Research on ESG Score and Company Characteristics

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摘　要

In response to the global momentum toward sustainable development and the implementation of related regulations, corporations are increasingly prioritizing environmental, social, and governance (ESG) factors as strategic imperatives. This study investigates the impact of ESG scores and disclosure transparency on firm value and financial performance among publicly listed companies in Taiwan from 2015 to 2022. Utilizing data from the Taiwan Economic Journal (TEJ) and applying regression analysis, the study adopts Tobin's Q to measure market performance and return on equity (ROE) for financial performance.

The research incorporates environmental, social, and governance sub-scores, the aggregated TESG score, and ESG disclosure transparency as key independent variables. To explore deeper causal relationships, the study introduces green financemeasured by green bond issuanceand the green economyrepresented by green energy firm developmentas mediating variables. Additionally, carbon disclosure, top talent recruitment, and board characteristics are assessed for their influence on ESG outcomes and corporate sustainability practices.

Empirical findings reveal that green bond issuance and green economic development partially mediate the relationship between ESG performance and firm value, underscoring the role of green financial instruments and sustainable business models in enhancing corporate

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valuation. Moreover, carbon disclosure, the presence of top talent, and directors' shareholding ratios exhibit significant positive effects on ESG scores and transparency. These elements contribute to improved sustainability performance by reinforcing environmental accountability, enhancing governance structures, and aligning board incentives with long-term corporate goals.

The study further demonstrates that companies with stronger ESG performance and more transparent disclosures tend to exhibit higher firm valuations and superior financial outcomes. These firms are typically more active in green finance initiatives and green economy participation, reflecting a deeper integration of sustainability into their core strategies. A higher level of carbon disclosure and greater board diversity are also associated with better ESG ratings, suggesting that robust governance and human capital strategies are crucial for ESG excellence.

Overall, this research provides empirical evidence that strong ESG performance, bolstered by green financial activities and enhanced transparency, positively influences firm value and financial performance. The results offer actionable insights for corporate managers aiming to boost competitiveness through sustainability, investors seeking to evaluate ESG-related risks and opportunities, and policymakers striving to promote responsible business conduct. By elucidating the mechanisms through which ESG performance impacts corporate outcomes, the study contributes to the growing literature on sustainable finance and offers strategic guidance for achieving long-term value creation in alignment with global sustainability objectives.

Keywords: ESG Score, Firm Value, Financial Performance, Green Finance, Carbon Disclosure

JEL Classification No.: G11, G32, M14, Q56

1. Introduction

1.1 Research Background and Motivation

The world is currently facing the threat of climate change, with issues such as green finance, green energy, and sustainable development increasingly gaining international attention. Governments worldwide are rolling out supportive policies. The Conference of the Parties (COP), initiated in Berlin in 1995, aims to implement the United Nations Framework Convention on Climate Change (UNFCCC), which was signed by 154 countries in 1992. Its goal is to stabilize atmospheric concentrations of greenhouse gases and to mitigate climate change through international negotiations. The 28th session of COP in 2023, which also marks the 18th meeting of the Kyoto Protocol and the 5th session of the Paris Agreement, saw participation from 198 countries and organizations. According to the World Meteorological Organization, data released on the first day of the conference stated that 2023 was the warmest year on record, with temperatures rising 1.4 degrees Celsius since the preindustrial era. Amidst severe criticism and a challenging climate scenario, the conference's goals not only sought to keep global warming below 1.5 degrees Celsius through international collaboration but also to initiate the first Global Stocktake under the Paris Agreement and address fossil fuel issues relevant to the host country. My country has also responded actively, with the Environmental Protection Agency revising the Climate Change Response Act, establishing strategies for climate change adaptation, reducing and managing greenhouse gas emissions, and upholding the responsibilities of environmental justice, intergenerational justice, and a just transition to protect the environment and ensure national sustainable development. The historical evolution of sustainable development is a critical issue of our time. With globalization, climate change, environmental pollution, labor rights, and other social issues coming to the fore, the concept of sustainable development has become a focal point. Common initiatives or terms related to sustainable development include Corporate Social Responsibility (CSR), Environmental, Social, and Governance (ESG) criteria, and Sustainable Development Goals (SDGs), all promoted by the United Nations and receiving significant attention in recent years.

This research, through an in-depth examination of corporate responsibility issues, aims to reveal the complex relationships between these issues and both firm value and financial performance, offering concrete and expert insights for businesses in the field of sustainable development. The literature on the relationship and impact of corporate responsibility issues on

firm value and financial performance presents mixed views (e.g., Edmans, 2011; Krüger, 2015; Flammer, 2015; Saeidi et al., 2015). Additionally, some studies have found that senior executives considerations of ESG factors are significantly influenced by the financial performance of their firms (Zhu and Lai, 2016).

This study employs green finance and the green economy as mediators, aiming to explore the impact mechanisms of ESG scores on firm value and financial performance. Green finance, as a mediator, emphasizes the investment and financing mechanisms in environmentally sustainable projects during the capital flow process. With the growing influence of green finance, many researchers have begun examining its impact on the financial performance of banks (Scholtens and Dam, 2007). The green economy, viewed as a crucial framework for companies transitioning to low-carbon and sustainable models, includes renewable energy and other environmentally focused industries. These mediators help explain how ESG scores influence a company performance in green finance and the green economy, thereby impacting firm value and financial performance. This analysis provides a deeper understanding of how ESG scores indirectly affect firm value and financial performance through influencing capital structures and business models.

This research is distinctive in several ways, primarily examining the impacts of ESG scores and TESG total scores on firm value and financial performance, while observing whether the factors of green finance and the green economy can enhance the relationship between ESG and both firm value and financial performance, innovatively measuring the sustainable social responsibilities of listed companies. Additionally, using ESG scores and TESG total scores as dependent variables, the study explores the effects of carbon disclosure, top talent recruitment, and director shareholding ratios as independent variables. The empirical results have practical implications for regulatory authorities, investors, and corporate management. With Taiwan 2050 net-zero transition goals, mechanisms like green bonds and green company development can effectively encourage managers to engage in ESG activities, particularly benefiting the environmental aspect. Through carbon disclosure, companies demonstrate their commitment to environmental protection and transparency, likely attracting investor and stakeholder attention. This confirms the positive influence of the "environmental" factor within ESG on firm value, as the market increasingly values corporate environmental performance.

1.2 Research Purpose

This study aims to delve deeply into the relationship between environmental, social, and governance (ESG) scores and various corporate characteristics. It strives to provide a comprehensive analysis covering all aspects of corporate traits, including the impact mechanisms of ESG scores and disclosures on firm value and financial performance. Through an exhaustive analysis of variables such as green finance, green economy, carbon disclosure, top talent recruitment, and director shareholding ratios, the research seeks to understand how a company ESG scores and disclosures interact with its unique characteristics. This, in turn, aids in gaining a deeper understanding of sustainable development practices and corporate behaviors in the contemporary business environment. Specifically, the study will focus on the following aspects:

(1) This study investigates the mediating role of green finance and the green economy in the relationship between environmental, social, and governance (ESG) scores and disclosures and firm value and financial performance. By thoroughly analyzing the interplay between these mediators and ESG, we will reveal how ESG factors influence capital flows and corporate operational models, thereby impacting firm value and financial performance. This will enhance a more comprehensive understanding of the substantive impact mechanisms of ESG and provide concrete policy recommendations for corporations in sustainable development.

(2) The study will also validate the association between carbon disclosure, top talent, and director shareholding ratios with ESG scores and disclosures. By examining the interactions between these variables and ESG scores, the research aims to disclose how these factors influence corporate ESG performance. Carbon disclosures will be explored for their positive impact within ESG, particularly on the environmental aspect; top talent will be considered in terms of ESG social dimension; and director shareholding ratios will be analyzed for their close connection with ESG governance dimension. This will aid in deepening the understanding of ESG evaluation factors and provide practical guidelines for improving corporate ESG performance.

The purpose of this study is to provide a comprehensive understanding of how ESG scores and disclosures influence firm value and financial performance, thereby offering

substantial references for the implementation of more effective ESG strategies and policies by businesses.

1.3 Research Framework and Process

The structure of this study is divided into six chapters. Chapter 1: Introduction, this chapter outlines the research background, motivation, and objectives, clarifying the research issues to be explored. Chapter 2: Literature Review and Hypothesis Development - This chapter reviews and synthesizes literature on the impacts of ESG on firm value and financial performance, green finance, the green economy, and the relations between carbon disclosure, top talent, and director shareholding ratios with ESG. Based on this literature, research hypotheses are developed. Chapter 3: Research Methodology - Based on the established hypotheses, empirical models are constructed. This chapter defines each variable and explains their measurement methods, and introduces the process of research sample selection and data sources. Chapter 4: Empirical Results Analysis - This chapter validates the research hypotheses, including the effects of individual ESG scores, TESG total scores, and ESG disclosures on firm value and financial performance. It examines whether green finance and the green economy have a mediating effect, and considers the impact of carbon disclosure, top talent, and board characteristics on individual ESG scores, TESG total scores, and ESG disclosures. Chapter 5: Sensitivity Analysis - This chapter conducts tests for delayed effects, exclusion of outliers, and checks for autocorrelation to ensure the robustness of the empirical results. Chapter 6: Conclusion and Recommendations - This chapter presents the conclusions and limitations of the study and proposes directions for future research.

2. Literature Review and Hypothesis Development

2.1 ESG Score and Disclosure on Firm Value and Financial Performance

The main theoretical connection between ESG and firm value and financial performance is grounded in stakeholder theory, which posits that the value of a company largely depends on meeting the demands of its stakeholders. ESG is crucial for reducing information asymmetry between companies and stakeholders, which can decrease risk and provide a risk-averse effect for investors (Frydman and Wang, 2020). Studies have found that companies that prioritize

ESG and focus on the interests of stakeholders often outperform their peers in profitability and market value, thus creating market value (e.g., Amina, et al., 2019; Sadiq, Singh, Raza, and Mohamad, 2020).

Current literature on the relationship between ESG scores and firm value and financial performance presents various perspectives, including positive, negative, nonlinear, and no-impact relationships. Many studies find a positive correlation between ESG and firm value and financial performance. Proponents argue that through corporate social responsibility (CSR), companies can enhance trust and support from stakeholders, thereby creating competitive advantages and improving corporate reputation and brand image, which in turn enhances firm value and financial performance (e.g., Cochran and Wood, 1984; McGuire, Sundgren, and Schneeweis, 1988; Waddock and Graves, 1997; De Geer et al., 2009; Friede, Busch, and Bassen, 2015; Maqbool and Zameer, 2018; Amina, et al., 2019). In competitive industries, ESG enhances financial performance.

Orlitzky, Schmidt, and Rynes (2003) found a positive correlation between corporate social environmental performance and financial performance; Barnett and Salomon (2006) believed financial performance was enhanced due to social dimensions; Galema, Plantinga, and Scholtens (2008) found significant impacts of socially responsible investing on performance; Mishra and Suar (2010) argued that stakeholder-responsible business practices could bring profits and benefits to businesses; Martínez-Ferrero and Frias-Aceituno (2015) found a positive impact of environmental management on financial performance.

Conversely, some literature suggests a negative correlation between ESG and financial performance (e.g., Hamilton, 1995; Brammer, Brooks, and Pavelin, 2006; Barnea and Rubin, 2010; Ciciretti, Dalò, and Dam, 2023; Hong and Kacperczyk, 2009; Flammer, 2015; Chen, Hung, and Wang, 2018; Duque-Grisales and Aguilera-Caracuel, 2021; Pedersen, Fitzgibbons, and Pomorski, 2021). Empirical analysis found that companies not prioritizing ESG had better financial performance than those that did (Price and Sun, 2017). Additionally, some literature suggests a nonlinear relationship between ESG and financial performance, with lower environmental performance correlating negatively with financial performance, while higher environmental performance correlates positively (e.g., Brammer and Millington, 2008; Barnett and Salomon, 2012). Some studies argue that ESG has no significant impact on corporate

financial performance (e.g., Theodoulidis, Diaz, Crotto, and Rancati, 2017; McWilliams and Siegel, 2000).

ESG represents a comprehensive investment philosophy and corporate evaluation standard. As non-financial practice indicators, ESG has become a crucial tool for investors to assess management systems (e.g., Wong et al., 2021; Baker et al., 2021). Sustainable development is a long-term concept involving the harmonious coexistence of the economy, nature, and society (Su et al., 2021). ESG is not only a standard for measuring corporate social responsibility but also a key driver for measuring corporate sustainability and value. In producing goods and providing services, businesses often have adverse effects on society and public health, thereby generating negative externalities (Edmans, 2023). Therefore, the ESG philosophy requires businesses to consider not only their competitiveness in the market but also to mitigate adverse effects on the environment and society (Eliwa, Aboud, and Saleh, 2021).

Lin, Chen, and Yang (2024) found that the individual scores and TESG total of environmental, social, and governance (ESG) significantly positively impacted both market-based Tobin Q ratio and financial ROE performance. Initially, at the market level, these scores showed a clear positive association with the Tobin Q ratio, an indicator measuring the relationship between a company market value and its net asset value. Higher levels of ESG performance are seen as a market-endorsed signal, indicating superior performance in environmental, social, and governance aspects, thereby enhancing its market value. As investors and stakeholders increasingly focus on corporate social responsibility, companies with proactive ESG performance are more likely to be favored by the market, thus enhancing their Tobin Q ratio. On the other hand, from a financial performance perspective, high ESG scores are also positively associated with ROE. Companies with superior environmental, social, and governance practices are able to reduce operational risks, enhance capital efficiency, and thereby positively influence their ROE growth. Investors and financial institutions increasingly consider ESG factors in their investment portfolios, so active pursuit of sustainable development practices helps companies achieve superior financial performance.

Chen and Xie (2022) found that ESG disclosures have a significant positive impact on corporate financial performance; Bahaaeddin and Allam (2020) found that corporate environmental, social, and governance (ESG) disclosures are associated with different

company operational (ROA), financial (ROE), and market performance (Tobin Q) relationships, with ESG disclosures positively impacting the company performance indicators. However, individual measurements of ESG components, environmental and corporate social responsibility disclosures are negatively related to ROA and ROE. Environmental and ESG disclosures are positively related to Tobin Q; Orlitzky et al. (2003) found that disclosures of non-financial information more similar to those of other companies in the industry reduce a company ESG scores, while digital transformation behaviors cause the company disclosures to affect non-financial information in ESG scores. Veeravel, Murugesan, and Narayanamurthy (2024) research results show a positive correlation between ESG disclosures and company performance, indicating that companies hoping to improve performance need to pay more attention to sustainable development information disclosure. The positive impact of ESG disclosures on corporate financial performance is more evident in companies with ESG investors as well as companies that are older, have higher media attention, and have higher agency costs. In addition, investors with ESG preferences have a significant moderating role in the relationship between ESG disclosures and financial performance; Mohmed, Flynn, and Grey (2019) explored the relationship between ESG disclosures and corporate profit quality, obtaining a positive correlation; Liang and Yang (2024) found that green finance can amplify the peer effects of ESG information disclosure by mitigating financing constraints. This helps to understand the interaction mechanisms between green finance and corporate ESG information disclosure, providing policy implications for strengthening ESG information disclosure at the corporate level.

Research has found that ESG disclosure affects company financial and market performance under normal market conditions and during times of crisis (e.g., Folger-Laronde et al., 2022; La Torre et al., 2020); another important consequence of ESG disclosure is risk reduction because of increased transparency (e.g., Kaiser and Welters, 2019; Lin and Dong, 2018).

In summary, the research on the relationship between ESG and firm value and financial performance exhibits various differences, primarily due to different sources of databases, research methodologies, model design and limitations, and differences between long-term and short-term impacts. However, despite these differences, most literature shows a positive association. The following hypotheses are proposed:

H 1: There is a positive relationship between ESG scores and firm value.

H 2: There is a positive relationship between TESG total scores and firm value.

H 3: There is a positive relationship between ESG disclosures and firm value.

H 4: There is a positive relationship between ESG scores and financial performance.

H 5: There is a positive relationship between TESG total scores and financial performance.

H 6: There is a positive relationship between ESG disclosures and financial performance.

2.2 Green Finance

Green finance, also known as sustainable finance, involves financial investment schemes launched for sustainable development projects that channel substantial funds into initiatives aimed at reducing the negative impacts on the climate. It represents a business model that balances environmental protection with continuous corporate profitability. Common green finance initiatives include green bonds, green financing, and green insurance, with funds primarily directed towards developing green accounts and investment plans, such as renewable energy and circular economy products.

Past literature has predominantly focused on exploring the relationship between corporate social responsibility and boards of directors (e.g., Nadeem, Zaman, and Saleem, 2017; Seckin-Halac, Erdener-Acar, and Zengin-Karaibrahimoglu, 2021), and the impact of corporate social responsibility on stock returns (e.g., Kotchen and Moon, 2012; Ortas, Burritt, and Moneva, 2013; Kim and Kim, 2014; Cellier and Chollet, 2016; Zhou, Zhu, Qi, Yang, and An, 2021; Feng, Goodell, and Shen, 2022; Xu, Chen, Zhou, Dong, and He, 2023; Yu, Liang, Liu, and Wang, 2023). However, the conclusions have been highly divergent, with significant variations in sustainable development and environmental issues. Recently, research on ESG in the bond market has been gaining attention.

Among the financial instruments in the green finance system, green bonds have been the fastest growing in recent years, increasingly recognized for their role in enhancing firm value and financial performance. Green bonds are a type of themed bond, with funds raised required to be fully invested in green projects and must be certified by the Taipei Exchange. Studies have found that fiscal constraints exacerbate the negative impact of economic policy

uncertainty on green innovation (Cui, Wang, Sensoy, Liao, and Xie, 2023). Firms can enhance green financial innovation by investing in environmental protection (Eiadat, Kelly, Roche, and Eyadat, 2008). Research has shown that green financial innovation can meet and manage the needs of stakeholders (Barnett, 2007). Furthermore, studies have suggested that green finance can attract more investment (Dowell, Hart, and Yeung, 2000). Research has found that green bonds are a crucial factor in supporting sustainable development, benefiting from favorable regulatory environments and improved disclosure quality (Bhutta, Tariq, Farrukh, Raza, and Iqbal, 2022). The majority of the literature on the impact of green finance on ESG, firm value, and financial performance has been positive. This study focuses on the issuance of green bonds, proposing the following hypotheses:

H1A: There is a positive relationship between ESG scores, green bonds, and firm value.

H2A: There is a positive relationship between TESG total scores, green bonds, and firm value.

H3A: There is a positive relationship between ESG disclosure, green bonds, and firm value.

H4A: There is a positive relationship between ESG scores, green bonds, and financial performance.

H5A: There is a positive relationship between TESG total scores, green bonds, and financial performance.

H6A: There is a positive relationship between ESG disclosure, green bonds, and financial performance.

2.3 Green Economy

As economies rapidly grow, the increasing severity of environmental threats such as climate change, biodiversity loss, and pollution has made ecological degradation a significant obstacle to economic development. The Intergovernmental Panel on Climate Change (IPCC) highlights that each incremental increase in global warming intensifies various hazards, including more severe heatwaves, heavier rainfall, and other extreme weather events, further escalating risks to human health and ecosystems. Thus, global environmental governance faces unprecedented challenges in maintaining green development and high economic growth without disrupting ecological balance. Research identifies the green economy as a core concept

and shared vision for global sustainable development, with businesses playing a crucial role in driving economic sustainability (e.g., Lu et al., 2018; Shin et al., 2022).

In December 2019, the European Union unveiled the European Green Deal, aimed at addressing the environmental impacts of climate change, with the goal of achieving zero greenhouse gas emissions by 2050, utilizing resources efficiently, and fostering a more competitive economic system. Subsequently, in January 2020, the EU announced the European Green Deal Investment Plan to promote sustainable finance and assist European businesses in transitioning to a green economy, thereby achieving sustainable corporate governance and corporate social responsibility objectives. Derwall, Guenster, Bauer, and Koedijk (2005) suggest that companies with higher environmental performance can generate higher returns. Nobletz (2022) notes that the world green energy companies are now a significant economic force, directing capital flows towards a low-emission society. Cortez, Andrade, and Silva (2022) found that companies in the green energy sector outperform the market financially, with recent performance improvements driving the superior performance of green investments. Molina-Azorín, Claver-Cortés, López-Gamero, and Tarí (2009) argue that green environmental management can reduce operational costs, positively impact financial performance, and enhance competitiveness. Liu, Blankenburg, and Wang (2023) indicate a positive correlation between the profitability and earnings of green enterprises. Literature shows that capital markets are increasingly valuing sustainability, providing positive feedback to green businesses (Bolton and Kacperczyk, 2021). Studies also show that investors are more inclined to engage in proactive ESG practices, and high-quality business development is foundational to economic growth.

The literature predominantly reflects positive impacts of the green economy on financial performance. This study defines the green economy as companies focusing on green energy development within listed firms, selecting those involved in green environmental practices, solar energy, biomass energy, recycling and regeneration, wind power generation, 2050 net-zero carbon emissions, and the development of energy storage systems as green energy companies. Based on this, the following hypotheses are proposed:

H1B: There is a positive relationship between ESG scores, the green economy, and firm value.

H2B: There is a positive relationship between TESG total scores, the green economy, and firm value.

H3B: There is a positive relationship between ESG disclosure, the green economy, and firm value.

H4B: There is a positive relationship between ESG scores, the green economy, and financial performance.

H5B: There is a positive relationship between TESG total scores, the green economy, and financial performance.

H6B: There is a positive relationship between ESG disclosure, the green economy, and financial performance.

2.4 Green Finance and Green Economy

The purpose of green finance is to foster environmentally friendly investments through the provision of funds and capital market instruments, such as renewable energy, energy efficiency improvements, and clean technology research and development. These financial mechanisms can include green bonds, green loans, and green insurance (Chatziantoniou, Abakah, Gabauer, and Tiwari, 2022).

Wang, Zhao, Jiang, and Li (2022) demonstrate that there is a positive causal relationship between green finance and sustainable development, with green finance being a vital financing tool for sustainable development, guiding sustainable green investments and facilitating contributions to sustainable development actions globally. Yang, Du, Razzaq, and Shang (2022) found that measuring green financing and clean energy through ESG has significant and positive implications in the critical determinants of green economic development. Green financial products will play a constructive role in the development of the green economy and can provide stable financial returns to investors in the long term. Therefore, incorporating green bonds and the development of green energy companies into the investment decision process will help enhance the long-term performance of investment portfolios. Based on this, the following hypotheses are proposed:

H1C: There is a positive relationship between ESG scores, green bonds, the green economy, and firm value.

H2C: There is a positive relationship between TESG total scores, green bonds, the green economy, and firm value.

H3C: There is a positive relationship between ESG disclosure, green bonds, the green economy, and firm value.

H4C: There is a positive relationship between ESG scores, green bonds, the green economy, and financial performance.

H5C: There is a positive relationship between TESG total scores, green bonds, the green economy, and financial performance.

H6C: There is a positive relationship between ESG disclosure, green bonds, the green economy, and financial performance.

2.5 Carbon Disclosure, Top Talents, Director Shareholding Ratio and ESG

Wan, Zhang, and Li (2024) empirically found that low-carbon city pilot policies significantly contribute to the improvement of corporate ESG practices, especially for companies with ongoing institutional investors, larger scale, and high-quality internal controls. Safiullah, Kabir, and Miah (2021) found that companies with high carbon emissions face higher cash flow uncertainty, leading to lower credit ratings. Carbon emissions are a focus of international regulation and national scrutiny, bringing about strict rules and regulations from regulatory bodies and leading to higher costs for businesses. The increased regulatory costs often erode profitability and future cash flows (Jung, Herbohn, and Clarkson, 2018; Subramaniam et al., 2015; Ullman, 2016), potentially distorting the ability to repay debts and interest. Moreover, high carbon-emitting companies may damage their reputational image, thereby harming their future operations, competitive advantage, and future cash flows (Karpoff et al., 2005). Studies by Ngwakwe and Msweli (2013), Matsumura, Prakash, and Vera-Muñoz (2014), and Saka and Oshika (2014) found that when pursuing profit objectives, enterprises should consider the impact of environmental issues on operations, reduce greenhouse gas emissions and environmental negative impacts, and lower unit energy consumption to reduce operational costs and risks.

Human capital theory, originating from economic research in the 1960s, was pioneered by American economists Schultz and Becker, opening new perspectives on human productive

capacity. The theory posits that education is relevant because it creates skills, a critical component of an individual capabilities. Literature shows a positive correlation between education and individual capabilities (e.g., Cohen et al., 1982; Gurin et al., 2002).

Amore et al. (2019) analyzed the impact of CEO education level on environmental decisions. Using a sample of Danish companies from 1996 to 2012, they found that CEO education significantly improved the company energy efficiency. Freeman (1984, 1994) defines stakeholders as any group or individual who can affect or is affected by organizational goals. Employees, as significant human capital, profoundly influence corporate operations.

Tsang, Frost, and Cao (2023) found that the primary factor for companies voluntarily disclosing ESG is concern for stakeholders. ESG reporting can achieve long-term competitive advantages and improve performance (Ryou, Tsang, and Wang, 2022), conveying the company ESG commitments and enabling stakeholders to make informed decisions. For investors, the company provides a signal of prioritizing responsibilities in various areas (Kim, Park, and Wier, 2012). Proactive ESG disclosure by companies reduces information asymmetry between the business and its stakeholders and can also lower capital and debt costs.

Sila, Gonzalez, and Hagendorff (2017) argue that a company reputation significantly impacts its stock price. Highly educated executives understand the advantages of transparency in improving company performance and personal salaries, thus motivated to disclose ESG decisions. Goldin (2006) and Griliches (1997) highlighted the crucial role of education in accumulating human capital. Therefore, highly educated individuals are more likely to have a long-term vision for the company, prompting them to advocate for ESG disclosure to attract potential investors. Research has found a positive correlation between employee performance, trust, and corporate social responsibility (e.g., Sun and Yu, 2015; Sakdanuwatwong, 2020).

Wan, Hong, Liu, and Cui (2023) used data on executives' education from 2012 to 2021 to explore the impact of executive education level on ESG disclosure. The findings show that executives with advanced degrees, such as masters or doctorates, exhibit a greater willingness to engage in ESG disclosure, with executive education having a positive effect on the company ESG disclosure, especially in terms of social responsibility.

ESG encompasses responsibilities across economic, legal, ethical, and philanthropic dimensions, reflecting different perspectives on investment attractiveness and future development strategies. These actions are influenced by administrative decisions. Studies have

found that highly educated managers are expected to enhance corporate performance. Atkins et al., (2023) and Welch and Yoon (2023) found that the capabilities of top executives also affect the execution of a company ESG. However, direct research investigating the impact of top human capital on company ESG scores is noticeably lacking. This study aims to address this research gap.

According to resource dependency theory, companies with high uncertainty tend to employ external directors with rich background resources as members of the board (Hillman, Cannella, and Paetzold, 2000).

Literature extensively studies the regulatory methods of corporate operations. Gillan, Koch, and Starks (2021) found that a company ownership structure, CEO characteristics, and compensation structure are correlated with ESG or CSR scores. Borghesi, Houston, and Naranjo (2014) suggest that female CEOs increase corporate social responsibility commitment. Borghesi et al., 2014, and McGuinness et al., 2017 found a correlation between corporate social responsibility commitment and a higher presence of women directors.

Research on the extent of director functions has shown both positive and negative impacts on the company sustainable development actions and reporting, and the quality of information disclosure. Suttipun (2021) found that board size, the proportion of female directors, compensation committees, and corporate social responsibility committees have a significant positive correlation with ESG disclosure, whereas audit committees and CEO compensation have a significant negative correlation. Olayinka (2022) discovered that board size, board independence, female directors, and director shareholdings significantly affect sustainability reporting, while the dual role of chairman and CEO has no significant impact.

The choices of companies that perform well in ESG factors may be largely driven by director characteristics. However, when non-financial reporting on environmental, social, and governance issues is mandatory, director characteristics may lose some or all of their importance in determining company ESG policies. Some literature studies director characteristics independently, such as cultural diversity (e.g., Lau, Lu, and Liang, 2016; Rao and Tilt, 2016), the presence of independent directors (Liu et al., 2015), and the existence of corporate social responsibility committees (e.g., Spitzeck, 2009; Helfaya and Moussa, 2017), finding a positive correlation with corporate social responsibility. Companies should strive to

establish a board with high independence, diversity, a focus on social responsibility, and environmental sustainability to enhance ESG performance.

Freeman research in 1984 and 1994 indicates that an organization's stakeholders include any group or individual who can affect or is affected by organizational goals. These stakeholders may include managers and employees, shareholders, customers, suppliers, investors, governments, local communities, disadvantaged groups, partners, unions, non-profits, and other civil society groups. The theory suggests that there is a dynamic relationship between the company and its stakeholders, with the agent duty to maximize the principal wealth while considering the interests of other stakeholders. In this context, directors, as agents, bear significant responsibility to numerous stakeholders, and must be accountable for the company operations and performance (Parkinson, 1995). Companies not only have obligations to their primary stakeholders, such as shareholders, customers, or workers, but also to secondary stakeholders, such as social groups, local governments, subcontractors, and NGOs (Parmar et al., 2010). This study primarily focuses on carbon disclosure, top talent, and director shareholding ratio as core elements and proposes the following hypotheses:

H7: There is a positive relationship between carbon disclosure, top talent, director shareholding ratio on E score.

H8: There is a positive relationship between carbon disclosure, top talent, director shareholding ratio on S score.

H9: There is a positive relationship between carbon disclosure, top talent, director shareholding ratio on G score.

H10: There is a positive relationship between carbon disclosure, top talent, director shareholding ratio on TESG score.

H11: There is a positive relationship between carbon disclosure, top talent, director shareholding ratio on ESG disclosure.

3. Research Methods

3.1 Research design

This study employs regression analysis. In the regression equation, the dependent variables hypothesized in this study are firm value (TQ) and financial performance (ROE), which include both market-based and financial performance. The independent variables are the individual scores for environment, social, and governance, the TESG total score, and ESG disclosure (ESGD). The mediating variables are green finance (GB) and green economy (GEC). Additionally, this study uses individual scores for environment, social, and governance, and the comprehensive TESG sustainability score as dependent variables, exploring the impact of carbon disclosure (CD), highly educated (HE), and director shareholding ratio (DSR) as independent variables. The control variables in this study include company size (SIZE), leverage ratio (LEV), company age (AGE), dual role of chairman and CEO (DUAL), and research and development expense ratio (RD), along with year and industry fixed effects. The research method adopted primarily utilizes regression analysis and tests the research hypotheses using the mediation model proposed by Baron and Kenny (1986).

3.2 Data Sources and Sample Selection

This study utilizes the TESG Sustainability Index established in the TEJ database from 2015 to 2022 as the data source, focusing on listed companies in Taiwan. The index dimensions are clearly defined, with complete CSR reports, annual reports, and links to other external information databases, aligning with international standards and corroborated by industry classifications from the Global Reporting Initiative (GRI) and the Sustainability Accounting Standards Board (SASB). In terms of sample selection, this study initially obtained 13,415 samples. After excluding samples from the finance, insurance, securities industries, and missing values, the final sample comprises 12,920 observations over an eight-year period, with data frequency on an annual basis.

3.3 Variable Description

In this study, variables are categorized as follows: dependent variables, which include financial performance indicators such as Tobin Q and Return on Equity (ROE); independent variables, which encompass scores for Environmental (E), Social (S), and Governance (G) factors, together with TESG total scores and ESG disclosures. Mediating variables include green finance and green economy. Additionally, this research considers Environmental (E), Social (S), and Governance (G) scores, TESG total scores, and ESG disclosures as dependent variables, examining the relationships and impacts of independent variables such as carbon disclosure, top talent, and director shareholding ratio. Control variables include company size, debt ratio, company age, whether the chairman also serves as CEO, and the ratio of research and development expenses. The study also controls for fixed effects by year and industry. Detailed definitions of study variables are shown in Table 1.

Table 1 Summary of the Definitions of the Variables

Variable	Constructs	Code Name	Definitions
Dependent Variable	Firm Value	TQ	Taking Tobin Q as a proxy variable, Tobin Q is ratio of market capitalization plus liabilities to total assets (company market value + total liabilities)/total assets.
	ROE	ROE	Net profit after tax/total average shareholders' equity.
Independent Variable	Environmental Score	E score	(1) The original quantitative score of ESG is the weighted score of the three pillars of environment, society and corporate governance. The weight of each industry is calculated with reference to the SASB Industry Significance Map Index. (2) The original quantitative score of ESG can be obtained by multiplying the score of the topic and the score of the disclosure item of the pillar by 75% and 25% of the weight respectively, and then summing up. (3) ESG original quantitative score plus ESG news threshold score can get E, S, G and TESG score. (4) E, S, G and TESG score (0~100) 0 is the worst and 100 is the best.
	Social Score	S score	
	Governance score	G score	
	Environmental, Social and Governance total score	TESG score	

Table 1 Summary of the Definitions of the Variables

Variable	Constructs	Code Name	Definitions
	ESG disclosure	ESGD	ESGD is a dummy variable. If a company listed on the Taiwan Stock Exchange discloses ESG, it is 1, otherwise it is 0.
	Carbon Disclosure	CD	CD is a dummy variable. If a company listed on the Taiwan Stock Exchange discloses carbon emissions, it is 1, otherwise it is 0.
	Highly Educated	HE	HE is a dummy variable, which equals 1 for senior executive of companies listed on the Taiwan Stock Exchange with a doctorate degree, and 0 otherwise.
	Director Shareholding Ratio	DSR	Number of company shares held by directors/Total number of issued shares of the company
Mediating Variable	Green Bonds	GB	GB is a dummy variable that if the company by Taiwanese Listed Companies on the Taipei Exchange have issued green bonds equals 1; 0, otherwise.
	Green Energy Company	GEC	GEC is a dummy variable that equals 1 in green energy development; 0, otherwise.
Control Variable	Company Size	SIZE	SIZE is measured in natural logarithmic of the company's total assets.
	Debt Ratio	LEV	LEV is a financial ratio that measures a company's leverage, percent of total liabilities/ total assets
	Company Age	AGE	AGE is since the establishment of the company to the demonstration period.
	Chairman and CEO Dual Roles	DUAL	DUAL is a dummy variable that if the chairman of the company is also the CEO equals 1; 0, otherwise.
	R&D Expense Rate (%)	RD	The R&D expense ratio (research and development expenses/net operating income) measures the company's future growth opportunities.

Source: Compiled in this study.

3.4 Empirical Model

3.4.1 ESG Scores, TESG Total Scores, and ESG Disclosures

The effects of ESG scores, TESG total scores, and ESG disclosures on firm value and financial performance, as outlined in equations (1) to (6).

$$TQ_{i,j,t}=C_0+\alpha_j+\alpha_t+\beta_1 E\ score_{i,j,t}+\beta_2 S\ score_{i,j,t}+\beta_3\ G\ score_{i,j,t}+\beta_4 X_{i,j,t}+\varepsilon_{i,j,t} \quad (1)$$

$$TQ_{i,j,t}=C_0+\alpha_j+\alpha_t+\beta_1 TESG\ score_{i,j,t}+\beta_2 X_{i,j,t}+\varepsilon_{i,j,t} \quad (2)$$

$$TQ_{i,j,t}=C_0+\alpha_j+\alpha_t+\beta_1 ESGD_{i,j,t}+\beta_2 X_{i,j,t}+\varepsilon_{i,j,t} \quad (3)$$

$$ROE_{i,j,t}=C_0+\alpha_j+\alpha_t+\beta_1 E\ score_{i,j,t}+\beta_2 S\ score_{i,j,t}+\beta_3\ G\ score_{i,j,t}+\beta_4 X_{i,j,t}+\varepsilon_{i,j,t} \quad (4)$$

$$ROE_{i,j,t}=C_0+\alpha_j+\alpha_t+\beta_1 TESG\ score_{i,j,t}+\beta_2 X_{i,j,t}+\varepsilon_{i,j,t} \quad (5)$$

$$ROE_{i,j,t}=C_0+\alpha_j+\alpha_t+\beta_1 ESGD_{i,j,t}+\beta_2 X_{i,j,t}+\varepsilon_{i,j,t} \quad (6)$$

3.4.2 Green Financial

The models incorporate the issuance of green bonds to explore the effects of ESG scores, TESG total scores, and ESG disclosures on firm value and financial performance, as specified in equations (1A) to (6A).

$$TQ_{i,j,t}=C_0+\alpha_j+\alpha_t+\beta_1 E\ score_{i,j,t}+\beta_2 S\ score_{i,j,t}+\beta_3\ G\ score_{i,j,t}+\beta_4 GB_{i,j,t}+\beta_5 X_{i,j,t}+\varepsilon_{i,j,t} \quad (1A)$$

$$TQ_{i,j,t}=C_0+\alpha_j+\alpha_t+\beta_1 TESG\ score_{i,j,t}+\beta_2 GB_{i,j,t}+\beta_3 X_{i,j,t}+\varepsilon_{i,j,t} \quad (2A)$$

$$TQ_{i,j,t}=C_0+\alpha_j+\alpha_t+\beta_1 ESGD_{i,j,t}+\beta_2 GB_{i,j,t}+\beta_3 X_{i,j,t}+\varepsilon_{i,j,t} \quad (3A)$$

$$ROE_{i,j,t}=C_0+\alpha_j+\alpha_t+\beta_1 E\ score_{i,j,t}+\beta_2 S\ score_{i,j,t}+\beta_3\ G\ score_{i,j,t}+\beta_4 GB_{i,j,t}+\beta_5 X_{i,j,t}+\varepsilon_{i,j,t} \quad (4A)$$

$$ROE_{i,j,t}=C_0+\alpha_j+\alpha_t+\beta_1 TESG\ score_{i,j,t}+\beta_2 GB_{i,j,t}+\beta_3 X_{i,j,t}+\varepsilon_{i,j,t} \quad (5A)$$

$$ROE_{i,j,t}=C_0+\alpha_j+\alpha_t+\beta_1 ESGD_{i,j,t}+\beta_2 GB_{i,j,t}+\beta_3 X_{i,j,t}+\varepsilon_{i,j,t} \quad (6A)$$

3.4.3 Green Economic

The models incorporate factors related to developing green energy companies to examine the effects of ESG scores, TESG total scores, and ESG disclosures on firm value and financial performance, as delineated in equations (1B) to (6B).

$$TQ_{i,j,t}=C_0+\alpha_j+\alpha_t+\beta_1 E\ score_{i,j,t}+\beta_2 S\ score_{i,j,t}+\beta_3\ G\ score_{i,j,t}+\beta_4 GEC_{i,j,t}+\beta_5 X_{i,j,t}+\varepsilon_{i,j,t} \quad (1B)$$

$$TQ_{i,j,t}=C_0+\alpha_j+\alpha_t+\beta_1 TESG\ score_{i,j,t}+\beta_2 GEC_{i,j,t}+\beta_3 X_{i,j,t}+\varepsilon_{i,j,t} \quad (2B)$$

$$TQ_{i,j,t}=C_0+\alpha_j+\alpha_t+\beta_1 ESGD_{i,j,t}+\beta_2 GEC_{i,j,t}+\beta_3 X_{i,j,t}+\varepsilon_{i,j,t} \quad (3B)$$

$$ROE_{i,j,t}=C_0+\alpha_j+\alpha_t+\beta_1 E\ score_{i,j,t}+\beta_2 S\ score_{i,j,t}+\beta_3\ G\ score_{i,j,t}+\beta_4 GEC_{i,j,t}+\beta_5 X_{i,j,t}+\varepsilon_{i,j,t} \quad (4B)$$

$$ROE_{i,j,t}=C_0+\alpha_j+\alpha_t+\beta_1 TESG\ score_{i,j,t}+\beta_2 GEC_{i,j,t}+\beta_3 X_{i,j,t}+\varepsilon_{i,j,t} \quad (5B)$$

$$ROE_{i,j,t}=C_0+\alpha_j+\alpha_t+\beta_1 ESGD_{i,j,t}+\beta_2 GEC_{i,j,t}+\beta_3 X_{i,j,t}+\varepsilon_{i,j,t} \quad (6B)$$

3.4.4 Green Financial and Green Economic

The models incorporate factors related to issuing green bonds and developing green energy companies to examine the effects of ESG scores, TESG total scores, and ESG disclosures on firm value and financial performance, as outlined in equations (1C) to (6C).

$$\begin{aligned}TQ_{i,j,t} = {} & C_0 + \alpha_j + \alpha_t + \beta_1 E\ score_{i,j,t} + \beta_2 S\ score_{i,j,t} + \beta_3\ G\ score_{i,j,t} + \beta_4 GB_{i,j,t} \\ & + \beta_5 GEC_{i,j,t} + \beta_6 X_{i,j,t} + \varepsilon_{i,j,t}\end{aligned} \quad (1C)$$

$$TQ_{i,j,t} = C_0 + \alpha_j + \alpha_t + \beta_1 TESG\ score_{i,j,t} + \beta_2 GB_{i,j,t} + \beta_3 GEC_{i,j,t} + \beta_4 X_{i,j,t} + \varepsilon_{i,j,t} \quad (2C)$$

$$TQ_{i,j,t} = C_0 + \alpha_j + \alpha_t + \beta_1 ESGD_{i,j,t} + \beta_2 GB_{i,j,t} + \beta_3 GEC_{i,j,t} + \beta_4 X_{i,j,t} + \varepsilon_{i,j,t} \quad (3C)$$

$$\begin{aligned}ROE_{i,j,t} = {} & C_0 + \alpha_j + \alpha_t + \beta_1 E\ score_{i,j,t} + \beta_2 S\ score_{i,j,t} + \beta_3\ G\ score_{i,j,t} + \beta_4 GB_{i,j,t} \\ & + \beta_5 GEC_{i,j,t} + \beta_6 X_{i,j,t} + \varepsilon_{i,j,t}\end{aligned} \quad (4C)$$

$$ROE_{i,j,t} = C_0 + \alpha_j + \alpha_t + \beta_1 TESG\ score_{i,j,t} + \beta_2 GB_{i,j,t} + \beta_3 GEC_{i,j,t} + \beta_4 X_{i,j,t} + \varepsilon_{i,j,t} \quad (5C)$$

$$ROE_{i,j,t} = C_0 + \alpha_j + \alpha_t + \beta_1 ESGD_{i,j,t} + \beta_2 GB_{i,j,t} + \beta_3 GEC_{i,j,t} + \beta_4 X_{i,j,t} + \varepsilon_{i,j,t} \quad (6C)$$

3.4.5 Carbon Disclosure, Highly Educated and Director Shareholding Ratio on E, S, G Score, TESG Total Score, and ESG Disclosure

The models explore the impact of carbon disclosure, highly educated and director shareholding ratio on E, S, G Score, TESG total score, and ESG disclosure, as outlined in equations (7) to (11).

$$\text{E Score}_{i,j,t} = C_0 + \alpha_j + \alpha_t + \beta_1 CD_{i,j,t} + \beta_2 HE_{i,j,t} + \beta_3 DSR_{i,j,t} + \beta_4 X_{i,j,t} + \varepsilon_{i,j,t} \quad (7)$$

$$\text{S Score}_{i,j,t} = C_0 + \alpha_j + \alpha_t + \beta_1 CD_{i,j,t} + \beta_2 HE_{i,j,t} + \beta_3 DSR_{i,j,t} + \beta_4 X_{i,j,t} + \varepsilon_{i,j,t} \quad (8)$$

$$\text{G Score}_{i,j,t} = C_0 + \alpha_j + \alpha_t + \beta_1 CD_{i,j,t} + \beta_2 HE_{i,j,t} + \beta_3 DSR_{i,j,t} + \beta_4 X_{i,j,t} + \varepsilon_{i,j,t} \quad (9)$$

$$\text{TESG Score}_{i,j,t} = C_0 + \alpha_j + \alpha_t + \beta_1 CD_{i,j,t} + \beta_2 HE_{i,j,t} + \beta_3 DSR_{i,j,t} + \beta_4 X_{i,j,t} + \varepsilon_{i,j,t} \quad (10)$$

$$\text{ESGD}_{i,j,t} = C_0 + \alpha_j + \alpha_t + \beta_1 CD_{i,j,t} + \beta_2 HE_{i,j,t} + \beta_3 DSR_{i,j,t} + \beta_4 X_{i,j,t} + \varepsilon_{i,j,t} \quad (11)$$

In equations, the variable subscripts *i*, *j* and *t* represent company *i* in *j* industry in year *t*. Dependent variable $E\ score_{i,j,t}$ is the environmental dimension score of company, $S\ score_{i,j,t}$ is the social dimension score of company, $G\ score_{i,j,t}$ is the corporate governance dimension score of company, $TESG\ score_{i,j,t}$ is the total score of the three dimensions of environment, society and corporate governance of the company. $ESGD_{i,j,t}$. is a dummy variable that if the company listed on the Taipei have disclosure ESG equals 1; 0, otherwise. C_0 is the intercept item, α_j and α_t are industry and annual control effects respectively, $\beta_1\ \beta_2\ \beta_3\ \beta_4\ \beta_5\ \beta_6$ are regression parameters. $GB_{i,j,t}$ is a dummy variable that if the company listed on the Taipei Exchange have issued green bonds equals 1; 0, otherwise. $GEC_{i,j,t}$ is a dummy variable that equals 1 in green energy development; 0, otherwise. $CD_{i,j,t}$ is a dummy variable. Taiwan listed companies that disclose carbon emissions are 1, and 0 otherwise. $HE_{i,j,t}$ is a dummy variable that equals 1 the companies listed on the Taipei have senior executives with doctorate degrees, and 0 otherwise. $DSR_{i,j,t}$ is the shareholding ratio of directors of Taiwan listed company. Furthermore, $X_{i,j,t}$ are control variables, including company size, debt ratio, company age, Chairman and CEO dual roles, and research and development expense ratio. The company size is measured by taking the natural logarithm of the total assets of the company. Finally, $\varepsilon_{i,j,t}$ is the error term.

4. Empirical Results and Analysis

This chapter presents the empirical results and analyses of this research, offering an evaluation of hypothesis testing, discussions on the correlations between variables, and a review of the consistency between these correlations and the hypothesized relationships. By estimating model parameters, the chapter simultaneously considers the roles of green finance and the green economy in explaining the impact on firm value and financial performance through ESG scores, TESG total scores, and ESG disclosures, and presents the estimation results and their implications. Additionally, from another perspective, the chapter analyzes the impact of carbon disclosure, top talent, and board characteristics on ESG scores, TESG total scores, and ESG disclosures. The chapter is structured into four sections: The first section covers descriptive statistical analysis; the second section deals with correlation analysis; the third section explains the mediating effects of green finance and the green economy on the relationships between individual ESG scores, TESG total scores, ESG disclosures, and firm value and financial performance; the fourth section explores the empirical results and implications of carbon disclosure, top talent, and board characteristics in relation to ESG scores, TESG total scores, and ESG disclosures, providing a comprehensive understanding of corporate sustainability development.

4.1 Descriptive Statistical Analysis

This study aggregates the descriptive statistics of the variables used in the empirical model, which are summarized in Table 2. These statistics include sample size, minimum and maximum values, mean, median, and standard deviation. The subjects of this study are listed companies, and the data span from 2015 to 2022. After filtering, the final number of observations is 12,920.

Table 2 displays the descriptive statistics for each variable. Firstly, the dependent variable, Tobin Q ratio (TQ), has observations ranging from 0.02 to 52.3, with a mean of 1.319, a median of 0.98, and a standard deviation of 1.347. Return on Equity (ROE) spans from -99.79 to 167.69, with a mean of 7.1, a median of 7.515, and a standard deviation of 16.884. The mean of TQ exceeds its median, indicating a right-skewed distribution, whereas ROE mean is below its median, indicating a left skew, suggesting that the financial performance of most companies is above the mean.

For the independent variables in the environmental, social, and governance (ESG) dimensions: the environmental score (E score) ranges from 0 to 90.96, with a mean of 53.69, a median of 52.38, and a standard deviation of 14.171. The social score (S score) ranges from 0 to 91, with a mean of 53.72, a median of 53.78, and a standard deviation of 13.409. The governance score (G score) ranges from 0 to 84.41, with a mean of 52.958, a median of 54.39, and a standard deviation of 13.303. The TESG total scores ranges from 0 to 83.73, with a mean of 53.403, a median of 53.8, and a standard deviation of 11.498. ESG disclosure (ESGD) ranges from 0 to 1, with a mean of 0.319, a median of 0, and a standard deviation of 0.466.

Aside from the environmental score (E Score) and ESG disclosure (ESGD), where the means are higher than the medians indicating a right-skewed distribution suggesting that some companies are proactively engaging in environmental activities and valuing transparency in ESG disclosures the averages for social (S Score), governance (G Score), and the TESG total scores are below their respective medians, demonstrating a left-skewed distribution. This indicates a need for firms to enhance their commitments and continuous improvements in social and governance dimensions in order to elevate their sustainability scores. Although there are variances among the variables, the average scores for E, S, G and TESG four dimensions exceed 50 points, showcasing Taiwan's proactive efforts in advancing ESG initiatives.

Regarding the mediating variables of issuing green bonds (GB) and developing green energy companies (GEC), the observed values for GB range from 0 to 1, with an average of 0.004, a median of 0, and a standard deviation of 0.066. For GEC, the observed values also range from 0 to 1, with an average of 0.065, a median of 0, and a standard deviation of 0.246. The data for both GB and GEC exhibit averages higher than their medians, indicating a right-skewed distribution. This skewness reveals that a significant number of companies have begun to prioritize the issuance of green bonds and the development of green energy enterprises, highlighting a shift towards sustainability-focused financial and operational strategies.

Furthermore, regarding carbon disclosure (CD), Highly educated (HE), and director shareholding ratio (DSR), the observed values for CD range from 0 to 1, with an average of 0.106, a median of 0, and a standard deviation of 0.308. For HE, the observed range is also from 0 to 1, with an average of 0.424, a median of 0, and a standard deviation of 0.494. The DSR spans from 0 to 99.43, with an average of 22.190, a median of 17.96, and a standard

deviation of 15.941. These findings indicate that the averages for CD, HE, and DSR are all higher than their respective medians, reflecting a right-skewed distribution. This skewness suggests that the majority of companies are focused on enhancing their corporate social responsibility profile, recruiting top talent, and increasing director shareholdings as part of their governance practices.

Finally, regarding the control variables, the range of observations for company size (SIZE) is from 10.085 to 22.326, with an average of 15.326, a median of 15.137, and a standard deviation of 1.498. The company age (AGE) varies from 1 to 77 , with an average of 35.35, a median of 34, and a standard deviation of 13.651. The debt ratio (LEV) spans from 0.38 to 97.87, with an average of 41.684, a median of 41.83, and a standard deviation of 18.353. The incidence of the chairman and CEO Dual Roles (DUAL) ranges from 0 to 1, with an average of 0.354, a median of 0, and a standard deviation of 0.478. Research and development expense ratio (RD) extend from 0 to 9085.56, with an average of 17.03, a median of 2.02, and a standard deviation of 222.237.

Except for the debt ratio (LEV), where the average is below the median indicating a left-skewed distribution, suggesting that some companies are not heavily leveraged and manage their debt well, all other variables such as company size (SIZE), company age (AGE), the dual role of chairman and CEO (DUAL), and research and development expenditure rate (RD) show averages higher than their medians, indicating a right-skewed distribution. This skewness reflects the presence of relatively larger companies, or those with higher R&D investments and longer histories within the corporate group. These companies contribute to the right skew of the overall data and represent a subset of the studied companies that are relatively resource-rich, larger, have longstanding histories, and have more centralized management structures. These companies are likely to allocate more resources to R&D and may prefer a management model where the chairman also serves as the CEO.

Table 2 Descriptive Statistics

Variable (Number of Samples = 12,920) Note 1	Minimum	Maximum	Mean	Median	Standard Deviation
TQ	0.020	52.300	1.319	0.980	1.347
ROE (%)	(99.790)	167.690	7.100	7.515	16.884
E Score	0.000	90.960	53.690	52.380	14.171
S Score	0.000	91.000	53.720	53.780	13.409
G Score	0.000	84.410	52.958	54.390	13.303
TESG Score	0.000	83.730	53.403	53.800	11.498
ESGD	0.000	1.000	0.319	0.000	0.466
GB	0.000	1.000	0.004	0.000	0.066
GEC	0.000	1.000	0.065	0.000	0.246
CD	0.000	1.000	0.106	0.000	0.308
HE	0.000	1.000	0.424	0.000	0.494
DSR (%)	0.000	99.430	22.190	17.960	15.941
SIZE (log)	10.085	22.326	15.326	15.137	1.498
AGE	1.000	77.000	35.350	34.000	13.651
LEV (%)	0.380	97.870	41.684	41.830	18.353
DUAL	0.000	1.000	0.354	0.000	0.478
RD (%)	0.000	9,085.560	17.030	2.020	222.237

Note 1: TQ for Tobin Q Ratio; ROE is the return on equity; E Score is the environmental aspect score ; S Score is the social aspect score ; G Score is the governance aspect score ; TESG Score is the environmental, social and governance three aspect score. ; ESGD is ESG disclosure, companies with disclosures are 1 , and the rest are 0 ;GB is a green bond issuance, and the companies that have issued it are 1 , the rest are 0 ; GEC is a company that has developed green energy, 1 for those that have developed it , and the rest are 0 ; CD is carbon emissions disclosure, companies with disclosures are 1 , and the rest are 0 ; HE is the employee with a doctorate degree in the company, 1 for companies with doctoral degrees , and the rest are 0 ; DSR is the director's shareholding ratio; SIZE is the company size ; AGE is the company age ; LEV is the debt ratio ; DUAL is the chairman and CEO dual roles ; RD is the R&D expenditure rate .

Note 2: Some companies have no research expenditure during the sample period, so the minimum value is zero.

Source: Compiled from TEJ and this study

4.2 Related Analysis

Before proceeding with regression analysis, the Pearson correlation coefficient is used to determine potential collinearity among variables. Table 3 presents a correlation matrix of the variables, which is utilized to analyze inter-variable correlations. The Tobin Q ratio exhibits positive correlations with the environmental score (E Score), social score (S Score), governance score (G Score), the TESG total score (TESG Score), ESG Disclosure (ESGD), issuance of green bonds (GB), and development of green energy companies (GEC), all at significant levels. Similarly, return on equity (ROE) shows positive correlations with the environmental score (E Score), social score (S Score), governance score (G Score), the TESG total score (TESG Score), issuance of green bonds (GB), and development of green energy companies (GEC), also at significant levels.

The environmental score (E Score) exhibits a positive correlation with carbon disclosure (CD), companies with high-level executives holding doctoral educated (HE), and director shareholding ratio (DSR), all at significant levels. Similarly, the social score (S Score) demonstrates a positive correlation with carbon disclosure (CD), companies where high-level executives hold doctoral educated (HE), and director shareholding ratio (DSR), also at significant levels. The governance score (G Score) is positively correlated with carbon disclosure (CD), companies where high-level executives hold doctoral educated (HE), and director shareholding ratio (DSR), with these correlations also being statistically significant. Furthermore, the composite score for environmental, social, and governance dimensions (TESG Score) shows a positive correlation with Carbon Disclosure (CD), companies where high-level executives hold doctoral educated (HE), and director shareholding ratio (DSR), all at significant levels. Additionally, ESG disclosure (ESGD) is positively correlated with carbon disclosure (CD), companies where high-level executives hold doctoral educated (HE), and director shareholding ratio (DSR).

The Pearson correlation coefficient indicates a significant positive correlation at the 5% level between firm value and individual ESG scores, as well as the TESG total score, suggesting that higher ESG and TESG scores are associated with increased firm value. Financial performance also shows a significant positive correlation at the 5% level with individual ESG scores, TESG total scores, and ESG disclosure, implying that better ESG scores and disclosures are linked to higher financial performance. Additionally, individual ESG scores, TESG total scores, and ESG disclosure are significantly positively correlated with

carbon disclosure (CD) and companies where high-level executives hold doctoral educated (HE) at the 5% level, indicating that higher levels of CD and doctoral qualifications among employees lead to better ESG outcomes. This result preliminarily validates our hypotheses.

The correlation between Tobin Q and ROE with the main control variables is strong, suggesting that the selected control variables are appropriate. Furthermore, all other control variables exhibit correlation coefficients below 0.5, indicating that the model does not suffer from severe multicollinearity issues. Additionally, following the methodology of Cohen, Cohen, West, and Aiken (2013), the Variance Inflation Factor (VIF) was used to assess potential collinearity among variables. The test results show that all VIF values are below 10, demonstrating that there are no severe collinearity issues among the variables.

Table 3 Correlation Coefficient Matrix Table

	TQ	ROE	E Score	S Score	G Score	TESG Score	ESGD	GB	GEC	CD	HE	DSR	SIZE	AGE	LEV	DUAL	RD
TQ	1																
ROE	0.120**	1															
E Score	0.031**	0.052**	1														
S Score	0.056**	0.055**	0.686**	1													
G Score	0.075**	0.063**	0.525**	0.530**	1												
TESG Score	0.067**	0.069**	0.837**	0.871**	0.827**	1											
ESGD	0.003	0.111**	0.467**	0.486**	0.274**	0.467**	1										
GB	0.019*	0.045**	0.047**	0.084**	0.027**	0.061**	0.086**	1									
GEC	-0.021*	-0.029**	0.097**	0.085**	0.027**	0.077**	0.115**	0.059**	1								
CD	0.032**	0.098**	0.314**	0.289**	0.193**	0.302**	0.494**	0.054**	0.076**	1							
HE	0.095**	0.004	0.148**	0.254**	0.070**	0.185**	0.144**	0.051**	0.070**	0.000	1						
DSR	0.082**	0.017	0.087**	0.107**	0.172**	0.144**	0.016	0.006	0.025**	0.020*	-0.061**	1					
SIZE	-0.139**	0.178**	0.440**	0.477**	0.229**	0.434**	0.543**	0.146**	0.127**	0.328**	0.198**	-0.092**	1				
AGE	-0.215**	-0.040**	0.170**	0.188**	0.042**	0.149**	0.167**	0.032**	0.061**	0.084**	-0.084**	-0.121**	0.315**	1			
LEV	-0.219**	-0.057**	0.078**	0.047**	-0.017	0.034**	0.091**	0.023**	0.078**	0.067**	-0.020*	-0.016	0.333**	0.114**	1		
DUAL	0.013	-0.048**	0.000	0.000	-0.157**	-0.066**	-0.092**	-0.022*	-0.052**	-0.050**	0.005	-0.044**	-0.121**	-0.049**	-0.025**	1	
RD	0.190**	-0.134**	-0.039**	-0.022*	-0.019*	-0.028**	-0.021*	-0.004	-0.018*	-0.009	0.061**	0.022*	-0.057**	-0.091**	-0.099**	-0.005	1

Note 1: ***, ** and * indicate significance levels of 1%, 5% and 10% respectively.

Note 2: N= 12,920.

Source: Compiled from TEJ and this study.

4.3 Empirical Results

This section primarily validates the hypotheses 1 to 6C established in chapter 2 of this research, employing regression analysis to investigate the empirical effects of green finance and the green economy on individual ESG scores, TESG total scores, and ESG disclosure, and their influence on firm value and financial performance.

4.3.1 ESG Scores, TESG Total Scores, and ESG Disclosures

The empirical results from Models 1, 2, and 3 in Table 4 indicate that individual ESG scores, TESG total scores, and ESG disclosure have a positive and significant impact on Tobin Q, with regression coefficients of 0.005, 0.008, 0.003, 0.015, and 0.197, significant at the 1% level. This suggests that higher ESG scores and greater transparency in related disclosures are associated with higher Tobin Q, implying that the market holds positive expectations for the future growth and profitability of these companies.

The empirical results from Models 4, 5, and 6 in Table 4 demonstrate that the coefficient for the environmental dimension is -0.015, not significant; the social dimension coefficient is -0.090, significant at the 1% level; the governance dimension coefficient is 0.033, significant at the 5% level as positive; the TESG total score coefficient is -0.061, significant at the 1% level; and the ESG disclosure coefficient is -0.764, significant at the 10% level. The results for the environmental dimension imply that the short-term financial returns on environmental investments are not evident, or the environmental strategies have not yet effectively translated into corporate financial performance. The results for the Social dimension suggest that high social responsibility performance might increase operational costs or fail to bring the anticipated financial benefits in the short term. The results for the Governance dimension indicate that sound governance practices positively affect the company’s financial performance, aligning with Agency Theory, which posits that strengthened governance structures can reduce agency problems and enhance corporate efficiency. The results for the TESG total score suggest that high performance in TESG may put financial performance under pressure in the short term. The results for ESG disclosure indicate that high transparency in ESG might raise concerns about future economic burdens or risks in the market, leading to a significant negative impact on ROE.

Overall, the empirical results of this study confirm Hypotheses 1, 2, and 3; however, they do not support Hypotheses 4, 5, and 6. The findings suggest that companies need to consider

the short-term and long-term impacts of different ESG dimensions when formulating their ESG strategies. In particular, investments in social and environmental dimensions should be carefully evaluated for their immediate financial impacts and contributions to long-term sustainability. Additionally, strengthening the governance dimension should be viewed as a key strategy for enhancing firm value. Regarding ESG disclosure, companies should balance transparency with the need to avoid excessive disclosure that could lead to market concerns.

Table 4 Empirical Results of the Impact of ESG Scores, TESG Total Scores, and ESG Disclosure on Firm Value and Financial Performance

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Variable	**TQ**	**TQ**	**TQ**	**ROE**	**ROE**	**ROE**
Intercept	2.723***	2.580***	2.682***	-23.656***	-20.859***	-24.935***
	(19.858)	(19.754)	(18.059)	(-13.408)	(-12.405)	(-13.105)
E Score	0.005***			-0.015		
	(3.953)			(-1.010)		
S Score	0.008***			-0.090***		
	(6.279)			(-5.601)		
G Score	0.003***			0.033**		
	(2.638)			(2.469)		
TESG Score		0.015***			-0.061***	
		(13.563)			(-4.382)	
ESGD			0.197***			-0.764*
			(6.461)			(-1.954)
SIZE	-0.078***	-0.068***	-0.050***	3.256***	3.060***	2.973***
	(-8.015)	(-7.286)	(-4.917)	(25.849)	(25.294)	(22.792)
AGE	-0.015***	-0.015***	-0.014***	-0.135***	-0.140***	-0.144***
	(-15.153)	(-14.925)	(-13.903)	(-10.619)	(-11.073)	(-11.375)
LEV	-0.010***	-0.010***	-0.010***	-0.158***	-0.157***	-0.154***
	(-14.338)	(-14.342)	(-15.180)	(-18.012)	(-17.954)	(-17.668)
DUAL	0.008	0.023	0.020	-0.454	-0.782***	-0.767***
	(0.320)	(1.001)	(0.854)	(-1.484)	(-2.617)	(-2.566)
RD	0.001	0.001***	0.001***	-0.011***	-0.011***	-0.011***
	(17.592)	(17.596)	(17.185)	(-16.414)	(-16.459)	(-16.350)
Industry Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.165	0.164	0.155	0.120	0.121	0.117
F-Statistic	55.388	57.469	53.728	38.585	39.521	39.132
Observations	12,920	12,920	12,920	12,920	12,920	12,920

Note 1 : TQ is Tobin Q ratio; ROE is return on equity; E Score is environmental aspect score; S Score is social aspect score; G Score is governance aspect score; TESG Score is environmental, social and governance three aspect score; ESGD is ESG disclosure, companies with disclosures are 1, and the rest are 0; SIZE is the company size; AGE is the age of the company; LEV is the debt ratio; DUAL is the chairman and CEO dual roles; RD is the R&D expenditure rate.

Note 2: * * *, * * and * represent respectively 1%, 5% and 10% significance levels.

Source: Compiled from TEJ and this study

4.3.2 Green Finance

The empirical results of Models 1A, 2A, and 3A, as displayed in Table 5, indicate that incorporating the issuance of green bonds has a positive and significant impact on the individual ESG scores, the TESG total score, and ESG disclosure on Tobin Q. The regression coefficients are 0.005, 0.008, 0.003, 0.015, and 0.196, significant at the 1% level. It is observed that the coefficient for ESG disclosure dropped slightly from 0.197 to 0.196 after including the green bond issuance factor, suggesting a partial mediating effect of green bond issuance on ESG disclosure. This result implies that issuing green bonds may enhance the positive impact of ESG factors on a firm's market value.

The empirical results from Models 4A, 5A, and 6A presented in Table 5 reveal the impact of incorporating green bond issuance factors on individual ESG scores, the TESG total score, and ESG disclosure on Return on Equity (ROE). Specifically, the coefficient for the environmental dimension is -0.014, which is not significant, suggesting that environmental investments do not have a direct, notable contribution to ROE within the context of green bond issuance. The social dimension coefficient is -0.091, significant at the 1% level, indicating that social responsibility investments may have a significant negative short-term impact on a company's capital return. The governance dimension coefficient is 0.033, significantly positive at the 1% level, illustrating that good governance practices positively affect company ROE. The TESG total score coefficient is -0.060, significant at the 1% level, implying that high TESG performance might negatively impact financial performance in the short term. The coefficient for ESG disclosure is -0.769, significant at the 10% level, suggesting that ESG disclosure exerts pressure on ROE.

Overall, the empirical study validates Hypotheses 1A, 2A, and 3A but does not support Hypotheses 4A, 5A, and 6A. In the context of green bond issuance, companies need to balance the impact of various ESG dimensions on the rate of capital return. It is especially important to note that while good governance can enhance ROE, high levels of ESG disclosure and social responsibility investments might pressure financial performance in the short term. Therefore, companies should thoroughly assess the cost-effectiveness of each dimension when formulating ESG policies and decisions and consider their long-term potential impact on firm value. Concurrently, green bond issuance strategies should align with the company's overall ESG goals and financial objectives to maximize sustainable development and shareholder value.

Table 5 Empirical Results of the Impact of ESG Scores, TESG Total Scores, and ESG Disclosure on Firm Value and Financial Performance after Adding Green Financial Factors

	Model 1A	Model 2A	Model 3A	Model 4A	Model 5A	Model 6A
Variable	**TQ**	**TQ**	**TQ**	**ROE**	**ROE**	**ROE**
Intercept	2.784***	2.643***	2.742***	-23.275***	-20.494***	-24.572***
	(20.132)	(20.042)	(18.327)	(-13.079)	(-12.065)	(-12.818)
E Score	0.005***			-0.014		
	(4.046)			(-0.964)		
S Score	0.008***			-0.091***		
	(6.175)			(-5.649)		
G Score	0.003***			0.033***		
	(2.670)			(2.484)		
TESG Score		0.015***			-0.060***	
		(13.583)			(-4.375)	
ESGD			0.196***			-0.769*
			(6.435)			(-1.968)
GB	0.562***	0.569***	0.550***	3.536***	3.278	3.359
	(3.337)	(3.382)	(3.246)	(1.632)	(1.512)	(1.548)
SIZE	-0.083***	-0.073***	-0.054***	3.23***	3.035***	2.949***
	(-8.378)	(-7.682)	(-5.274)	(25.432)	(24.852)	(22.441)
AGE	-0.015***	-0.015***	-0.014***	-0.135***	-0.140***	-0.144***
	(-15.194)	(-14.969)	(-13.944)	(-10.637)	(-11.090)	(-11.393)
LEV	-0.010***	-0.010***	-0.010***	-0.157***	-0.157***	-0.154***
	(-14.284)	(-14.282)	(-15.126)	(-17.982)	(-17.923)	(-17.640)
DUAL	0.008	0.023	0.020	-0.454	-0.783***	-0.768***
	(0.319)	(0.992)	(0.844)	(-1.484)	(-2.621)	(-2.571)
RD	0.001***	0.001***	0.001***	-0.011***	-0.011***	-0.011***
	(17.590)	(17.592)	(17.180)	(-16.419)	(-16.465)	(-16.356)
Industry Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.166	0.165	0.156	0.120	0.118	0.117
F-Statistic	54.509	56.514	52.828	37.842	38.715	38.338
Observations	12,920	12,920	12,920	12,920	12,920	12,920

Note 1 : TQ is Tobin Q ratio; ROE is return on equity; E Score is environmental aspect score; S Score is social aspect score; G Score is governance aspect score; TESG Score is environmental, social and governance three aspect score; ESGD is ESG disclosure, companies with disclosures are 1 , and the rest are 0 ;GB is a green bond issuance, and the companies that have issued it are 1 , the rest are 0; SIZE is the company size; AGE is the age of the company; LEV is the debt ratio; DUAL is the chairman and CEO dual roles; RD is the R&D expenditure rate.

Note 2: * * *, * * and * represent respectively 1%, 5% and 10% significance levels.

Source: Compiled from TEJ and this study

4.3.3 Green Economic

The empirical results from Models 1B, 2B, and 3B presented in Table 6 show that after incorporating factors associated with companies developing green energy, the impact on individual ESG scores, the TESG total score, and ESG disclosure on Tobin Q is significantly positive. The regression coefficients are 0.004, 0.008, 0.003, 0.015, and 0.196, significant at the 1% level. Specifically, the coefficient for the environmental dimension decreased from 0.005 to 0.004 after the inclusion of green energy development factors, indicating a partial mediating effect of these factors on the E dimension score. Similarly, the coefficient for ESG disclosure slightly decreased from 0.197 to 0.196, suggesting a partial mediation by green energy development, which implies that the involvement of green energy companies has made environmental performance more prominent, thus affecting the overall effect of ESG disclosure.

The empirical results from Models 4B, 5B, and 6B presented in Table 6 demonstrate the effects of incorporating green energy development factors on individual ESG scores, the TESG total score, and ESG disclosure on Return on Equity (ROE). The coefficients for the environmental dimension are -0.010, showing no significant impact, which indicates that environmental investments may not contribute directly to ROE in the short term as the economic benefits of such investments often require a longer period to materialize. The social dimension coefficient of -0.090, significant at the 1% level, suggests that intensifying social responsibility can negatively impact immediate financial performance, likely due to the additional short-term costs associated with enhancing social responsibility practices. The governance dimension coefficient of 0.031, significantly positive at the 1% level, indicates that excellent governance can effectively improve financial performance by enhancing operational capabilities and market trust, thus positively affecting ROE. The TESG total score coefficient is -0.057, significant at the 1% level, implying that high TESG performance might negatively impact financial performance in the short term. The ESG disclosure coefficient of -0.661, significant at the 10% level, reflects that while increased transparency and disclosure aid market assessment and oversight, they may also subject the company to short-term financial pressures, particularly as disclosure might draw attention to potential future risks and negative factors.

Overall, the empirical study validates Hypotheses 1B, 2B, and 3B but does not support Hypotheses 4B, 5B, and 6B. The development of green energy plays a mediating role in

enhancing corporate environmental behavior and strategic transparency, while companies must balance the impact of various dimensions on capital returns during their green transition. It is crucial to note that while good governance can enhance ROE, high levels of ESG disclosure and social responsibility investments might pressure financial performance in the short term. Therefore, when formulating ESG policies and decisions, companies should thoroughly assess the cost-effectiveness of each dimension and consider their long-term potential impact on firm value. Concurrently, green bond issuance strategies should align with the company's overall ESG goals and financial objectives to maximize sustainable development and shareholder value.

Table 6 Empirical Results of the Impact of ESG Scores, TESG Total Scores, and ESG Disclosure on Firm Value and Financial Performance after Adding Green Economic Factors

	Model 1B	Model 2B	Model 3B	Model 4B	Model 5B	Model 6B
Variable	TQ	TQ	TQ	ROE	ROE	ROE
Intercept	2.728***	2.588***	2.692***	-24.760***	-22.130***	-25.993***
	(19.785)	(19.665)	(18.051)	(-13.975)	(-13.080)	(-13.625)
E Score	0.004***			-0.010		
	(3.924)			(-0.655)		
S Score	0.008***			-0.090***		
	(6.276)			(-5.575)		
G Score	0.003**			0.031***		
	(2.647)			(2.294)		
TESG Score		0.015***			-0.057***	
		(13.535)			(-4.159)	
ESGD			0.196***			-0.661*
			(6.425)			(-1.693)
GEC	0.018	0.026	0.037	-3.908***	-4.004***	-4.058***
	(0.356)	(0.502)	(0.726)	(-5.957)	(-6.108)	(-6.185)
SIZE	-0.079***	-0.069***	-0.051***	3.312***	3.126***	3.034***
	(-8.019)	(-7.301)	(-4.958)	(26.253)	(25.774)	(23.222)
AGE	-0.015***	-0.015***	-0.014***	-0.131***	-0.136***	-0.140***
	(-15.152)	(-14.930)	(-13.921)	(-10.323)	(-10.739)	(-11.013)
LEV	-0.010***	-0.010***	-0.010***	-0.154***	-0.154***	-0.151***
	(-14.333)	(-14.345)	(-15.195)	(-17.639)	(-17.555)	(-17.265)
DUAL	0.008	0.023	0.020	-0.500***	-0.809***	-0.795***
	(0.329)	(1.009)	(0.864)	(-1.634)	(-2.713)	(-2.663)
RD	0.001***	0.001***	0.001***	-0.011***	-0.011***	-0.010***
	(17.586)	(17.590)	(17.177)	(-16.373)	(-16.422)	(-16.317)
Industry Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.165	0.164	0.155	0.123	0.121	0.120
F-Statistic	54.233	56.222	52.569	38.622	39.582	39.224
Observations	12,920	12,920	12,920	12,920	12,920	12,920

Note 1: TQ is Tobin Q ratio; ROE is return on equity; E Score is environmental aspect score; S Score is social aspect score; G Score is governance aspect score; TESG Score is environmental, social and governance three aspect score; ESGD is ESG disclosure, companies with disclosures are 1, and the rest are 0; GEC is a company that has developed green energy. The number of companies that have developed green energy is 1, and the rest are 0; SIZE is the company size; AGE is the age of the company; LEV is the debt ratio; DUAL is the chairman and CEO dual roles; RD is the R&D expenditure rate.

Note 2: * * *, * * and * represent respectively 1%, 5% and 10% significance levels.

Source: Compiled from TEJ and this study

4.3.4 *Green* Financial *and Green* Economic

The empirical findings from Models 1C, 2C, and 3C presented in Table 7 demonstrate that after incorporating factors related to the issuance of green bonds and the development of green energy companies, the individual ESG scores, the TESG total score, and ESG disclosure positively and significantly affect Tobin Q. The regression coefficients are 0.005, 0.008, 0.003, 0.015, and 0.195, significant at the 1% level. Observing the change in coefficients for ESG disclosure from 0.197 to 0.195 after including these green factors suggests that green bond issuance and green energy development serve a partial mediating role in ESG disclosure. This indicates that these green strategies have forged a new linkage between corporate ESG performance and transparency, affecting how investors perceive firm value.

The empirical results from Models 4C, 5C, and 6C presented in Table 7 indicate that after integrating factors related to the issuance of green bonds and the development of green energy companies, the individual ESG scores, the TESG total score, and ESG disclosure have a significant impact on Return on Equity (ROE). The coefficients for the environmental dimension are -0.009, showing no significant impact; this suggests that the economic benefits from environmental enhancements driven by green bonds and green energy developments are not immediately apparent in ROE. The social dimension coefficient is -0.090, significant at the 1% level, indicating that while investments in social responsibility can bolster stakeholder support and social capital, they may adversely affect financial performance in the short term due to increased costs or diversion from core business focus. The governance dimension coefficient is 0.031, significant at the 5% level, demonstrating that enhanced governance structures and transparency measures, such as those implemented through green energy developments and green bond management, contribute positively to operational efficiency and shareholder value, thereby positively affecting ROE. The overall TESG score coefficient is -0.057, significant at the 1% level, suggesting that companies with high ESG ratings, while aiming for long-term sustainability, might face financial performance pressures in the short term due to higher costs or longer payback periods for investments. The ESG disclosure coefficient of -0.666, significant at the 10% level, indicates that companies with greater transparency might face stricter market scrutiny due to more extensive information disclosure, which could negatively impact shareholder returns in the short term.

Overall, the empirical study validates Hypotheses 1C, 2C, and 3C but does not support Hypotheses 4C, 5C, and 6C. The results underscore the complex impacts of green strategies on

various ESG dimensions and financial performance, offering an in-depth look at the potential challenges and opportunities faced by companies implementing green strategies. Companies pursuing ESG strategies need to balance their responsibilities to stakeholders with their financial commitments to shareholders. When investing in ESG, they must consider the potential long-term value contributions against the immediate economic impacts.

Table 7 Empirical Results of the Impact of ESG Scores, TESG Total Scores, and ESG Disclosure on Firm Value and Financial Performance after Adding Green Financial and Green Economy Factors

	Model 1C	Model 2C	Model 3C	Model 4C	Model 5C	Model 6C
Variable	**TQ**	**TQ**	**TQ**	**ROE**	**ROE**	**ROE**
Intercept	2.788***	2.651***	2.750***	-26.807***	-21.759***	-25.624***
	(20.058)	(19.953)	(18.318)	(-14.974)	(-12.734)	(-13.334)
E Score	0.005***			-0.009		
	(4.018)			(-0.608)		
S Score	0.008***			-0.090***		
	(6.173)			(-5.624)		
G Score	0.003***			0.031**		
	(2.678)			(2.309)		
TESG Score		0.015***			-0.057***	
		(13.556)			(-4.152)	
ESGD			0.195***	3.619*	3.353	-0.666*
			(6.399)	(1.672)	(1.548)	(-1.707)
GB	0.562***	0.569***	0.549***	3.619*	3.353	3.427
	(3.335)	(3.379)	(3.242)	(1.672)	(1.548)	(1.582)
GEC	0.017	0.025	0.036	-3.915***	-4.009***	-4.063***
	(0.335)	(0.484)	(0.709)	(-5.968)	(-6.117)	(-6.194)
SIZE	-0.083***	-0.073***	-0.055***	3.285***	3.100***	3.009***
	(-8.380)	(-7.695)	(-5.312)	(25.832)	(25.327)	(22.867)
AGE	-0.015***	-0.015***	-0.014***	-0.131***	-0.136***	-0.140***
	(-15.192)	(-14.792)	(-13.962)	(-10.341)	(-10.756)	(-11.030)
LEV	-0.010***	-0.010***	-0.010***	-0.154***	-0.153***	-0.151***
	(-14.277)	(-14.284)	(-15.140)	(-17.608)	(-17.523)	(-17.236)
DUAL	0.008	0.023	0.020	-0.050	-0.811*	-0.796***
	(0.328)	(0.999)	(0.855)	(-1.635)	(-2.717)	(-2.668)
RD	0.001***	0.001***	0.001***	-0.011***	-0.011***	-0.011***
	(17.585)	(17.586)	(17.173)	(-16.378)	(-16.428)	(-16.317)
Industry Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.166	0.165	0.156	0.123	0.121	0.120
F-Statistic	53.395	55.313	51.712	37.896	38.795	38.447
Observations	12,920	12,920	12,920	12,920	12,920	12,920

Note 1: TQ is Tobin Q ratio; ROE is return on equity; E Score is environmental aspect score; S Score is social aspect score; G Score is governance aspect score; TESG Score is environmental, social and governance three aspect score.; ESGD is ESG disclosure, companies with disclosures are 1 , and the rest are 0 ;GB is a green bond issuance, and the companies that have issued it are 1 , the rest are 0; GEC is a company that has developed green energy. The number of companies that have developed green energy is 1, and the rest are 0; SIZE is the company size; AGE is the age of the company; LEV is the debt ratio; DUAL is the chairman and CEO dual roles; RD is the R&D expenditure rate.
Note 2: * * *, * * and * represent respectively 1%, 5% and 10% significance levels.
Source: Compiled from TEJ and this study

4.4 Empirical Results of Carbon Emissions Disclosure, Top Talents, and Board Characteristics on E, S, G Score TESG Total Score and ESG Disclosure

4.4.1 Carbon Disclosure

The empirical results from Models 7, 8, 9, 10, and 11 in Table 8 demonstrate that carbon disclosure (CD) has a significant positive impact on the individual scores for Environment (E Score), Social (S Score), and Governance (G Score), as well as on the TESG total score (TESG Score) and ESG disclosure (ESGD). The regression coefficients are 8.921, 6.582, 4.461, 6.331, and 0.482, respectively, all significant at the 1% level. This implies that enhanced carbon disclosure not only significantly boosts corporate performance in environmental, social, and governance aspects but also underscores the importance of transparency in corporate sustainability strategies. Furthermore, these findings reinforce the strategic value of corporate carbon emissions disclosure and provide empirical support for related policy formulation and practice, suggesting that corporations and regulatory bodies should further prioritize transparency in carbon emissions to enhance overall ESG performance.

4.4.2 Highly Educated

The empirical results from Models 7, 8, 9, 10, and 11 in Table 8 indicate that highly educated (HE) has a significant positive impact on individual scores for Environment (E Score), Social (S Score), and Governance (G Score), as well as on the TESG total score (TESG Score) and ESG disclosure (ESGD). The regression coefficients are 2.222, 4.830, 1.192, 2.751, and 0.066, respectively, significant at the 1% level. This signifies that the introduction of highly educated significantly enhances corporate performance in environmental, social, and governance dimensions. The findings highlight the critical role of highly educated in enhancing corporate ESG performance. These empirical results and theoretical insights emphasize the importance for businesses to focus on attracting and developing highly educated within their talent strategies to foster progress in sustainable development.

4.4.3 Director Shareholding Ratio

The empirical results from Models 7, 8, 9, 10, and 11 in Table 8 indicate that the director shareholding ratio (DSR) has a significant positive impact on individual scores for Environment (E Score), Social (S Score), Governance (G Score), the TESG total score (TESG Score), and ESG disclosure (ESGD). The regression coefficients are 0.135, 0.146, 0.158,

0.145, and 0.001, respectively, all significant at the 1% level. Notably, the governance (G Score) coefficient is the highest, highlighting the importance of board shareholding in enhancing corporate governance quality.

Overall, the results of this empirical study validate Hypotheses 7, 8, 9, 10, and 11. This empirical analysis examines the significant positive relationships between carbon emissions disclosure, the top talent, and board characteristics with the individual ESG scores, TESG total scores, as well as ESG disclosures. Our findings indicate that carbon emissions disclosure has the strongest impact on the environmental component, suggesting that transparent reporting of carbon metrics substantially enhances a firm's environmental responsibility and ESG performance. Furthermore, companies with top talent notably excel in the social dimension, indicating that skilled personnel with expertise in sustainability are pivotal in boosting social practices and scores. Additionally, a higher proportion of director shareholding correlates most strongly with the governance dimension, underscoring that alignment of director interests with long-term company goals through shareholding significantly influences governance practices. These results collectively demonstrate how specific corporate characteristics can drive comprehensive improvements in ESG performance and disclosure.

Table 8 Empirical Results Analysis of Carbon Disclosure (CD) on E, S, G Score, TESG Total Score and ESG Disclosure

	Model 7	Model 8	Model 9	Model 10	Model 11
Variable	**E Score**	**S Score**	**G Score**	**TESG Score**	**ESGD**
Intercept	-9.427***	-14.872***	22.345***	1.437	-1.878***
	(-6.794)	(-11.830)	(15.633)	(1.284)	(-48.541)
CD	8.921***	6.582***	4.461***	6.331***	0.482***
	(21.731)	(17.698)	(10.549)	(19.121)	(42.132)
HE	2.222***	4.830***	1.192***	2.751***	0.066***
	(8.903)	(21.632)	(4.638)	(13.666)	(9.496)
DSR	0.135***	0.146***	0.158***	0.145***	0.001***
	(19.669)	(23.444)	(22.393)	(26.202)	(7.189)
SIZE	3.742***	4.954***	2.023***	3.115***	0.143***
	(41.111)	(47.949)	(21.575)	(42.430)	(56.462)
AGE	0.118***	0.119***	0.030	0.084***	-0.001***
	(12.180)	(13.578)	(2.964)	(10.745)	(-2.595)
LEV	-0.037***	-0.067***	-0.076***	-0.063***	-0.002***
	(-5.560)	(-11.277)	(-11.198)	(-11.907)	(-9.714)
DUAL	1.610***	1.856***	-3.602***	-0.245	-0.010
	(7.132)	(9.071)	(-15.485)	(-1.343)	(-1.639)
RD	-0.002***	-0.001***	-0.002***	-0.001***	0.000
	(-3.911)	(-2.311)	(-3.275)	(-3.621)	(-0.858)
Industry Effect	Yes	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.286	0.346	0.141	0.295	0.487
F-Statistic	111.326	146.339	46.071	115.897	262.015
Observations	12,920	12,920	12,920	12,920	12,920

Note 1: E Score is the environmental aspect score; S Score is the social aspect score; G Score is the governance aspect score; TESG Score is the environmental, social and governance three aspect score; ESGD is ESG disclosure, companies with disclosures are 1, and the rest are 0 ;CD is carbon emission disclosure, and companies with disclosures are: 1, and the rest are 0; HE is the senior executives with a doctorate degree in the company, and there are the number of companies owned is 1 , and the rest are 0; DSR is the shareholding ratio of directors; SIZE is the company size; AGE is the age of the company; LEV is the debt ratio; DUAL is the chairman and CEO dual roles; RD is the R&D expenditure rate.

Note2: * * *, * * and * represent respectively 1%, 5% and 10% significance levels.

Source: Compiled from TEJ and this study

5. Sensitivity Analysis

This chapter conducts a sensitivity analysis to examine whether the outcomes for different dependent variables, their lag effects, and the results from changes in the sample differ under various conditions.

5.1 The Deferred Effects of the Dependent Variables

This study uses future Tobin Q ratio ($TQ_{i,t+1}$) and future return on equity ($ROE_{i,t+1}$) to measure models 1 through 6C, examining whether empirical results vary accordingly.

Table 9, Model 1 demonstrates that the Environmental (E Score) dimension's influence on Tobin Q for the subsequent period ($TQ_{i,t+1}$) is represented by a coefficient of 0.004, with a p-value <0.01. Similarly, the Social (S Score) dimension has a coefficient of impact on $TQ_{i,t+1}$ of 0.004, also with a p-value <0.01, and the Governance (G Score) dimension exhibits a coefficient of 0.003, with a p-value <0.01. In Model 2, the TESG total score (TESG Score) shows an impact coefficient on $TQ_{i,t+1}$ of 0.011, significant at a p-value <0.01. Model 3 illustrates that ESG disclosure affects TQi,t+1 with a coefficient of 0.179, with a p-value <0.01. Model 4 reveals that the Environmental (E Score) dimension score negatively impacts the Return on Equity for the subsequent period ($ROE_{i,t+1}$) with a coefficient of -0.030, significant at a p-value <0.05. The Social (S Score) dimension score has a negative effect on $ROE_{i,t+1}$ with a coefficient of -0.063, p-value <0.01, while the Governance (G Score) dimension score positively affects $ROE_{i,t+1}$ with a coefficient of 0.059, with a p-value <0.01. Model 5 indicates that the TESG total score (TESG Score) negatively impacts $ROE_{i,t+1}$ with a coefficient of -0.023, with a p-value <0.1. Finally, Model 6 shows that ESG disclosure negatively affects $ROE_{i,t+1}$ with a significant coefficient of -0.803, with a p-value <0.05, aligning closely with the findings from previous Table 4.

Table 9 Sensitivity Analysis of the Impact of ESG Scores, TESG Total Scores, and ESG Disclosure on Firm Value and Financial Performance

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Variable	$TQ_{i,t+1}$	$TQ_{i,t+1}$	$TQ_{i,t+1}$	$ROE_{i,t+1}$	$ROE_{i,t+1}$	$ROE_{i,t+1}$
Intercept	2.215***	2.153***	2.542***	-27.066***	-23.952***	-25.731***
	(15.239)	(15.553)	(16.241)	(-15.286)	(-14.186)	(-13.105)
E Score	0.004***			-0.030**		
	(3.222)			(-2.035)		
S Score	0.004***			-0.063***		
	(3.279)			(-3.912)		
G Score	0.003***			0.059***		
	(2.594)			(4.443)		
TESG Score		0.011***			-0.023*	
		(9.523)			(-1.655)	
ESGD			0.179***			-0.803**
			(5.566)			(-2.053)
SIZE	-0.027***	-0.022**	-0.014	3.363***	3.151***	3.211***
	(-2.581)	(-2.228)	(-1.341)	(26.646)	(25.991)	(24.587)
AGE	-0.016***	-0.016***	-0.015***	-0.150***	-0.156***	-0.158***
	(-15.1179)	(-15.109)	(-14.374)	(-11.777)	(-12.319)	(-12.493)
LEV	-0.011***	-0.011***	-0.012***	-0.165***	-0.165***	-0.165
	(-15.763)	(-15.747)	(-16.266)	(-18.807)	(-18.845)	(-18.890)
DUAL	-0.020	-0.013	-0.015	-0.089	-0.476	-0.478
	(-0.797)	(-0.545)	(-0.624)	(-0.289)	(-1.59)	(-1.596)
RD	0.001***	0.001***	0.001***	-0.010***	-0.010***	-0.010***
	(12.442)	(12.428)	(12.181)	(-14.796)	(-14.822)	(-14.792)
Industry Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.142	0.142	0.138	0.118	0.116	0.116
F-Statistic	46.48	48.454	46.914	37.799	38.63	38.667
Observations	12,920	12,920	12,920	12,920	12,920	12,920

Note 1 : TQ is Tobin Q ratio; ROE is return on equity; E Score is environmental aspect score; S Score is social aspect score; G Score is governance aspect score; TESG Score is environmental, social and governance three aspect score; ESGD is ESG disclosure, companies with disclosures are 1 , and the rest are 0; SIZE is the company size; AGE is the age of the company; LEV is the debt ratio; DUAL is the chairman and CEO dual roles; RD is the R&D expenditure rate.

Note 2: * * *, * * and * represent respectively 1%, 5% and 10% significance levels.

Source: Compiled from TEJ and this study

Table 10, Model 1A indicates that the Environmental (E Score) dimension's influence on Tobin Q for the subsequent period ($TQ_{i,t+1}$) is reflected by a coefficient of 0.004, with a p-value <0.01. Similarly, the Social (S Score) dimension shows a coefficient of impact on $TQ_{i,t+1}$ of 0.004, at a p-value <0.01, and the Governance (G Score) dimension has a coefficient of 0.003, with a p-value <0.01. Model 2A demonstrates that the TESG total score (TESG Score) impacts $TQ_{i,t+1}$ with a coefficient of 0.011, with a p-value <0.01. Model 3A shows that ESG disclosure affects $TQ_{i,t+1}$ with a coefficient of 0.178, at a p-value <0.01. Model 4A reveals that the Environmental (E Score) dimension negatively impacts the Return on Equity for the subsequent period ($ROE_{i,t+1}$) with a coefficient of -0.030, with a p-value <0.05. The Social (S Score) dimension negatively affects $ROE_{i,t+1}$ with a coefficient of -0.063, with a p-value <0.01, and the Governance (G Score) dimension positively impacts $ROE_{i,t+1}$ with a coefficient of 0.059, at a p-value <0.01. Model 5A indicates that the TESG total score (TESG Score) impacts $ROE_{i,t+1}$ with a negative coefficient of -0.023, with a p-value <0.05. Finally, Model 6A shows that ESG disclosure negatively affects $ROE_{i,t+1}$ with a coefficient of -0.805, with a p-value <0.05, aligning closely with the findings from previous Table 5.

Table 11, Model 1B demonstrates that the Environmental (E Score) dimension's influence on Tobin Q for the subsequent period ($TQ_{i,t+1}$) is reflected by a coefficient of 0.004, with a p-value <0.01. Similarly, the Social (S Score) dimension shows a coefficient of impact on $TQ_{i,t+1}$ of 0.004, also significant at a p-value <0.01, while the Governance (G Score) dimension has a coefficient of 0.003, at a p-value <0.05. Model 2B indicates that the TESG total score (TESG Score) affects $TQ_{i,t+1}$ with a coefficient of 0.011, with a p-value <0.01. Model 3B shows that ESG disclosure impacts $TQ_{i,t+1}$ with a coefficient of 0.179, at a p-value <0.01. Model 4B reveals that the Environmental (E Score) dimension negatively impacts the Return on Equity for the subsequent period ($ROE_{i,t+1}$) with a coefficient of -0.025, with a p-value <0.05. The Social (S Score) dimension negatively affects $ROE_{i,t+1}$ with a coefficient of -0.063, with a p-value <0.01, and the Governance (G Score) dimension positively impacts $ROE_{i,t+1}$ with a coefficient of 0.057, at a p-value <0.01. Model 5B indicates that the TESG total score (TESG Score) impacts $ROE_{i,t+1}$ with a negative coefficient of -0.020. Finally, Model 6B shows that ESG disclosure negatively affects $ROE_{i,t+1}$ with a coefficient of -0.710, with a p-value <0.05, aligning closely with the findings from previous Table 6.

Table 10 Sensitivity Analysis of the Impact of ESG Scores, TESG Total Scores, and ESG Disclosure on Firm Value and Financial Performance after Adding Green Financial Factors

	Model 1A	Model 2A	Model 3A	Model 4A	Model 5A	Model 6A
Variable	$TQ_{i,t+1}$	$TQ_{i,t+1}$	$TQ_{i,t+1}$	$ROE_{i,t+1}$	$ROE_{i,t+1}$	$ROE_{i,t+1}$
Intercept	2.269***	2.209***	2.595***	-26.954***	-23.855***	-25.632***
	(15.485)	(15.804)	(16.459)	(-15.091)	(-13.984)	(-13.356)
E Score	0.004***			-0.030**		
	(3.301)			(-2.021)		
S Score	0.004***			-0.063***		
	(3.191)			(-3.925)		
G Score	0.003***			0.059***		
	(2.621)			(4.447)		
TESG Score		0.011***			-0.023**	
		(9.538)			(-1.653)	
ESGD			0.178***			-0.805**
			(5.543)			(-2.057)
GB	0.507***	0.506***	0.490***	1.029	0.868	0.924
	(2.849)	(2.844)	(2.746)	(0.474)	(0.400)	(0.425)
SIZE	-0.031***	-0.026***	-0.018**	3.355***	3.144***	3.204***
	(-2.924)	(-2.596)	(-1.663)	(26.367)	(25.693)	(24.356)
AGE	-0.016***	-0.016***	-0.015***	-0.150***	-0.156***	-0.158***
	(-15.213)	(-15.145)	(-14.408)	(-11.781)	(-12.322)	(-12.496)
LEV	-0.011***	-0.011***	-0.012***	-0.165***	-0.165***	-0.165***
	(-15.716)	(-15.695)	(-16.219)	(-18.795)	(-18.833)	(-18.879)
DUAL	-0.020	-0.014	-0.016	-0.089	-0.476	-0.478
	(-0.798)	(-0.553)	(-0.633)	(-0.289)	(-1.591)	(-1.597)
RD	0.001***	0.001***	0.001***	-0.010***	-0.010***	-0.010***
	(12.439)	(12.423)	(12.175)	(-14.797)	(-14.822)	(-14.793)
Industry Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.142	0.142	0.138	0.118	0.116	0.116
F-Statistic	45.706	47.603	46.081	37.014	37.791	37.828
Observations	12,920	12,920	12,920	12,920	12,920	12,920

Note 1 : TQ is Tobin Q ratio; ROE is return on equity; E Score is environmental aspect score; S Score is social aspect score; G Score is governance aspect score; TESG Score is environmental, social and governance three aspect score; ESGD is ESG disclosure, companies with disclosures are 1 , and the rest are 0 ;GB is a green bond issuance, and the companies that have issued it are 1 , the rest are 0; SIZE is the company size; AGE is the age of the company; LEV is the debt ratio; DUAL is the chairman and CEO dual roles; RD is the R&D expenditure rate.

Note 2: * * *, * * and * represent respectively 1%, 5% and 10% significance levels.

Source: Compiled from TEJ and this study

Table 11 Sensitivity Analysis of the Impact of ESG Scores, TESG Total Scores, and ESG Disclosure on Firm Value and Financial Performance after Adding Green Economy Factors

	Model 1B	Model 2B	Model 3B	Model 4B	Model 5B	Model 6B
Variable	$TQ_{i,t+1}$	$TQ_{i,t+1}$	$TQ_{i,t+1}$	$ROE_{i,t+1}$	$ROE_{i,t+1}$	$ROE_{i,t+1}$
Intercept	2.213***	2.153***	2.543***	-28.074***	-25.134***	-26.703***
	(15.146)	(15.437)	(16.185)	(-15.786)	(-14.792)	(-13.980)
E Score	0.004***			-0.025**		
	(3.221)			(-1.713)		
S Score	0.004***			-0.063***		
	(3.279)			(-3.884)		
G Score	0.003**			0.057***		
	(2.590)			(4.281)		
TESG Score		0.011***			-0.020	
		(9.516)			(-1.450)	
ESGD			0.179***			-0.710**
			(5.556)			(-1.817)
GEC	-0.005	0.000	0.007	-3.576***	-3.735***	-3.720***
	(-0.086)	(0.008)	(0.122)	(-5.438)	(-5.684)	(-5.659)
SIZE	-0.027***	-0.022**	-0.014	3.414***	3.212***	3.266***
	(-2.568)	(-2.220)	(-1.346)	(27.004)	(26.427)	(24.970)
AGE	-0.016***	-0.016***	-0.015***	-0.146***	-0.152***	-0.154***
	(-15.154)	(-15.086)	(-14.356)	(-10.323)	(-12.001)	(-12.154)
LEV	-0.011***	-0.011***	-0.012***	-0.162***	-0.162***	-0.162***
	(-15.728)	(-15.715)	(-16.240)	(-18.462)	(-18.471)	(-18.517)
DUAL	-0.020	-0.013	-0.015	-0.130	-0.501**	-0.503**
	(-0.799)	(-0.545)	(-0.622)	(-0.426)	(-1.677)	(-1.683)
RD	0.001***	0.001***	0.001***	-0.010***	-0.010***	-0.010***
	(12.442)	(12.427)	(12.179)	(-14.756)	(-14.783)	(-14.758)
Industry Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.142	0.142	0.138	0.120	0.118	0.118
F-Statistic	45.508	47.397	45.891	37.710	38.585	38.614
Observations	12,920	12,920	12,920	12,920	12,920	12,920

Note 1: TQ is Tobin Q ratio; ROE is return on equity; E Score is environmental aspect score; S Score is social aspect score; G Score is governance aspect score; TESG Score is environmental, social and governance three aspect score; ESGD is ESG disclosure, companies with disclosures are 1, and the rest are 0; GEC is a company that has developed green energy. The number of companies that have developed green energy is 1, and the rest are 0; SIZE is the company size; AGE is the age of the company; LEV is the debt ratio; DUAL is the chairman and CEO dual roles; RD is the R&D expenditure rate.

Note 2: * * *, * * and * represent respectively 1%, 5% and 10% significance levels.

Source: Compiled from TEJ and this study

Table 12, Model 1C indicates that the Environmental (E Score) dimension's influence on Tobin Q for the subsequent period ($TQ_{i,t+1}$) is represented by a coefficient of 0.004, with a p-value <0.01. Similarly, the Social (S Score) dimension shows a coefficient of impact on $TQ_{i,t+1}$ of 0.004, at a p-value <0.01, and the Governance (G Score) dimension has a coefficient of 0.003, with a p-value <0.01. Model 2C demonstrates that the TESG total score (TESG Score) affects $TQ_{i,t+1}$ with a coefficient of 0.011, with a p-value <0.01. Model 3C shows that ESG disclosure impacts $TQ_{i,t+1}$ with a coefficient of 0.178, at a p-value <0.01. Model 4C reveals that the Environmental (E Score) dimension negatively impacts the Return on Equity for the subsequent period ($ROE_{i,t+1}$) with a coefficient of -0.025, with a p-value <0.05. The Social (S Score) dimension negatively affects $ROE_{i,t+1}$ with a coefficient of -0.063, with a p-value <0.01, and the Governance (G Score) dimension positively impacts $ROE_{i,t+1}$ with a coefficient of 0.057, significant at a p-value <0.01. Model 5C indicates that the TESG total score (TESG Score) impacts $ROE_{i,t+1}$ with a negative coefficient of -0.020. Finally, Model 6C shows that ESG disclosure negatively affects $ROE_{i,t+1}$ with a coefficient of -0.712, significant with a p-value <0.05, aligning closely with the findings from previous Table 7.

Table 12 Sensitivity Analysis of the Impact of ESG Scores, TESG Total Scores, and ESG Disclosure on Firm Value and Financial Performance after Adding Green Finance and Green Economy Factors

	Model 1C	Model 2C	Model 3C	Model 4C	Model 5C	Model 6C
Variable	$TQ_{i,t+1}$	$TQ_{i,t+1}$	$TQ_{i,t+1}$	$ROE_{i,t+1}$	$ROE_{i,t+1}$	$ROE_{i,t+1}$
Intercept	2.268***	2.209***	2.596***	-27.955***	-25.029***	-26.597***
	(15.392)	(15.688)	(16.403)	(-15.585)	(-12.734)	(-13.821)
E Score	0.004***			-0.025**		
	(3.301)			(-1.698)		
S Score	0.004***			-0.063***		
	(3.191)			(-3.897)		
G Score	0.003***			0.057***		
	(2.616)			(4.285)		
TESG Score		0.011***			-0.020	
		(9.531)			(-1.448)	
ESGD			0.178***			-0.712**
			(5.533)			(-1.821)
GB	0.508***	0.506***	0.490***	1.107	0.940	0.989
	(2.850)	(2.844)	(2.745)	(1.510)	(0.433)	(0.456)
GEC	-0.006	0.000	0.006	-3.579***	-3.737***	-3.721***
	(-0.105)	(-0.009)	(0.107)	(-5.441)	(-5.686)	(-5.661)
SIZE	-0.030***	-0.026***	-0.018***	3.406***	3.205***	3.259***
	(-2.909)	(-2.585)	(-1.666)	(26.721)	(26.123)	(24.735)
AGE	-0.016***	-0.016***	-0.015***	-0.146***	-0.152***	-0.154***
	(-15.188)	(-15.121)	(-14.389)	(-11.505)	(-12.005)	(-12.158)
LEV	-0.011***	-0.011***	-0.012***	-0.162***	-0.162***	-0.162***
	(-15.679)	(-15.662)	(-16.193)	(-18.450)	(-18.458)	(-18.505)
DUAL	-0.020	-0.014	-0.016	-0.130	-0.502**	-0.504**
	(-0.800)	(-0.553)	(-0.631)	(-0.426)	(-1.679)	(-1.685)
RD	0.001***	0.001***	0.001***	-0.010***	-0.010***	-0.010***
	(12.439)	(12.422)	(12.173)	(-14.757)	(-14.784)	(-14.759)
Industry Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.142	0.142	0.138	0.120	0.118	0.118
F-Statistic	44.770	46.586	45.098	36.943	37.765	37.795
Observations	12,920	12,920	12,920	12,920	12,920	12,920

Note 1: TQ is Tobin Q ratio; ROE is return on equity; E Score is environmental aspect score; S Score is social aspect score; G Score is governance aspect score; TESG Score is environmental, social and governance three aspect score.; ESGD is ESG disclosure, companies with disclosures are 1 , and the rest are 0 ;GB is a green bond issuance, and the companies that have issued it are 1 , the rest are 0; GEC is a company that has developed green energy. The number of companies that have developed green energy is 1, and the rest are 0; SIZE is the company size; AGE is the age of the company; LEV is the debt ratio; DUAL is the chairman and CEO dual roles; RD is the R&D expenditure rate.

Note 2: * * *, * * and * represent respectively 1%, 5% and 10% significance levels.

Source: Compiled from TEJ and this study

5.2 Robustness Analysis to Exclude Outliers

In statistical analysis, outliers can adversely affect results, distorting metrics such as mean and standard deviation. Therefore, to ensure the accuracy and reliability of the analysis, this study employed statistical methods and visualization techniques to identify and address outliers within the dataset.

This research utilized the TESG Sustainability Index, established from 2015 to 2022 by TEJ, focusing on listed companies in Taiwan. Initially, the study obtained 13,415 samples. After excluding samples from the financial, insurance, and securities sectors, as well as incomplete samples, the final dataset comprised 12,920 observations over an eight-year period, with data frequency on an annual basis. Examination of the descriptive statistics table in Table 9 revealed extreme values, such as a minimum Return on Equity (ROE) of -99.79 and a maximum Research and Development expenditure rate (RD) of 9085.56. After review, the study addressed 114 outliers in ROE and 41 outliers in RD, ensuring the overall analysis's robustness. Post-outlier treatment, the sample size was reduced from 12,920 to 12,765 observations. The sample selection process is detailed further in Table 13.

Table 13 Sample Screening Status Table to Exclude Outliers

Sample data (2015 to 2022)	Number of Observations
Original data: Total number of samples of listed companies	12,920
Delete: ROE outliers	(114)
Delete: RD outliers	(41)
Number of observations after filtering	12,765

Source: Compiled by this study.

Through conducting robustness analyses, one can more accurately understand the data and derive reliable statistical conclusions, thereby enhancing the credibility and reliability of the analysis.

Table 14, Model 1 shows that the coefficient of the Environmental (E Score) dimension on Tobin Q (TQ) is 0.005, with a p-value <0.01. The Social (S Score) dimension's impact on TQ is represented by a coefficient of 0.007, with a p-value <0.01, while the Governance (G Score) dimension has a coefficient of 0.002, also with a p-value <0.05. Model 2 indicates that the TESG total score (TESG Score) has an impact coefficient on TQ of 0.014, with a p-value <0.01. Model 3 demonstrates that ESG disclosure (ESGD) affects TQ with a coefficient of 0.180, significant at a p-value <0.01. Model 4 reveals that the Environmental (E Score)

dimension negatively impacts return on equity (ROE) with a coefficient of -0.006. The Social (S Score) dimension significantly impacts ROE negatively, with a coefficient of -0.078 and a p-value <0.01. The Governance (G Score) dimension impacts ROE with a coefficient of 0.019. Model 5 shows that the TESG total score (TESG Score) has a negative impact on ROE, with a coefficient of -0.057 and a p-value <0.01. Finally, Model 6 demonstrates that ESG disclosure (ESGD) negatively affects ROE with a coefficient of -0.043, aligning closely with the findings from Table 4.

Table 14 Robustness Analysis of the Impact of ESG Scores, TESG Total Scores, and ESG Disclosure on Firm Value and Financial Performance

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Variable	**TQ**	**TQ**	**TQ**	**ROE**	**ROE**	**ROE**
Intercept	2.216***	2.075***	2.467***	-16.073***	-13.942***	-13.956***
	(16.629)	(16.356)	(17.128)	(-9.975)	(-9.085)	(-8.045)
E Score	0.005***			-0.006		
	(4.239)			(-0.446)		
S Score	0.007***			-0.078***		
	(5.864)			(-5.368)		
G Score	0.002**			0.019		
	(2.315)			(1.560)		
TESG Score		0.014***			-0.057***	
		(13.093)			(-4.541)	
ESGD			0.180***			-0.043
			(6.152)			(-0.121)
SIZE	-0.063***	-0.053***	-0.036***	2.489***	2.341***	2.136***
	(-6.631)	(-5.841)	(-3.609)	(21.608)	(21.182)	(17.901)
AGE	-0.015***	-0.014***	-0.014***	-0.146***	-0.150***	-0.152***
	(-15.516)	(-15.279)	(-14.334)	(-12.691)	(-13.064)	(-13.278)
LEV	-0.010***	-0.010***	-0.011***	-0.101***	-0.101***	-0.096***
	(-15.280)	(-15.271)	(-16.091)	(-12.549)	(-12.466)	(-11.959)
DUAL	0.016	0.032	0.028	-0.740***	-0.977***	-0.954***
	(0.701)	(1.418)	(1.267)	(-2.672)	(-3.616)	(-3.526)
RD	0.002***	0.002***	0.002***	-0.060***	-0.060***	-0.060***
	(6.698)	(6.711)	(6.539)	(-14.932)	(-15.016)	(-14.928)
Industry Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.151	0.148	0.139	0.106	0.104	0.103
F-Statistic	48.290	50.081	46.633	33.034	33.929	33.417
Observations	12,765	12,765	12,765	12,765	12,765	12,765

Note 1 : TQ is Tobin Q ratio; ROE is return on equity; E Score is environmental aspect score; S Score is social aspect score; G Score is governance aspect score; TESG Score is environmental, social and governance three aspect score; ESGD is ESG disclosure, companies with disclosures are 1 , and the rest are 0; SIZE is the company size; AGE is the age of the company; LEV is the debt ratio; DUAL is the chairman and CEO dual roles; RD is the R&D expenditure rate.

Note 2: * * *, * * and * represent respectively 1%, 5% and 10% significance levels.

Source: Compiled from TEJ and this study

Table 15 examines the impact of green finance factors on six models. Model 1A shows that the coefficient of the Environmental (E Score) dimension on Tobin Q (TQ) is 0.005, with a p-value <0.01. The Social (S Score) dimension's impact on TQ has a coefficient of 0.007, with a p-value <0.01, while the Governance (G Score) dimension has a coefficient of 0.002, with a p-value <0.05. Model 2A indicates that the TESG total score (TESG Score) has an impact coefficient on TQ of 0.014, with a p-value <0.01. Model 3A demonstrates that ESG Disclosure (ESGD) affects TQ with a coefficient of 0.180, significant at a p-value <0.01. Model 4A reveals that the Environmental (E Score) dimension negatively impacts Return on Equity (ROE) with a coefficient of -0.005. The Social (S Score) dimension significantly impacts ROE negatively, with a coefficient of -0.079 and a p-value <0.01. The Governance (G Score) dimension impacts ROE with a coefficient of 0.019. Model 5A shows that the TESG total score (TESG Score) negatively impacts ROE, with a coefficient of -0.057 and a p-value <0.01. Model 6A demonstrates that ESG Disclosure (ESGD) negatively affects ROE with a coefficient of -0.049, aligning closely with the findings from Table 5.

Table 16 examines the impact of green economy factors on six models. Model 1B shows that the coefficient of the Environmental (E Score) dimension on Tobin Q (TQ) is 0.005, with a p-value <0.01. The Social (S Score) dimension's impact on TQ has a coefficient of 0.007, with a p-value <0.01, while the Governance (G Score) dimension has a coefficient of 0.002, with a p-value <0.05. Model 2B indicates that the TESG total score (TESG Score) has an impact coefficient on TQ of 0.014, with a p-value <0.01. Model 3B demonstrates that ESG disclosure (ESGD) affects TQ with a coefficient of 0.180, significant at a p-value <0.01. Model 4B reveals that the Environmental (E Score) dimension negatively impacts return on equity (ROE) with a coefficient of -0.002. The Social (S Score) dimension significantly impacts ROE negatively, with a coefficient of -0.078 and a p-value <0.01. The Governance (G Score) dimension impacts ROE with a coefficient of 0.017. Model 5B shows that the TESG total score (TESG Score) negatively impacts ROE, with a coefficient of -0.054 and a p-value <0.01. Model 6B demonstrates that ESG disclosure (ESGD) negatively affects ROE with a coefficient of -0.039, aligning closely with the findings from Table 6.

Table 15 Robustness Analysis of the Impact of ESG Scores, TESG Total Scores, and ESG Disclosure on Firm Value and Financial Performance after Adding Green Financial Factors

	Model 1A	Model 2A	Model 3A	Model 4A	Model 5A	Model 6A
Variable	TQ	TQ	TQ	ROE	ROE	ROE
Intercept	2.275***	2.137***	2.525***	-15.560***	-13.439***	-13.463***
	(16.932)	(16.678)	(17.405)	(-9.573)	(-8.668)	(-7.703)
E Score	0.005***			-0.005		
	(4.333)			(-0.379)		
S Score	0.007***			-0.079***		
	(5.761)			(-5.440)		
G Score	0.002**			0.019		
	(2.346)			(1.582)		
TESG Score		0.014***			-0.057***	
		(13.114)			(-4.531)	
ESGD			0.180***			-0.049
			(6.128)			(-0.140)
GB	0.539***	0.544***	0.526***	4.647**	4.416***	4.458**
	(3.346)	(3.377)	(3.250)	(2.385)	(2.265)	(2.285)
SIZE	-0.067***	-0.058***	-0.040***	2.453***	2.307***	2.103***
	(-7.008)	(-6.252)	(-3.979)	(21.128)	(20.674)	(17.493)
AGE	-0.015***	-0.015***	-0.014***	-0.146***	-0.150***	-0.153***
	(-15.557)	(-15.323)	(-14.376)	(-12.718)	(-13.091)	(-13.306)
LEV	-0.010***	-0.010***	-0.011***	-0.101***	-0.100***	-0.096***
	(-15.221)	(-15.207)	(-16.033)	(-12.505)	(-12.420)	(-11.916)
DUAL	0.016	0.031	0.028	-0.740***	-0.979***	-0.955***
	(0.699)	(1.408)	(1.257)	(-2.674)	(-3.623)	(-3.534)
RD	0.002***	0.002***	0.002***	-0.060***	-0.060***	-0.060***
	(6.703)	(6.713)	(6.540)	(-14.933)	(-15.019)	(-14.931)
Industry Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.149	0.148	0.139	0.106	0.104	0.103
F-Statistic	47.555	49.281	45.844	32.477	33.314	32.815
Observations	12,765	12,765	12,765	12,765	12,765	12,765

Note 1 : TQ is Tobin Q ratio; ROE is return on equity; E Score is environmental aspect score; S Score is social aspect score; G Score is governance aspect score; TESG Score is environmental, social and governance three aspect score. ; ESGD is ESG disclosure, companies with disclosures are 1 , and the rest are 0 ;GB is a green bond issuance, and the companies that have issued it are 1 , the rest are 0; SIZE is the company size; AGE is the age of the company; LEV is the debt ratio; DUAL is the chairman and CEO dual roles; RD is the R&D expenditure rate.

Note 2: * * *, * * and * represent respectively 1%, 5% and 10% significance levels.

Source: Compiled from TEJ and this study.

Table 16 Robustness Analysis of the Impact of ESG Scores, TESG Total Scores, and ESG Disclosure on Firm Value and Financial Performance after Adding Green Economy Factors

	Model 1B	Model 2B	Model 3B	Model 4B	Model 5B	Model 6B
Variable	**TQ**	**TQ**	**TQ**	**ROE**	**ROE**	**ROE**
Intercept	2.222***	2.084***	2.477***	-16.966***	-14.963***	-14.824***
	(16.582)	(16.304)	(17.130)	(-10.483)	(-9.688)	(-8.521)
E Score	0.005***			-0.002		
	(4.207)			(-0.133)		
S Score	0.007***			-0.078***		
	(5.862)			(-5.344)		
G Score	0.002**			0.017		
	(2.326)			(1.402)		
TESG Score		0.014***			-0.054***	
		(13.063)			(-4.348)	
ESGD			0.180***			-0.039
			(6.114)			(-0.111)
GEC	0.020	0.028	0.039	-3.154***	-3.209***	-3.304***
	(0.415)	(0.580)	(0.789)	(-5.311)	(-5.409)	(-5.565)
SIZE	-0.063***	-0.054***	-0.036***	2.534***	2.395***	2.186***
	(-6.643)	(-5.869)	(-3.658)	(21.966)	(21.606)	(18.288)
AGE	-0.015***	-0.015***	-0.014***	-0.143***	-0.147***	-0.149***
	(-15.517)	(-15.287)	(-14.355)	(-12.423)	(-12.764)	(-12.949)
LEV	-0.010***	-0.010***	-0.011***	-0.099***	-0.098***	-0.094***
	(-15.278)	(-15.278)	(-16.109)	(-12.232)	(-12.132)	(-11.615)
DUAL	0.016	0.032	0.029	-0.777***	-1.000***	-0.977***
	(0.712)	(1.426)	(1.279)	(-2.809)	(-3.704)	(-3.616)
RD	0.002***	0.002***	0.002***	-0.060***	-0.060***	-0.060***
	(6.697)	(6.710)	(6.537)	(-14.983)	(-15.026)	(-14.938)
Industry Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.148	0.147	0.139	0.107	0.106	0.105
F-Statistic	47.285	48.997	45.632	33.003	33.901	33.441
Observations	12,765	12,765	12,765	12,765	12,765	12,765

Note 1: TQ is Tobin Q ratio; ROE is return on equity; E Score is environmental aspect score; S Score is social aspect score; G Score is governance aspect score; TESG Score is environmental, social and governance three aspect score.; ESGD is ESG disclosure, companies with disclosures are 1, and the rest are 0; GEC is a company that has developed green energy. The number of companies that have developed green energy is 1, and the rest are 0; SIZE is the company size; AGE is the age of the company; LEV is the debt ratio; DUAL is the chairman and CEO dual roles; RD is the R&D expenditure rate.

Note 2: * * *, * * and * represent respectively 1%, 5% and 10% significance levels.

Source: Compiled from TEJ and this study

Table 17 explores the effects of integrating green finance and green economy factors into six models. Model 1C reveals that the Environmental (E Score) dimension impacts Tobin Q (TQ) with a coefficient of 0.005, p-value <0.01. The Social (S Score) dimension shows a coefficient of 0.007, p-value <0.01, and the Governance (G Score) dimension has a coefficient of 0.002, p-value <0.05 on TQ. Model 2C indicates that the TESG total score (TESG Score) impacts TQ with a coefficient of 0.014, p-value <0.01. Model 3C demonstrates that ESG disclosure (ESGD) significantly affects TQ with a coefficient of 0.179, p-value <0.01. Model 4C shows that the Environmental (E Score) dimension has a minor negative impact on return on equity (ROE) with a coefficient of -0.001. The Social (S Score) dimension significantly impacts ROE negatively, with a coefficient of -0.079, p-value <0.01, and the Governance (G Score) dimension positively affects ROE with a coefficient of 0.017. Model 5C indicates that the TESG total score (TESG Score) negatively impacts ROE with a coefficient of -0.054, p-value <0.01. Model 6C reveals that ESG disclosure (ESGD) negatively affects ROE with a coefficient of -0.033, aligning closely with the findings from Table 7.

Table 17 Robustness Analysis of the Impact of ESG Scores, TESG Total Scores, and ESG Disclosure on Firm Value and Financial Performance after Adding Green Financial and Green Economy Factors

	Model 1C	Model 2C	Model 3C	Model 4C	Model 5C	Model 6C
Variable	**TQ**	**TQ**	**TQ**	**ROE**	**ROE**	**ROE**
Intercept	2.281***	2.146***	2.535***	-16.448***	-14.455***	-14.326***
	(16.883)	(16.624)	(17.405)	(-10.078)	(-9.266)	(-8.174)
E Score	0.005***			-0.001		
	(4.302)			(-0.064)		
S Score	0.007***			-0.079***		
	(5.759)			(-5.416)		
G Score	0.002**			0.017		
	(2.356)			(1.423)		
TESG Score		0.014***			-0.054***	
		(13.085)			(-4.338)	
ESGD			0.179***	3.619***		-0.033
			(6.090)	(1.672)		(-0.093)
GB	0.539***	0.544***	0.526***	4.716**	4.477**	4.516**
	(3.343)	(3.373)	(3.246)	(2.422)	(2.299)	(2.317)
GEC	0.019	0.028	0.038	-3.163***	-3.217***	-3.312***
	(0.393)	(0.561)	(0.772)	(-5.328)	(-5.423)	(-5.578)
SIZE	-0.068***	-0.058***	-0.040***	2.498***	2.360***	2.153***
	(-7.017)	(-6.277)	(-4.025)	(21.482)	(21.094)	(17.877)
AGE	-0.015***	-0.015***	-0.014***	-0.143***	-0.147***	-0.149***
	(-15.557)	(-15.330)	(-14.396)	(-12.450)	(-12.791)	(-12.976)
LEV	-0.010***	-0.010***	-0.011***	-0.098***	-0.098***	-0.093***
	(-15.218)	(-15.212)	(-16.050)	(-12.186)	(-12.084)	(-11.570)
DUAL	0.016	0.032	0.028	-0.778***	-1.002***	-0.979***
	(0.709)	(1.417)	(1.269)	(-2.812)	(-3.711)	(-3.624)
RD	0.002***	0.002***	0.002***	-0.060***	-0.060***	-0.060***
	(6.702)	(6.712)	(6.538)	(-14.939)	(-15.030)	(-14.942)
Industry Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.149	0.148	0.139	0.108	0.106	0.105
F-Statistic	46.585	48.236	44.919	32.462	33.304	32.855
Observations	12,765	12,765	12,765	12,765	12,765	12,765

Note 1: TQ is Tobin Q ratio; ROE is return on equity; E Score is environmental aspect score; S Score is social aspect score; G Score is governance aspect score; TESG Score is environmental, social and governance three aspect score; ESGD is ESG disclosure, companies with disclosures are 1 , and the rest are 0 ;GB is a green bond issuance, and the companies that have issued it are 1 , the rest are 0; GEC is a company that has developed green energy. The number of companies that have developed green energy is 1, and the rest are 0; SIZE is the company size; AGE is the age of the company; LEV is the debt ratio; DUAL is the chairman and CEO dual roles; RD is the R&D expenditure rate.

Note 2: * * *, * * and * represent respectively 1%, 5% and 10% significance levels.

Source: Compiled from TEJ and this study

Table 18 presents findings from five models examining the impact of carbon disclosure (CD) on various ESG metrics. Model 7 indicates that carbon disclosure (CD) has a substantial effect on the Environmental (E Score) dimension, with an impact coefficient of 8.993 and a p-value <0.01. Model 8 shows that carbon disclosure (CD) significantly influences the Social (S Score) dimension, with an impact coefficient of 6.527 and a p-value <0.01. Model 9 reveals that carbon disclosure (CD) affects the Governance (G Score) dimension, with an impact coefficient of 4.461 and a p-value <0.01. Model 10 demonstrates that carbon disclosure (CD) has a notable effect on the TESG total score (TESG Score), with an impact coefficient of 6.328 and a p-value <0.01. Model 11 indicates that carbon disclosure (CD) impacts ESG disclosure (ESGD) with an impact coefficient of 0.479 and a p-value <0.01. These results align closely with the findings from previous Table 8.

Table 18 presents the findings from five models examining the impact of highly educated (HE) on various ESG metrics. Model 7 indicates that highly educated (HE) significantly affects the Environmental (E Score) dimension, with an impact coefficient of 2.262 and a p-value <0.01. Model 8 shows that highly educated (HE) has a substantial influence on the Social (S Score) dimension, with an impact coefficient of 4.829 and a p-value <0.01. Model 9 reveals that highly educated (HE) impacts the Governance (G Score) dimension, with an impact coefficient of 1.192 and a p-value <0.01. Model 10 demonstrates that highly educated (HE) significantly affects the TESG total score (TESG Score), with an impact coefficient of 2.783 and a p-value <0.01. Model 11 indicates that highly educated (HE) influences ESG disclosure (ESGD) with an impact coefficient of 0.066 and a p-value <0.01. These results are consistent with the findings from previous Table 8.

Table 18 presents findings from five models examining the impact of Director Shareholding Ratio (DSR) on various ESG metrics. Model 7 shows that the director shareholding ratio (DSR) has a significant effect on the Environmental (E Score) dimension, with an impact coefficient of 0.135 and a p-value <0.01. Model 8 indicates that the director shareholding ratio (DSR) significantly influences the Social (S Score) dimension, with an impact coefficient of 0.145 and a p-value <0.01. Model 9 reveals that the director shareholding ratio (DSR) impacts the Governance (G Score) dimension, with an impact coefficient of 0.158 and a p-value <0.01. Model 10 demonstrates that the director shareholding ratio (DSR) significantly affects the TESG total score (TESG Score), with an impact coefficient of 0.144 and a p-value <0.01. Model 11 shows that the director shareholding ratio (DSR) has a minimal impact on ESG disclosure (ESGD) with an impact coefficient of 0.001 and a p-value <0.01. These results align closely with the findings from previous Table 8.

Table 18 Robustness Analysis of Carbon Disclosure (CD), Highly Educated (HE) and Director Shareholding Ratio (DSR) on E, S, G Score, TESG Total Score and ESG Disclosure

	Model 7	Model 8	Model 9	Model 10	Model 11
Variable	E Score	S Score	G Score	TESG Score	ESGD
Intercept	-9.521***	-15.199***	22.829***	1.520	-1.903***
	(-6.769)	(-11.917)	(15.760)	(1.340)	(-48.452)
CD	8.993***	6.527***	4.461***	6.328***	0.479***
	(21.789)	(17.439)	(10.505)	(19.011)	(41.582)
HE	2.262***	4.829***	1.192***	2.783***	0.066***
	(9.020)	(21.237)	(4.818)	(13.764)	(9.433)
DSR	0.135***	0.145***	0.158***	0.144***	0.001***
	(19.519)	(23.102)	(21.759)	(25.742)	(7.562)
SIZE	3.781***	3.997***	2.023***	3.136***	0.146***
	(40.877)	(47.657)	(21.183)	(42.049)	(56.334)
AGE	0.112***	0.115***	0.030**	0.079***	-0.001***
	(11.486)	(13.033)	(2.531)	(10.106)	(-2.803)
LEV	-0.042***	-0.070***	-0.076***	-0.066***	-0.002***
	(-6.224)	(-11.529)	(-11.193)	(-12.198)	(-10.276)
DUAL	1.633***	1.836***	-3.602***	-0.244	-0.010
	(7.194)	(8.917)	(-15.361)	(-1.333)	(-1.581)
RD	-0.011***	-0.003	-0.002**	-0.007**	0.000*
	(-3.243)	(-1.082)	(-2.473)	(-2.525)	(-1.758)
Industry Effect	Yes	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.287	0.345	0.139	0.294	0.488
F-Statistic	110.529	144.041	44.759	113.954	259.446
Observations	12,765	12,765	12,765	12,765	12,765

Note 1: E Score is the environmental aspect score; S Score is the social aspect score; G Score is the governance aspect score; TESG Score is the environmental, social and governance three aspect score; ESGD is ESG disclosure, companies with disclosures are 1, and the rest are 0 ;CD is carbon emission disclosure, and companies with disclosures are: 1, and the rest are 0; HE is the senior executives with a doctorate degree in the company, and there are the number of companies owned is 1 , and the rest are 0; DSR is the shareholding ratio of directors; SIZE is the company size; AGE is the age of the company; LEV is the debt ratio; DUAL is the chairman and CEO dual roles; RD is the R&D expenditure rate.

Note2: * * *, * * and * represent respectively 1 %, 5 % and 10 % significance levels.

Source: Compiled from TEJ and this study

5.3 Correlation Analysis of the Regression Model

To ensure that the variables used in this study were not affected by autocorrelation, the Durbin-Watson statistic was employed to estimate this relationship. Here are the results of the test:

The Durbin–Wu–Hausman test is a statistical hypothesis test used in econometrics, named after James Durbin, De-Min Wu, and Jerry A. Hausman. This test assesses the consistency of an estimator in comparison to an alternative estimator that is known to be less efficient but consistent. It helps evaluate whether a statistical model corresponds well with the data.

The Durbin-Watson statistic is a method used to detect the presence of autocorrelation in the residuals of a regression model. This statistic typically ranges between 0 and 4. A Durbin-Watson statistic close to 2 suggests that there is no first-order autocorrelation in the residuals. When the Durbin-Watson statistic approaches 0 or 4, it indicates strong positive or negative autocorrelation, respectively. In this study, the results from Hypotheses 1 through 11 indicate the absence of autocorrelation.

6. Conclusion

The conclusions of this study can be divided into two main aspects. Firstly, the investigation focused on the mediating role of green finance and green economy in ESG scoring and disclosures, particularly in terms of their impact on market-based performance, as measured by Tobin Q, and financial performance, as reflected in Return on Equity. Secondly, the study delved deeper into the effects of carbon disclosure, top talent, and board characteristics on individual ESG scores, the TESG total score, and disclosures.

Through comprehensive exploration, this research provides deeper insights into the mechanisms through which ESG sustainability influences market and financial performance, offering empirical support for the decision-making processes of relevant stakeholders.

6.1 The Impact of Green Finance and Green Economy on ESG Scores, TESG Total Score, and ESG Disclosure on Tobin Q and Return on Equity

This study explores the mediating role of green bond issuances and the development of green energy companies on the environmental, social, and governance (ESG) scores, TESG

total score (TESG), and disclosure transparency in influencing market value (Tobin Q ratio) and financial performance (ROE). Empirical results indicate that the issuance of green bonds and the development of green energy companies positively impact individual ESG scores, the TESG total, and disclosure transparency, which significantly enhances the Tobin Q of firm value. This suggests that the market assigns a higher valuation to firms that implement proactive sustainability policies and maintain high transparency.

However, regarding financial performance as measured by ROE, enhancements in environmental scores, social scores, TESG total scores, and disclosure transparency had a negative impact, except for the governance scores. This reflects that environmental and social investments require substantial capital expenditures in the initial stages, which may not translate into immediate financial returns in the short term, potentially depressing ROE performance.

These findings highlight the importance of green bonds and the development of green energy companies. They serve not only as effective tools for promoting corporate ESG performance but also provide investors with new perspectives to assess long-term value and risk. Green financial instruments and sustainable economic models contribute to the potential benefits of enhancing corporate market valuation while emphasizing the critical role of transparency in strengthening these relationships. Additionally, this underscores that companies need to balance the short-term and long-term financial impacts when advancing environmental and social objectives, as well as how to optimize financial performance through improved governance practices.

6.2 The Impact of Carbon Disclosure, Top Talent, and Board Characteristics on ESG Scores, TESG Total Score, and ESG Disclosure

The impact of carbon disclosure on environmental, social, and governance (ESG) assessments, particularly focusing on its effects on individual ESG scores, TESG total Score (TESG), and ESG disclosure levels, is significant. Empirical analysis demonstrates that transparent carbon disclosure has a markedly positive impact on ESG ratings, with a particularly significant effect on environmental scores. This finding underscores the pivotal role of carbon disclosure in assessing environmental performance. When companies proactively disclose detailed information about their carbon emissions, they not only enhance

transparency in the environmental dimension but also strengthen external understanding and trust in their environmental commitments and practices. Such transparency not only helps companies establish a green image in the market but also aids in attracting shareholders and investors who value sustainable investments. Furthermore, proactive actions in carbon disclosure elevate the TESG total and the quality of overall ESG disclosures, reflecting a company's maturity in comprehensive ESG performance management. Through comprehensive and transparent information disclosure, companies can more effectively communicate their strategies and achievements in addressing climate change challenges to stakeholders, thereby enhancing their overall ESG evaluation.

The impact of highly educated on environmental, social, and governance (ESG) ratings, including individual ESG scores, TESG total score (TESG), and ESG disclosure is substantial. Empirical results demonstrate that highly educated significantly enhances these indicators, with a particularly notable effect on social scores. This finding highlights the crucial role of highly educated in advancing corporate social responsibility and social performance. highly educated typically possesses strong strategic thinking, innovative capabilities, and leadership skills, which enable them to promote effective social practices within the company, such as improving employee benefits, fostering diversity and inclusivity in the workplace, and enhancing community engagement and support. These activities not only bolster the company's social image but also materially improve the corporate ESG rating on social dimensions. Additionally, the presence of highly educated also enhances the overall level of ESG disclosure, leading to superior performance in transparency and accountability reporting. Through comprehensive and detailed ESG reporting, companies can more effectively communicate with external stakeholders about their efforts and achievements in environmental protection, social responsibility, and governance structure.

The influence of director shareholding ratio on environmental, social, and governance (ESG) indicators, encompassing individual ESG scores, TESG total Score (TESG), and ESG disclosure, reveals significant findings. Empirical results demonstrate a notable positive impact of director shareholding ratios on these indices, with the strongest effect observed on governance scores. This outcome underscores the close link between director shareholdings and the quality of corporate governance. When directors hold a higher proportion of company shares, their interests align more closely with those of shareholders, thereby motivating directors to focus more on the company's long-term development and value creation. Such an

equity structure facilitates transparent decision-making and responsible governance practices, enhancing the company's governance scores.

Additionally, a high shareholding ratio by directors also promotes overall attention to and improvement in ESG performance and disclosure quality. This indicates that directors continually monitor the company's ESG strategies and performance and push for increased transparency to ensure all stakeholders are well informed about the company's efforts and achievements in ESG aspects. Therefore, the director shareholding ratio is not only a crucial indicator for assessing corporate governance quality but also a key driver for continual improvement in corporate ESG performance. This finding provides new insights into how corporate governance structures influence ESG performance and offers a robust basis for companies to formulate related policies.

In summary, companies with higher ESG scores and robust ESG disclosures generally possess better firm value. These companies are also more active in green finance investments and green economic activities, demonstrating their commitment to sustainable development. Additionally, these companies exhibit higher levels of carbon disclosure and transparency, which helps enhance their market reputation and investor confidence. The research also shows that companies with top talent and diverse boards are more likely to have high ESG ratings, highlighting the crucial role of sound governance structures and talent strategies in enhancing ESG performance.

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