** (0.829)	0.0466 (0.0672)	0.808*** (0.270)	2.312*** (0.693)
Observations	4,275	4,275	4,275	4,275	4,275	4,275
Pseudo R^2	0.0615	0.0386	0.0326	0.0029	0.0300	0.0660

Notes: Table shows the regression results of ESG influence on firm risk and stock return. The dependent variables are firm risk and stock return. Environmental social governance (ESG) is our independent variable. The control variables include financial leverage, return on assets (ROA), return on equity (ROE), firm size and assets liquidity. Outcomes include SQR at the 50th quantile, at the 75th quantile and at the 90th quantiles. Under the coefficients, the standard errors are presented in parentheses. Statistical significance denoted with asterisks at the 10% (*), 5% (**) and 1% (***)
Source: Compiled by authors from Stata 17.0 estimations

ESG disclosure is positive and statistically significant at different levels of significance across the quantiles. This indicates that higher levels of ESG disclosure are associated with higher stock returns, regardless of the position in the return distribution. Several studies in the literature, Lööf *et al.* (2022), Sassen *et al.* (2016), He *et al.* (2023), María del Carmen Valls *et al.* (2022), Liu *et al.* (2023), Kumar *et al.* (2016) and Balcilar *et al.* (2017), reported similar results, indicating that firms with greater ESG disclosure manage to demonstrate reduced risk profiles. Theoretically, agency theory, stakeholder theory and market-based views advocate that the ESG has a beneficial effect on the behaviour of firms, their interactions with stakeholders and investor confidence. Therefore, this disclosure has implications for both firm risk and return.

The robustness analysis reinforces and endorses the findings of our main analysis. The results demonstrate consistent associations between ESG disclosure, risk and returns across various quantiles. This consistency reinforces the robustness of our main analysis findings and provides further support for the positive impact of ESG disclosure on risk mitigation and stock market performance in the energy sector.

5. Conclusion and implications

This study has provided valuable insights into the relationship between ESG disclosure, firm risk and stock returns in the energy sector of China. Through a comprehensive analysis using various econometric techniques, including OLS, FE, RE, FGLS, two-step GMM and SQR, we have gained a deeper understanding of the implications of ESG disclosure for risk and returns in Chinese energy companies. The results consistently demonstrate that higher levels of ESG disclosure are associated with lower firm risk and higher stock returns. This finding supports the notion that effective ESG practices can contribute to risk reduction and enhance financial performance in the energy sector of China. The findings are robust, as they are confirmed across different regression models and quantiles.

The study contributes to the theoretical understanding of the relationship between ESG disclosure and stock volatility. It expands upon existing theories, such as agency theory, stakeholder theory and market-based theories, by providing empirical evidence and insights into how ESG disclosure can influence risk management and stock market performance. The findings support the theoretical frameworks by demonstrating the expected relationships between ESG disclosure, firm risk and stock returns. This validation enhances the credibility and applicability of agency theory, stakeholder theory and market-based theories in explaining the impact of ESG disclosure on risk and financial performance. By focusing on China's energy industry, the study contributes to sector-specific theoretical development. It acknowledges the unique challenges and opportunities faced by energy companies in managing ESG risks and integrating sustainable practices. This sector-specific analysis can be extrapolated to other industries, providing insights into how ESG disclosure impacts risk and performance in different contexts.

An ethical investor and ESG practice theory is proposed in which investors increasingly consider ESG factors in their investment strategies, seeking companies with strong ESG performance. Energy companies improve their risk management and stock market performance by enhancing ESG practice and disclosure. ESG disclosure, in turn, influences investor perceptions and decision-making. Transparent ESG disclosure can strengthen stakeholder relationships, including customers, employees, communities and regulators. Energy companies can use effective communication and engagement strategies to address stakeholder concerns and build trust. This can enhance reputation, attract socially responsible investors and contribute to long-term business sustainability.

This study suggests that energy companies can leverage this trend by enhancing their ESG disclosure practices to attract ESG-conscious investors, potentially lowering the cost of capital and gaining a competitive edge in capital markets. This study has implications for policymakers and regulators. The findings can inform the development of regulatory measures, industry standards and reporting requirements to encourage widespread ESG disclosure practices within the energy sector. Clear and standardised guidelines can facilitate comparability and ensure consistency in ESG reporting, benefiting both companies and stakeholders. The study emphasises the integration of sustainability principles into business strategies. Energy companies can proactively incorporate ESG considerations into their decision-making processes, setting ambitious sustainability goals and aligning their operations with global environmental objectives. Effective ESG disclosure can demonstrate a company's commitment to sustainability, attracting environmentally conscious stakeholders and promoting positive social and environmental impacts.

Overall, the theoretical and practical implications highlight the importance of ESG disclosure as a strategic tool for managing risk, attracting investors and promoting sustainable business practices. The study's findings can guide energy companies, investors, policymakers and other stakeholders in making informed decisions and fostering a more sustainable and responsible energy sector. This study has significant social implications. Our findings support the global transition to sustainable energy practices by emphasising the positive effects of ESG disclosure on risk management and stock performance in the energy sector. It informs investors about the value of ESG-conscious investments, advocates for stronger regulatory frameworks and encourages community engagement. The study reinforces the perception that corporations have a broader responsibility beyond profit generation. It encourages firms to embrace corporate social responsibility by adopting sustainable practices, which, in turn, can lead to positive social outcomes and improved corporate reputations, which increases stock returns and lowers risk. Moreover, it underscores the broader responsibility of companies towards sustainable and socially responsible practices, contributing to a more equitable future.

This study thoroughly examines the relationship between ESG disclosure, firm risk and stock market performance. However, it is important to recognise significant limitations associated with this research. The conclusions of the study are reliant on the quality and accessibility of data pertaining to ESG disclosure, financial information of firms and market performance. The scope of this study is constrained by the availability of data, which is confined to a sample of 427 firms for ten years. It is important to acknowledge that these data restrictions may have an impact on the depth and accuracy of the analysis. The conclusions of the study are limited in their applicability to the overall energy industry or other businesses due to a specific sample from China for the period 2014–2022.

Future research can further explore how energy companies adopt ESG strategy and implement ESG practices to reduce risk and improve sustainable performance and how to involve stakeholders to build a trust-based network. Furthermore, it is recommended that future research investigates similar analyses within specific subsectors of the energy industry, such as renewable energy or fossil fuels, to gain a deeper understanding of how ESG dynamics differ across these segments. Conducting a comparative analysis across industries can determine whether the observed relationships between ESG disclosure, risk and return are specific to the energy sector or applicable to various sectors. Additionally, exploring the impact of changes in regulatory frameworks on the relationship between ESG disclosure, risk and return can provide valuable insights into the role of external factors. By addressing these research directions, scholars can enhance their understanding of the interconnectedness between ESG disclosure, risk and return.

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