박사학위논문

Three Essays on ESG and Corporate Management

- ESG Evaluation, TCFD, and CEO Non-Duality -

2023년

한 성 대 학 교 대 학 원

지식서비스&컨설팅학과

매니지먼트컨설팅전공

조 찬 희

박 사 학 위 논 문
지도교수 이형용

Three Essays on ESG and Corporate Management

- ESG Evaluation, TCFD, and CEO Non-Duality -

ESG와 기업경영에 관한 세 가지 소논문

2023년 6월 일

한 성 대 학 교 대 학 원

지식서비스&컨설팅학과

매니지먼트컨설팅전공

조 찬 희

박 사 학 위 논 문
지도교수 이형용

Three Essays on ESG and Corporate Management

- ESG Evaluation, TCFD, and CEO Non-Duality -

ESG와 기업경영에 관한 세 가지 소논문

위 논문을 컨설팅학 박사학위 논문으로 제출함

2023년 6월 일

한 성 대 학 교 대 학 원

지식서비스&컨설팅학과

매니지먼트컨설팅전공

조 찬 희

조찬희의 컨설팅학 박사학위 논문을 인준함

2023년 6월 일

심사위원장 엄 윤 성 (인)

심 사 위 원 장 우 진 (인)

심 사 위 원 안 현 철 (인)

심 사 위 원 하 성 욱 (인)

심 사 위 원 이 형 용 (인)

ABSTRACT

Three Essays on ESG and Corporate Management
- ESG Evaluation, TCFD, and CEO Non-Duality -

Cho, Chanhi

Major in Management Consulting

Dept. of Knowledge Service & Consulting

The Graduate School

Hansung University

This dissertation deals with ESG and corporate management in ESG consulting related to corporate management. It consists of three papers comparing ESG evaluation methods, TCFD, and CEO Non-Duality.

The first essay compares domestic and international ESG evaluation methods through the K-ESG guidelines. ESG diagnostic items that were not covered in previous studies were directly applied to corporates to measure the ease of application of the K-ESG guidelines, and the results of the evaluation to compare with domestic and international ESG ratings held by the corporate to study the appropriateness and location of the K-ESG guidelines. As a result, the ESG rating of the K-ESG guidelines was lower than Refinitiv among global ESG rating agencies, higher than MSCI, and lower than or similar to that of KCGS, a domestic ESG

evaluation institution. In addition, the ease of application of the K-ESG guidelines was high.

The second essay compares the efficiency of each group of corporates engaged in ESG management using a meta-frontier that uses TCFD scores and ESG ratings as input and output variables. Although studies on TCFD scores and corporate efficiency in Korea on greenhouse gas (GHG) topics are rare, this study compared the efficiency of different industries, such as financial corporates, non-financial corporates, and non-financial public corporates, using the meta-frontier. The order of meta-frontier efficiency under VRS was financial corporates (99.5%), non-financial public corporates (96.2%), and non-financial corporates (95.0%). The cause of inefficiency was pure technical efficiency in all three groups.

The third essay examines whether the performance of corporates implementing CEO Non-Duality is improved. Propensity score matching (PSM) and difference-in-differences (DID) were used to compare the value one year before and the average values three years after the implementation of the policy, and productivity changes over five years were measured using the Malmquist Productivity Index (MPI). As a result of the study obtained through the PSM-DID analysis, although a direct causal relationship between CEO Non-Duality and corporate performance improvement could not be proven, this study showed the possibility that appointing an outside director as the chairman of the board of directors(CBD) could have a positive effect on corporate performance. It is necessary to appropriately adjust the company's management strategy and organizational culture and strengthen outside directors' roles in electing board members.

The contributions of this study are as follows. The first essay will show the role of context in ESG evaluation and how important it is to

consider the context and suggest to the academic community the need for a standardized ESG evaluation method and examples that can be successfully applied. In addition, it implied that the government's role in promoting ESG evaluation is essential. The second essay compared the efficiency of ESG management activities of financial and non-financial corporates using TCFD guidance to previous studies that did not compare the efficiency of different industries. In addition, TCFD scores and ESG ratings, which were not previously used as input and output variables, were used to contribute to the academic development of the field. The third essay verifies the implementation effect through PSM-DID analysis of corporates that have implemented CEO Non-Duality among listed corporates in Korea and those that have not and used Malmquist (MPI), which was not used in previous studies, as a result of PSM-DID. It is an academic contribution to use as a method of additional verification.

【Keywords】 *ESG Evaluation, K-ESG Guidelines, TCFD, Meta-Frontier, CEO Non-Duality, Propensity Score Matching, Difference-in-Differences, Malmquist Production Index*

Contents

List of Tables

List of Figure

Chapter 1. Comparison of ESG Evaluation Methods: Focusing on the K-ESG Guidelines*

ESG management is becoming a necessity of the times. However, about 600 ESG evaluation indicators worldwide need to be clarified in the market as different ESG ratings were assigned to individual corporates according to evaluation institutions. In addition, since the method of applying ESG was kept a secret, there were few ways for corporates to introduce ESG management to get help. Accordingly, the Ministry of Trade, Industry, and Energy announced the K-ESG guidelines jointly with the ministries. In previous studies, few studies compared evaluation ratings by ESG evaluation corporate or the application of evaluation diagnostic items. Therefore, in this study, the ease of application and improvement of the K-ESG guidelines was attempted by applying the K-ESG guidelines to corporates that already have ESG ratings. The position of the K-ESG guidelines is also confirmed by comparing the scores calculated through the K-ESG guidelines for corporates with ESG ratings from global ESG evaluation institutions and domestic ESG evaluation institutions. As a result of the analysis, first, the K-ESG guidelines provide clear and detailed standards for individual corporates to set their own ESG goals and the direction of ESG practice. Second, the K-ESG guidelines are suitable for domestic and global ESG evaluation standards as it has 61 diagnostic items and 12 additional diagnostic items covering the evaluation indicators of global representative ESG evaluation institutions and KCGS in Korea. Third, the ESG rating of the K-ESG guidelines was higher than that of global ESG evaluation institutions and

---

* This essay was published in Cho & Lee (2023), Comparison of ESG Evaluation Methods: Focusing on the K-ESG Guideline, Journal of Intelligence and Information Systems 29(1), 1-25

lower than or similar to that of a domestic ESG evaluation institution. Fourth, the ease of application of the K-ESG guidelines is considered high. Fifth, the point to be improved in the K-ESG guidelines is that the government needs to compile average industry statistics on diagnostic items in the K-ESG environment pillar and publish them on the government's ESG-only site. In addition, the applied weights of E, S, and G by industry should be determined and disclosed. This study will help ESG evaluation institutions, corporate management, and ESG managers interested in ESG management in establishing ESG management strategies and contributing to providing improvements to be referenced when revising the K-ESG guidelines in the future.

【Keywords】*ESG, K-ESG guidelines, ESG evaluation indicators, ESG ratings*

1.1 Introduction

As global corporates went bankrupt during the 2008 financial crisis, interest in corporate sustainability increased. Since then, ESG investment by financial investment corporates has increased, and the number of institutions evaluating ESG has also increased in earnest (Maeil Economic Daily ESG Team, 2021). Therefore, various institutions such as media corporates, consulting corporates, and financial investment corporates have jumped into ESG evaluation projects. As of 2021, there are 600 ESG indicators at home and abroad and at least 125 ESG evaluation institutions worldwide (Maeil Economic Daily ESG Team, 2021). Some point out the problem that the difference in ESG evaluation indicators makes it very difficult for corporates to disclose ESG management-related content or organize ESG management strategies (Chun & Park, 2021). Different ESG evaluation pillars and industries have different weights, which means that each evaluation institution can arbitrarily perform ESG evaluation, and different evaluation methodologies for each evaluation institution may fall under discretionary areas. However, it is an important issue when linked to the reliability of ESG evaluation services. ESG ratings differ due to problems in evaluation methodology, structural problems in ESG rating evaluation, and data collection and processing (Bae et al., 2021). From the standpoint of a corporation, it is necessary to raise the ESG evaluation rating through an understanding of the evaluation institution's ESG evaluation questions rather than ignoring that the ratings of ESG evaluation institutions may be different due to the above structural problems (Bae et al., 2021). However, ESG application methods were kept a secret, and there needed more studies on ESG evaluation indicators by ESG evaluation institutions, which did not help corporates manage ESG. However, on December 1, 2021, the Ministry of

Trade, Industry, and Energy jointly issued the K-ESG guidelines to address the difficulties of these corporates.

This study aims to measure the ease of application of the K-ESG guidelines by directly applying ESG diagnostic items not covered in previous studies to corporates and to study the adequacy and location of the K-ESG guidelines by comparing the evaluation results with domestic and international ESG ratings held by the corporate. For measurement, three corporates, K corporate, D corporate, and H corporate, were selected out of 22 corporates with a wide gap between ESG evaluation ratings at domestic and international, and scores were calculated on the diagnostic items of the K-ESG guidelines based on their sustainable management reports, business reports, and disclosure data. Under these research objectives and research methods, the following items will be examined more intensively. First, it will be verified whether it helps individual corporates set ESG goals and the direction of ESG practice, which is the purpose of introducing the K-ESG guidelines. Second, the researcher will verify whether the K-ESG guidelines conform to international and domestic standards. Third, there is a big gap between ESG ratings from domestic and international ESG evaluation institutions for some corporates. The researcher will verify whether the results measured by the K-ESG guidelines can narrow the gap between domestic and international rating ratings. Fourth, the ease of application of the K-ESG guidelines will be verified. Practical difficulties and improvements will be found in finding data for evaluating diagnostic items in reports or websites. Fifth, The researcher would like to identify the improvements in the K-ESG guidelines and help them when revising the K-ESG guidelines in the future.

As a contribution point of this study, first, it will guide how to establish and apply ESG management strategies to corporates and related

people who want to introduce ESG management. Second, The researcher will provide the ease, and difficulty point information I grasped while applying the K-ESG guidelines. Third, the K-ESG guidelines will verify which is closed between the global ESG evaluation rating and the domestic ESG evaluation rating. Fourth, The researcher will now provide the necessary information for future revisions to complete the just-released K-ESG guidelines. The composition of this study is in the order of the concept of ESG and previous research in 1.2, a comparison of ESG evaluation institutions in 1.3, K-ESG evaluation results in 1.4, implications and limitations of the study in 1.5, and a conclusion in 1.6.

1.2 Literature Review

1.2.1 ESG Concepts and Trends

ESG is an abbreviation for environment, social, and governance as non-financial elements of a corporate. ESG activities significantly affect corporate sustainability and long-term value by minimizing the disadvantages corporations will cause to society and the environment and maximizing the effectiveness of governance structures (Kang & Jung, 2020). ESG refers to the three critical elements of corporate management to achieve sustainability by focusing on environmental management, social responsibility, and sound and transparent governance (Ministry of Trade, Industry and Energy & Korea Productivity Center, 2021). ESG began in the UK in 2000, and Germany, Belgium, and Sweden sequentially introduced the ESG information disclosure obligation system, establishing the concept. Socially Responsible Investment (SRI), which already invests in eco-friendly and moral corporates, has significantly been activated in developed capital markets such as Europe, the United States, and Japan (Baek & Choi, 2021). This trend has strengthened, and ESG has recently become a global trend. The interest of all members of society, including

consumers, governments, and investors, has increased, making it an essential factor for growth and survival, not a choice for corporates (Ministry of Trade, Industry and Energy & Korea Productivity Headquarters, 2021). ESG can be used as an indicator for corporates to manage the non-financial risks they face. For investors, it can serve as an investment guide to help select corporates by considering the non-financial risks of investee corporates in advance when forming an investment portfolio(Kang & Jung, 2020).

BlackRock, the world's most extensive asset management corporate, said it would consider the environment a key criterion when making investment decisions. Moreover, corporates that do not participate in the crisis response to climate change or earn more than 25% of their total profits using coal fuel will be excluded from investment by mid-2020 (Kim & Park, 2021), and the number of corporates receiving ESG evaluation is expected to expand further. Over the past 25 years, the world has seen an exponential increase in the number of corporates measuring and reporting ESG data on the environment(carbon emissions, water consumption, and waste generation), social(employees, products, and customers), and governance (political lobbying, anti-corruption commission diversity) (Amel-Zadeh & Serafim, 2018). Corporations worldwide have adopted sustainable reporting, given stakeholders' need for more transparency in ESG issues such as environment, social, and governance (Buallay, 2019). Today, publicly traded corporates worldwide are shifting from short-term goals of maximizing profits to long-term sustainable ESG environmental, social, and governance goals. People have realized that ESG has become an essential source of corporate risk and can affect financial performance and profitability (Zhao et al., 2018). Investors and stakeholders were able to develop an interest in ESG scores and obtain the information needed to make long-term decisions (Ballucci

et al., 2021; Senadheera et al., 2021). Therefore, ESG reporting has emerged as a platform for analyzing the sustainability of various institutions. Sustainability analysis has become a series of investment instruments primarily used to assess ESG-related risks and growth opportunities (Boffo et al., 2020; Li & Polychronopoulos, 2020; Senadheera et al., 2021). However, as ESG became a great business model and demand and supply for ESG management expanded, various difficulties arose from the perspective of corporates. Domestic and international evaluation institutions should provide consistent ESG evaluation indicators to individual corporates to eliminate confusion among corporates. Due to the difference, corporates are experiencing a problem receiving different report cards. No universal ESG framework is agreed upon among stakeholders, and academic research on country-specific ESG models still needs to be completed (Park & Jang, 2021). In other words, no standardized standard or systematic measurement method requires specific disclosure of ESG activities (Choe & Kim, 2021).

Therefore, regulatory institutions in many countries are trying to set standards to ensure the reliability and comparability of non-financial information, such as financial information. Accordingly, five organizations, including the Global Reporting Initiative (GRI), the International Integrated Reporting Commission (IIRC), the Carbon Disclosure Project (CDP), the Climate Information Disclosure Standards Board (CDSB), and the Sustainability Accounting Standards Board (SASB) In December of the same year, they agreed to establish a common standard. They published a draft in December of the same year. There has also been a movement in Korea to mandate the disclosure of ESG information. The Financial Services Commission mandated KOSPI-listed corporates with assets worth more than 2 trillion won to disclose corporate governance reports. In

addition, corporates with more than 1 trillion won must make mandatory disclosures from 2022, corporates with more than 500 billion won from 2024, and all KOSPI-listed corporates must make mandatory disclosures from 2026. In addition, KOSPI-listed corporates with assets of 2 trillion won or more must disclose ESG information from 2025, and all KOSPI-listed corporates must disclose sustainable management reports from 2030 (Social Responsibility Management Quality Institute & ESG Management Research Institute, 2021).

Following these moves to disclose ESG information at home and abroad and establish ESG standards, the Ministry of Trade, Industry, and Energy issued the K-ESG guidelines by integrating ministries. It provided good guides for corporates running or trying to start ESG.

1.2.2 Literature Review

ESG research focuses on ESG management's effect on corporate performance and ESG evaluation. Looking at a study of ESG management and corporate performance, Gillan et al. (2010) found that more robust ESG performance tends to increase operational performance, efficiency, and corporate value, with corporates with more robust ESG policies increasing efficiency and higher corporate value than their competitors. Moreover, Alareeni & Hamdan (2020) said ESG disclosure positively affects corporate performance measurement. According to Kotsantonis et al. (2016), corporates with above-average ESG scores outperformed their competitors on standard operational performance measures and stock market returns. Lee & Rhee (2020) said that corporates are engaged in numerous management activities to generate profits. When discussing corporate sustainability from the corporate

perspective, corporate sustainability comes down to the probability that a corporation will continue to carry out business activities in the future.

Prior research on ESG evaluation mainly includes research on ESG ratings, ESG evaluation indicators, and ESG evaluation systems. First, there are studies on ESG ratings, which examine the effects of ESG ratings on corporate value, free cash flow, excess returns, stock price volatility, credit ratings, and corporate social performance. As a result of their research, it has been studied that a good ESG rating has a positive effect on related variables (Kim & Lee, 2021; Kim, 2020; Do & Kim, 2019; Baik & Choi, 2021; Oh, 2021; Leem, 2019; Dorfleitner et al., 2015). As a study on ESG evaluation indicators, a study on the effect of top management and ESG risk factors on abnormal returns in the market response analysis of events used in the development of ESG evaluation indicators (Kang & Jung, 2020), ESG evaluation indicators In a study that ranked governance, ESG, and social responsibility as the order of magnitude of influence on corporate value (Oh & Lee, 2019), and a study comparing ESG evaluation indicators from the perspective of HRM, human resource management indicators accounted for a significant portion in ESG management evaluation. Some studies (Chun & Park, 2021) require the expansion of cross-country comparative research on the orientation of domestic and international evaluation indicators, as there are differences depending on the situation of the times and the business environment. Finally, as a study on the ESG rating system, Hughes et al. (2021) compared the ESG ratings of existing ESG evaluation institutions and AI-based ESG rating sets. In addition, there are studies on problems and improvement directions for the proliferation of ESG evaluation institutions and conflicting evaluation results (Lee, 2020; Jang, 2021; Billio et al., 2021).

As mentioned above, in the prior studies on ESG evaluation, there were no previous studies on evaluation indicators and evaluation ratings for the evaluation ratings of domestic and international ESG evaluation institutions and the newly released K-ESG guidelines. Therefore, this study compared the K-ESG guidelines with the ratings and indicators of global ESG evaluation institutions and KCGS, a representative institution among domestic ESG evaluation institutions.

〈Table 1-1〉 Recent Preceding Studies Related to ESG Evaluation

Researcher	Key findings
Kim & Lee (2021)	ESG has a discriminatory effect on corporate management performance and corporate value. Financial institutions do not use ESG as meaningful information when executing loans. ESG identified a significant positive relationship with corporate bond credit rating evaluation.
Kim(2020)	Higher ESG ratings have a positive effect on surplus cash flows. The increase in surplus cash flow suggests that corporate risk decreases as a corporate value and financial status become sound.
Do & Kim (2019)	For Korean corporates, the high environmental management evaluation index positively reduces stock price volatility and increases long-term excess returns, reducing asymmetric information. Artificial efforts such as rise and incorporation give investors negative signals of information asymmetry.
Baik & Choi (2021)	ESG rating has a significant positive relationship with debt ratio, bankruptcy risk, Beta, net return on equity, and operating profit on sales. It has a significant negative relationship with the turnover rate of tangible assets and the current ratio. Corporates with high dividend payout propensity, large corporate size, and high foreign ownership are likely to have higher ESG ratings. On the other hand, corporates with high cash flow and long corporate receipts are likely to have low ESG ratings.
Oh(2021)	Corporates with high ESG and credit ratings (AR) have higher corporate value (TQ). Credit rating variables significantly influence corporate value more than ESG variables. Controlling the interaction between foreign ownership and each rating has a more significant influence on credit ratings.

Researcher	Key findings
Leem(2019)	The final ESG rating, excluding environmental rating (E), social rating (S), and governance rating (G), have a high impact on corporate value for the current and next term, i.e., corporate social activities increase corporate value.
Dorfleitner et al. (2015)	The researcher compared empirically different evaluation approaches to a firm's social performance (CSP) with ESG scores. ESG ratings are highly relevant to managers and investors who incorporate ESG issues into decision-making.
Kang & Jung (2020)	Information on top management and ESG-related risk factors affect abnormal returns. When calculating ESG scores, focusing on the market response to events is necessary.
Oh & Lee (2019)	The order of influence on corporate value is the order of governance, ESG, and social responsibility. The order of influence on the stock price return is the order of governance and ESG.
Lee & Kim (2021)	Suggest improvements to the factors that make up ESG reliability. Solutions such as the method and scope of data collection and the authenticity of the collected information are needed. A consultative body centered on leading evaluation institutions must establish autonomous and common indicators. It is necessary to introduce qualification regulations for evaluators and evaluation institutions.
Chun & Park (2021)	Human resource management indicators account for a large portion of ESG management evaluation, and most of the critical indicators are linked to organizational culture, so human resource management is essential in ESG management. The difference in the orientation of evaluation indicators between domestic and international countries should be expanded to studies comparing convergent and diffuse values between countries.
Choe & Kim (2021)	ESG outstanding corporates perform better. When individual factors evaluate ESG performance, the benefits offset the cost, so there is no incentive to express profits in the short term. When ESG activities are a negative sign of the corporate's financial performance, managers can use ESG activities as an opportunistic decision-making tool.
Senadheera et al. (2021)	ESG's environmental management tools limit the usefulness of environmental scores due to limited comparability, biased score metrics, collective characteristics of various environmental factors, and lack of different methodologies and robust datasets implemented by evaluation providers.

Researcher	Key findings
Hughes et al. (2021)	Truvalue Labs provided a comparative analysis of MSCI ESG ratings and Alternative AI-based ESG ratings. We show that the difference in ratings is caused by four main factors: differences in ESG theory based on essential issue selection, differences in analyzed data sources, differences in weight structures for rating aggregation, and finally, differences in argument analysis.
Lee(2020)	The reliability between the ratings and the confidence in the ratings of domestic ESG evaluation institutions could be higher. If the scope and scope of information disclosure are broad, opinions on evaluation are somewhat mixed. ESG disclosure must be established according to the regulations stipulated through cooperation between related international organizations.
Jang(2021)	Due to the proliferation of ESG evaluations, a regulatory framework is needed for the entry of new businesses and the growth of existing evaluation institutions. Harmonization of legislation and self-regulation is needed. The National Pension's stewardship code must be supplemented through legislation to benefit the beneficiaries. The definition of ESG evaluation institution under the Capital Markets Act needs to be rearranged to relate to the financial investment business. Investor protection and effective regulation of registration of evaluation institutions should be enhanced by public disclosure of evaluation methodology and internal control policy.
Jin & Seong (2020)	CSR has many positive aspects. CSR has a low expenditure regarding the social return of corporate profits and has a negative view of its intention. It is studied in a problematic state to measure because there are no tools to evaluate corporate social responsibility. The overall CSR awareness of modern corporates is relatively high.
Billio et al. (2021)	When defining E, S, and G evaluation indicators of leading ESG evaluation bodies, there is no commonality in (i) characteristics, (ii) attributes, and (iii) the standard definition. Due to the heterogeneity of evaluation indicators, evaluation institutions provide conflicting evaluation results for the same evaluated corporate. These conflicting evaluation results affect sustainable investment, creating the identification of various investment universities and various benchmarks.

Data: Researchers have organized previous studies related to ESG evaluation.

1.3 ESG: Comparison by Evaluation Institution

1.3.1 Domestic and International ESG Evaluation Institutions

As more corporates adopt ESG management, the number of ESG evaluation institutions also increases. Various institutions, such as media corporates, consulting corporates, and financial investment corporates, have jumped into the ESG evaluation business. As of 2021, it is known that there are at least 125 ESG evaluation institutions worldwide, as well as about 600 ESG indicators at home and abroad (Maeil Business ESG Team, 2021). In this ESG evaluation, the evaluation of non-financial and unstructured data is high, so evaluation know-how, unstructured data collection, and various evaluation techniques are considered vital elements (Corporate Social Responsibility Management Quality Institute ESG Management Research Institute, 2021). Among numerous domestic and international ESG evaluation institutions, major ESG evaluation institutions are shown in 〈Table 1-2〉. As for global ESG evaluation institutions, large evaluation institutions such as Morgan Stanley (MSCI), Refinitiv (formerly Thomson Reuters), and Sustainalytics, which have participated in the market since the early days of ESG, have designed and sold standard or customized evaluation indicators. It is actively engaged in activities such as developing ESG indexes and specific indexes for individual investors at the forefront. On the other hand, domestic ESG evaluation institutions, Sustinvest, Korea Institute of Corporate Governance and Sustainability (KCGS), and Daeshin Economic Research Institute, mainly provide services. Among them, the Korea Corporate Governance Service conducts both quantitative and qualitative evaluations.

〈Table 1-2〉 Status of Evaluation Indicators by Domestic and International ESG Evaluation Institutions

Division	Institution name	Index Name	Evaluation Indicators	History	Evaluation Methods
Domest	Sustinvest	ESG	Use its	2006	Each pillar of ESG is

Division	Institution name	Index Name	Evaluation Indicators	History	Evaluation Methods
Domestic		Value	model		divided into subsystems by stage in the order of Category, KPI, and Data Point.
	KCGS	ESG evaluation	281 items	2011	Utilization of institutional data, corporate disclosure, and media data
	Daishin Economic Research Institute	–	–	2017	Quantitative item evaluation and primary survey based on a manual survey in principle
International	RepRisk	ESG Ratings	28 items	1998	Monitoring of 80,000 media and stakeholder data sources
	Dow Jones	DJSI	Up to 120 items	1999	Applying industry-specific standards according to industry, conducting surveys by industry (80-120 questions)
	Morgan Stanley	MSCI ESG Ratings	37 items	1999	Utilizing government databases, corporate disclosure data, and NGO data
	Sustainalytics	ESG Ratings	70 items	2008	70 indicatiors, 3 dimensions
	Refinitiv	ESG Score	Over 400 items	2009	Composed of ESG Scores ten categories. The more issues there are, the more weight.
	Bloomberg	ESG Data	120 items	2009	120 indicators, deductions for missing information

Source: Chun & Park(2021)

1.3.2 ESG Evaluation by MSCI (Morgan Stanley Capital International)

Morgan Stanley Capital International (MSCI), active since 1999, the early days of ESG, is a pioneer in ESG evaluation. ESG evaluation is conducted using government data, corporate information, and macro data released by acquiring the same evaluation corporate and an Analytics corporate such as Carbon Delta (Daily Economic ESG Team, 2021). The corporate scores ten categories and 35 diagnostic items for each environmental, social, and governance item according to a set weight. The evaluation ratings are seven ratings of AAA~CCC, and the overall evaluation and ESG ratings are also announced. An analysis review is provided about once a year (MSCI ESG Research, 2020).

〈Table 1-3〉 ESG Evaluation Index of MSCI

Pillar	Category	Evaluation index
Environment	Climate change	Carbon emissions, funding environmental impacts, climate change vulnerabilities, product carbon footprint
	Natural capital	Water scarcity, raw material provision, biodiversity and land use
	Pollution and waste	Waste and toxic emissions, packaging and waste, electronic waste
	Environmental opportunity	Opportunities for Clean Tech, Green Building, and Renewable Energy
Social	Human capital	Labor Management, Health and Safety, Human Capital Development, Supply Chain Labor Standards
	Product responsibility	Product safety and quality, chemical safety, financial product safety, privacy and data security, responsible investment, health and demographic risks
	Opposition of stakeholders	Controversial Sources, Community Relations
	Social planning	Access to communications, access to finance, access to healthcare, nutrition and health opportunities
Governance	Corporate governance	Ownership and control, committees, payments, accounting

Pillar	Category	Evaluation index
	Corporate action	Business ethics, tax transparency

Source: MSCI ESG Research(2020)

1.3.3 ESG Evaluationby Refinitiv (formerly Thomson Reuters)

Refinitiv has conducted ESG evaluations since 2002. The corporate uses more than 450 ESG metrics to provide one of its comprehensive ESG databases for corporates with more than 70% of the world's market capitalization. Since then, Refinitiv, Thomson Reuters' ESG evaluation institution, has provided services that can be easily integrated into portfolio analysis, equity research, screening, or quantitative analysis. The final ESG score is calculated by averaging ESG scores from 186 data points for each environment, society, and governance item from 10 categories and 27 diagnostic items. ESG content scores (ESGC) were calculated based on 23 data points. If the ESG score is greater than the ESG score, the ESG score is equal to the ESG score, and if the ESG score is less than the ESG score, the ESG score is calculated as the average of the ESG score and the ESG score. The percentile score may be converted into 12 character ratings, including A+, A, A-,~, D+, D, and D- (Refinitiv, 2021).

〈Table 1-4〉 ESG Evaluation Index of Refinitiv

Pillar	Category	Evaluation index
Environment	Dispose	Emissions, waste, biodiversity, environmental management systems.
	Innovation	Product innovation, green revenue, R&D and capital expenditure
	Resource utilization	Water, Energy, Sustainable Packaging, Environmental Supply Chain

Pillar	Category	Evaluation index
Social	Community	Equal importance for all industry groups, assign a median weight of 5 to all groups
	Human rights	Human rights
	Product responsibility	Responsible Marketing, Data Privacy, Product Quality
	Worker	Diversity and inclusion, career development and training, working conditions, health and safety workers
Governance	CSR strategy	ESG reporting and transparency, CSR strategy
	Management	Structure (independence, diversity, committees), compensation
	Shareholder rights	Shareholder Rights, Acquisition Defense

Source: Environmental, social and governance scores from Refivitiv (2021)

1.3.4 ESG Evaluation by KCGS (Korea Institute of Corporate Governance and Sustainability)

Korea Institute of Corporate Governance and Sustainability (KCGS) is a public corporation invested by the Korea Exchange, Korea Listed Corporates Council, KOSDAQ Association, and Korea Financial Investment Association in 2002. It provides advisory services. KCGS is a quantitative evaluation consisting of essential evaluation (additional point method) of 18 significant disclosure categories, such as corporate disclosure data, media data, and supervisory bodies, and in-depth evaluation (deduction point method) of 58 issues that may damage corporate value. Do Interviews target corporates whose quantitative evaluation scores exceed a certain standard. The final rating is calculated based on the difference between the essential evaluation score percentage

and the advanced evaluation score percentage. All ratings are given in October, and the ESG Rating Committee is held in January, April, and July of the following year to adjust the ratings reflecting ESG issues at any time (Maeil Economic Daily ESG Team, 2021). In 2021, KCGS said that the existing ESG best practices needed to be used more and that evaluation and gaps occurred and were revised. The Environmental and Social Best Practices have not been revised since their enactment in 2010. On the other hand, the best practices for corporate governance underwent the first revision in 2003 and the second in 2016. ESG-related global standards have continuously evolved to reflect non-financial information frameworks such as CDP, TCFD, and SASB in the environmental domain. In addition, the social sector was reorganized to emphasize socially responsible management. In corporate governance, the board of directors' responsibility was emphasized, and the ESG management perspective was introduced. Reflecting such changes in the market for the revitalization of ESG and responsible investment and the trend of improvement of ESG-related domestic and international systems and norms, the ESG best practices will be revised as shown in 〈Table 1-5〉. They will be reflected in the evaluation from 2022 (Korea Corporate Governance Service, 2021).

〈Table 1-5〉 ESG Evaluation Index of KCGS

Pillar	Category	Evaluation index
Environment	Environmental Management Plan	Environmental management strategies and policies, CEO's willingness to practice, environmental goals and plans, environmentally friendly organizational system, and environmentally friendly organizational culture.
	Execution of environmental management	Climate change response, environmentally friendly production, environmental risk management, and environmentally friendly supply chain management.

Pillar	Category	Evaluation index
	Environmental performance management and reporting	Environmental audit, environmental performance management, environmental information reporting, environmental accounting
	Stakeholder Response	Environmental protection activities, stakeholder participation activities
Social	Employee	Labor-management relations, safety and health in the workplace, employment and working conditions, manpower development and support, basic rights in the workplace.
	Partners and Competitors	Anti-corruption, fair trade, and promotion of social responsibility
	Consumer	Consumer safety and health, fair trade with consumers, communication with consumers, and protection of consumer privacy
	Community	Development of the local economy, participation in the local community, communication with the local community
Governance	Shareholder	Fair Treatment of Shareholders, Shareholder Rights, Shareholder Responsibilities
	Board of Directors	Composition of the board of directors and appointment of directors, functions of the board of directors, outside directors, evaluation and compensation, committees within the board of directors, duties of directors, operation of the board of directors, responsibilities of directors
	An audit organization	External auditor, internal audit body
	Interested parties	Stakeholder participation in management monitoring, protection of stakeholder rights
	Management monitoring by the market	Institutional investors, corporate management market, disclosure

Source: Korea Corporate Governance Service(2021)

〈Table 1-6〉 ESG Best Practices Revision Direction of KCGS

Pillar	Category	Evaluation index
Environment	Leadership and Governance	Environmental management strategy and goals, environmental management leadership, environmental management governance
	Risk management	Climate change risks and opportunities, identification of environmental risks and opportunities, risk management system
	Operations and Performance	Eco-friendly supply chain, eco-friendly products/services, eco-friendly workplace, environmental accounting, performance management, ecosystem conservation
	Stakeholder Communication	Stakeholder response activities, stakeholder settings, and environmental information disclosure
Social	Leadership and Governance	Strategy and policy, leadership, corporate culture, organization and decision making
	Non-financial risk management	Recognition of non-financial risks and opportunities, integrated management of non-financial risks, response to non-financial risks
	Operations and Performance	Labor Practices, Human Rights, Fair Operating Practices, Information Security, Sustainable Consumption, Community Engagement and Development
	Stakeholder Communication	Information Disclosure, Stakeholder Engagement
Governance	Board leadership	Roles and responsibilities of directors, roles and responsibilities of the board of directors, composition of the board of directors, operation of the board of directors, outside directors, committees within the board of directors
	Shareholder rights protection	Meeting of Shareholders, Rights of Shareholders
	Audit	External Audit, Internal Audit
	Stakeholder Communication	Information disclosure, direct communication with shareholders and stakeholders

Source: Korea Corporate Governance Service. (2021)

1.3.5 ESG Evaluation in the K-ESG Guidelines (Ministry of Trade, Industry, and Energy)

The K-ESG guidelines comprise 27 categories and 61 diagnostic items in four pillars: Environment, Public, Governance, and Social. In addition to 61 essential diagnostic items, 12 additional diagnostic items are provided that can utilize necessary factors depending on the corporate situation. However, they must be global evaluation indicators considering the characteristics of organizations and industries in each area. This additional diagnosis item can be replaced and used when essential diagnosis items are not applicable (Ministry of Trade, Industry and Energy, Korea Productivity Headquarters, 2021).

〈Table 1-7〉 The K-ESG Guidelines Diagnosis Items (Evaluation Indicators) System

Pillar	Category	Score	Weighted	Diagnostic items
Information Disclosure (5 Qs) (8.2%)	Information Disclosure Format	100	0.016	ESG Information Disclosure Method
		100	0.016	ESG information disclosure cycle
		100	0.016	Scope of ESG information disclosure
	Information Disclosure	100	0.016	ESG KPI and Core Issues
	Information Disclosure Verification	100	0.016	ESG information disclosure verification
Environment (17 Qs) (27.9%)	Environmental Management Goal	100	0.016	Establishment of environmental management goals
		100	0.016	Environmental Management Promotion System
	Raw subsidiary materials	100	0.016	Raw material consumption
		100	0.016	Percentage of recycled raw materials
	Greenhouse gas	100	0.016	GHG Emissions (Scope 1 & Scope 2)

Pillar	Category	Score	Weighted	Diagnostic items
		100	0.016	GHG Emissions (Scope 3)
		100	0.016	GHG Emission Verification
	Energy	100	0.016	Energy Usage
		100	0.016	Percentage of renewable energy use
	Water	100	0.016	Water consumption
		100	0.016	Reusable water rate
	Waste	100	0.016	Waste discharge
		100	0.016	Waste Recycling Ratio
	Pollutant	100	0.016	Air Pollutant Emissions
		100	0.016	Emissions of water pollutants
	Violation of environmental laws/regulations	100	0.016	Violation of environmental laws/regulations
	Environmental labeling	100	0.016	Percentage of Green Services and Certified Products
Socail (22 Qs) (36.1%)	Goals	100	0.016	Establishment and disclosure of objectives
	Labor	100	0.016	Recruitment and retention of employment
		100	0.016	Percentage of full-time employees
		100	0.016	Voluntary turnover
		100	0.016	Education and training expenses
		100	0.016	Welfare expenses
		100	0.016	Guarantee of freedom of association
	Diversity & gender equality	100	0.016	Percentage of female members
		100	0.016	Salary ratio for women (relative to average salary)
		100	0.016	Employment rate for people with disabilities
	Industrial Safety	100	0.016	Safety and Health Promotion System
		100	0.016	Industrial accident rate
	Human right	100	0.016	Establishment of human rights policy
		100	0.016	Human Rights Risk Assessment
	Shared growth	100	0.016	Supplier ESG Management
		100	0.016	Supplier ESG Support
		100	0.016	Supplier ESG Agreement
	Community	100	0.016	Strategic Social Contribution
		100	0.016	Member Volunteer

Pillar	Category	Score	Weighted	Diagnostic items
				Participation
	Information protecion	100	0.016	Establishment of information protection system
		100	0.016	Privacy Invasion and Remedy
	Violation of social laws & regulations	100	0.016	Violation of social laws and regulations
Governance (17 Qs) (27.9%)	Composition of the board of directors	100	0.016	Presenting ESG agenda within the board of directors
		100	0.016	Percentage of outside directors
		100	0.016	Separation of CEO and Chairman of the Board of Directors
		100	0.016	Board of Directors Gender Diversity
		100	0.016	Outside Director Expertise
	Board activities	100	0.016	Attendance rate of all directors
		100	0.016	Inside director attendance rate
		100	0.016	Committees under the Board of Directors
		100	0.016	Board agenda handling
	Shareholder rights	100	0.016	Announcement of convocation of general meeting of shareholders
		100	0.016	Held outside of the general meeting of shareholders
		100	0.016	Concentrated/Electronic/Written Voting System
		100	0.016	Dividend Policy and Implementation
	Ethical management	100	0.016	Disclosure of violations of the Code of Ethics
	Audit organization	100	0.016	Establishment of internal audit department
		100	0.016	Audit body expertise (accounting and finance experts within the audit body)
	Violation of laws & regulations	100	0.016	Violation of governance laws and regulations
Environment (Addition)	Responding to Climate Change			Forest carbon uptake
	Energy			Energy efficiency
Social	Shared			Supply chain stability

Pillar	Category	Score	Weighted	Diagnostic items
(Addition)	growth			
	Consumer			Provision of consumer information
				Consumer safety
				Operation of customer satisfaction response system
	Labor			Ratio of high school graduates among full-time employees
	Community			Win-win cooperation and ESG activities in rural areas (balanced development)
				Contributing to vitalization of industry-university cooperation
				Contribution to future society growth and education
	Management			Management Performance Evaluation and Compensation
	Ethical Management			Ethics Management Compliance with anti-corruption related laws and codes of conduct, etc.

Source: Ministry of Trade, Industry and Energy & Korea Productivity Center (2021)

1.3.6 Comparison of Rating Differences between Domestic and International ESG Evaluation Institutions

According to a survey of 22 corporates by the Federation of Korean Industries in 2021, the difference in ratings by ESG evaluation institutions at home and abroad widened by 2.2 out of 7 stages. In particular, the difference between MSCI and Refinitiv differed from up to 5 to 0, and the rating gap between global evaluation institutions and KCGS was up to 4 to 0. This is due to differences in ESG theories on ESG issues among evaluation institutions, differences in analyzed data sources, differences in weighting structures for rating aggregation, and differences

in debate analysis (Hughes et al., 2021). This study aims to check how much the ESG ratings, which vary by domestic and international ESG evaluation institutions, differ from the results obtained by applying the K-ESG guidelines announced in December 2021. Therefore, one corporate (K corporate) with an enormous average difference between M-K and R-K in 〈Table 1-9〉 and two corporates (D corporate and H corporate) with the slightest difference were selected as the target corporates for ESG evaluation by applying the K-ESG guidelines.

〈Table 1-8〉 ESG Evaluation Rating Name and Meaning

Division	MSCI (7th rating)	Refinitiv (out of 100)	K-ESG (out of 100)	KCGS (7th rating)	Meaning of KCGS Ratings
Rating 1	AAA	85.8 ~100	85.8 ~100	S	Having a faithful sustainable management system, there must be more room for shareholder value damage due to non-financial risks.
Rating 2	AA	71.5 ~85.7	71.5 ~85.7	A+	Having a sustainable management system faithfully, there is considerably little room for shareholder value damage due to non-financial risks.
Rating 3	A	57.2 ~71.4	57.2 ~71.4	A	Properly establishing a sustainable management system. Less room for shareholder value damage due to non-financial risk.
Rating 4	BBB	43.0 ~57.1	43.0 ~57.1	B+	Efforts to establish a sustainable management system are needed, and there is some room for damage to shareholder value due to non-financial risks.
Rating 5	BB	28.7 ~42.9	28.7 ~42.9	B	Efforts to establish a sustainable management system are needed, and

Division	MSCI (7th rating)	Refinitiv (out of 100)	K-ESG (out of 100)	KCGS (7th rating)	Meaning of KCGS Ratings
					there is room for damage to shareholder value due to non-financial risks.
Rating 6	B	14.4 ~28.6	14.4 ~28.6	C	Efforts to establish a sustainable management system are necessary, and there is much room for damage to shareholder value due to non-financial risks.
Rating 7	CCC	0 ~14.3	0 ~14.3	D	There is a concern that shareholder value may be damaged due to non-financial risks because there is little sustainable management system.

Source: Korea Economic Daily · Korea Economic Magazine Professional Reporter (2021) The name and meaning of the KCGS rating was modified by the researcher

* Refinitiv and K-ESG guidelines use a method that converts the 100-point score system classified by the Federation of Korean Industries into 7-level ratings at 14-point intervals

〈Table 1-9〉 Differences in Ratings of Major Domestic Corporates by Domestic and International ESG Evaluation Institutions

Corporate name	Adjustment rating[1]			Rating gap			
	Refinitiv (out of 100)	MSCI (7th rating)	KCGS (7th rating)	M-R[2]	R-K[2]	M-K[2]	Rating gap average
Hyundai Steel	AA	CCC	BBB	Step 5	Step 2	Step 3	Step 2.2
Kia Motors	A	CCC	A	Step 4	0	Step 4	
Hyundai Motors	AA	B	A	Step 4	Step 1	Step 3	
Samsung	A	CCC	BBB	Step 4	Step 1	Step 3	

Corporate name	Adjustment rating[1]			Rating gap			
	Refinitiv (out of 100)	MSCI (7th rating)	KCGS (7th rating)	M-R[2]	R-K[2]	M-K[2]	Rating gap average
Heavy Industries							
Korea Electric Power Corporation	AA	BB	A	Step 3	Step 1	Step 2	
Korea Gas Corporation	AA	BB	A	Step 3	Step 1	Step 2	
Modern Glovis	AA	BB	A	Step 3	Step 1	Step 2	
Hyundai Engineering & Construction	AA	BB	A	Step 3	Step 1	Step 2	
Doosan Heavy Industries & Construction	AA	BB	A	Step 3	Step 1	Step 2	
S-Oil	AA	BB	AA	Step 3	0	Step 3	
Hyundai Mobis	BBB	B	A	Step 2	Step 1	Step 3	
Lotte Shopping	BBB	B	A	Step 2	Step 1	Step 3	
E-Mart.	BB	B	A	Step 1	Step 2	Step 3	
Kumho Petrochemical	B	B	A	0	Step 3	Step 3	
BGF Retail	CCC	BB	A	Step 2	Step 4	Step 2	
S1	CCC	BB	BBB	Step 2	Step 3	Step 1	
CJ Korea Express	B	BB	A	Step 1	Step 3	Step 2	
Hotel Shilla	B	BB	A	Step 1	Step 3	Step 2	
Korea	B	BB	A	Step 1	Step 3	Step 2	

Corporate name	Adjustment rating[1]			Rating gap			
	Refinitiv (out of 100)	MSCI (7th rating)	KCGS (7th rating)	M-R[2]	R-K[2]	M-K[2]	Rating gap average
Aerospace Industries							
Ottogi	CCC	B	BBB	Step 1	Step 3	Step 2	
Samsung Electronics	AAA	A	BBB	Step 2	Step 3	Step 1	
LG Electronics	AAA	A	BBB	Step 2	Step 3	Step 1	

1. Rating System: (KCGS) S/A+/A/B+/B/C/D (MSCI) AAA/AA/A/BB/B/B/CCC (Refinitiv) Convert the score system out of 100 to 7 ratings by 14 points.
2. Abbreviations are M (MSCI), R (Refinitiv), and K (KCGS), which means the level of difference between the evaluation ratings of each institution.
※ Source: Federation of Korean Industries (2021)

1.4 K-ESG Evaluation Results

1.4.1 ESG Evaluation by KCGS

In the case of self-diagnosis using the K-ESG guidelines, the importance of diagnostic items can be determined by weighting each diagnostic item, which can be determined by combining the organization's ESG promotion direction and industry issues (Ministry of Trade, Industry and Energy, 2021). In this study, since there is no recommended weight for each item as shown in the guide of the K-ESG guidelines, a simple weight of 1/61 (0.016) was applied to 100 points, the highest point for each diagnostic item, as shown in 〈Table 1-6〉. ESG evaluation was conducted by referring to the website of individual corporates, sustainable management reports, and business reports disclosed in the Financial Supervisory Service DART when evaluating diagnostic items. In the

K-ESG guidelines, there is a performance check method by comparing the total domestic ratio of the item, the organization's previous year's target, the organization's target, and the organization's benchmark competition. Due to the lack of data in this study, the average of three years before the corresponding item of individual corporates was compared.

1.4.2 Comparison between K-ESG Ratings of Selected Corporates and ESG Ratings by Domestic and International Evaluation Institutions

The rating of K corporate calculated through the K-ESG guidelines was BBB, two steps higher than MSCI and Refinitiv and one step lower than KCGS. The acquisition score ratio for each pillar was low at 37% in the environmental pillar but 57% in the governance, social, and information disclosure pillars, respectively, higher than the integrated score of 55%. On the other hand, Corporate D's K-ESG rating was one step lower than Refinitiv as A was equivalent to KCGS and two steps higher than MSCI. The acquisition score ratio for each pillar was lower at 50% and 65% in the governance and environmental pillars, but 80% and 85% in the social and information disclosure pillars, respectively, higher than the integrated score of 67.7%. Finally, Corporate H's K-ESG rating was also one step lower than Refinitiv as A was equivalent to KCGS and two steps higher than MSCI. The acquisition score ratio for each pillar was low at 56% and 58% in the environmental and social pillars, but 76% and 85% in the governance and information disclosure pillars, respectively, higher than the integrated score of 64.8%. As shown in 〈Table 9〉, in the ESG ratings of the three selected corporates, MSCI ratings were given to only three corporates. The reason for the low rating of MSCI is that the corporate classifies corporates into 11

categories, including materials, energy, information technology, and finance, divides the detailed industries again, and gives MSCI its weight to derive the rating. This result is because the evaluation method is complicated, and the discrimination power of major individual indicators, such as carbon emissions, is low. It is also pointed out that global evaluation institutions such as MSCI reflect the interests of hedge funds. On the other hand, some point out that domestic ESG evaluation institutions are relatively less likely to reflect E, which is bright in Korea, but has limitations in terms of organizational capabilities and S-related indicators, which have controversy over the adequacy of standards (Korea Economic Daily, Korea Economic Magazine, 2021). However, as shown in 〈Table 1-10〉, the evaluation indicators of the K-ESG guidelines are abundant enough to encompass the evaluation indicators of KCGS or global evaluation institutions. Therefore, it is judged that corporates should prepare for ESG evaluation at home and abroad by referring to the evaluation indicators and evaluation methods of the K-ESG guidelines.

〈Table 1-10〉 Scorecard of the K-ESG Guidelines

Corporate name			Adjustment rating *		
			K Corporate	D Corporate	H Corporate
Domestic and international ESG Evaluation rating	MSCI (Rating 7)		B	BB	BB
	Refinitiv (out of 100)		B	AA	AA
	KCGS (Rating 7)		A	A	A
K-ESG Guidelines	Ratio of points earned to the total score by area	Information disclosure	70%	85%	85%
		E	37%	65%	56%
		S	64%	80%	58%

Corporate name			Adjustment rating *		
			K Corporate	D Corporate	H Corporate
		G	57%	50%	76%
	Overall (out of 100)		55.2	67.7	64.8
	Conversion rating		BBB	A	A

* Rating system: (KCGS) S / A+ / A / B+ / B / C / D (MSCI) AAA / AA / A / BBB / BB / B / CCC (Refinitiv)(K-ESG) Convert the score system of 100 points to 7 levels by 14 points.

〈Table 1-11〉 ESG Evaluation Index Comparison Table by Evaluation Institution

Division		MSCI	Refinitiv	KCGS 2022 ~	K-ESG
E	Pollution and waste	Toxic emissions and waste, packaging and waste, electronic waste	Emissions, waste, biodiversity, environmental management systems.	Eco-friendly products/services, eco-friendly businesses, ecosystem conservation	Waste emission, air pollutant emission, waste recycling ratio, water pollutant emission
	Weather change	Carbon emissions, funding environmental impacts, product carbon footprint, vulnerability to climate change		Identification of environmental risks and opportunities, climate change risks and opportunities, and risk management systems	GHG emissions (Scope 1 & Scope 2), GHG emissions verification, GHG emissions (Scope 3), forest carbon intake
	Natural capital	Lack of water,	Water, Energy,	Green supply chain,	Water usage, reuse water

Division		MSCI	Refinitiv	KCGS 2022 ~	K-ESG
		provision of raw materials, biodiversity and land use	Sustainable Packaging, Environmental Supply Chain	performance management, environmental accounting	ratio, raw material usage, renewable raw material ratio, energy usage, renewable energy usage ratio, energy efficiency
	Environmental opportunity	Opportunities for Clean Tech, Green Building, and Renewable Energy	Product innovation, green revenue, R&D and capital expenditure	Environmental information disclosure, stakeholder establishment, and stakeholder response activities	Proportion of eco-certified products and services, violation of environmental laws and regulations
	Environmental management plan			Environmental management governance, environmental management strategies and goals, and environmental management leadership.	Environmental management promotion system, environmental management goal establishment, goal establishment and disclosure
S	Human capital (workers, human rights)	Labor management, health and safety, human capital development, supply chain labor standards	Human rights, diversity and inclusion, career development and training, working conditions, health and safety	Human rights, labor practices, fair operational practices, sustainable consumption, information protection, community participation	Retention of new employment and employment, percentage of full-time employees, voluntary turnover, education and training, welfare, freedom of

Division		MSCI	Refinitiv	KCGS 2022 ~	K-ESG
				and development	association, human rights policy establishment, human rights risk evaluation, female membership ratio, female salary ratio (to average salary), percentage of full-time high school graduates
	Product Responsibility/Consumer	Product safety and quality, chemical safety, financial product safety, privacy and data security, responsible investment, health and demographic risks	Responsible marketing, product quality, data information protection	Sustainable consumption	Operation of consumer information provision, consumer safety, and customer satisfaction response system
	Shared growth			Fair operation practice	Partner ESG Management, Partner ESG Support, Partner ESG Agreement, Supply Chain Stabilization
	Stakehol	Controversi		Stakeholder	

Division		MSCI	Refinitiv	KCGS 2022 ~	K-ESG
	der commun ication	al Sources, Community Relations		engagement, disclosure of information	
	Commu nity		Equal importance for all industry groups, assign a median weight of 5 to all groups	Community Engagement and Development	Strategic social contribution, participation in member service, win-win cooperation and ESG activities in rural areas (balanced development), contribution to revitalization of industry-academi c cooperation, growth of future society and education.
	Social planning	Access to communicat ions, access to finance, access to healthcare, nutrition and health opportunitie s		Information protection, integrated management of non-financial risks, recognition of non-financial risks and opportunities, and response to non-financial risks	Violation of social laws/regulations, establishment of information protection system, personal information infringement and remedy, safety and health promotion system, industrial accident rate
	Sharehol der rights	Ownership and control	Shareholder Rights, Acquisition	Rights of shareholders	Announcement of convening a shareholders'

Division		MSCI	Refinitiv	KCGS 2022 ~	K-ESG
			Defense		meeting, holding other than the day of concentration of the shareholders' meeting, concentration/electronic/written voting system, dividend policy and implementation, management performance evaluation and compensation.
G	Board of Directors	Committees, Payments, Accounting	Structure (independence, diversity, committees), compensation	Roles and responsibilities of the board of directors, the roles and responsibilities of directors, the composition of the board of directors, outside directors, the operation of the board of directors, and the committee within the board of directors.	ESG agenda presentation within the board of directors, ratio of outside directors, separation of chairman of CEO board, gender diversity of the board of directors, expertise of outside directors, overall director attendance, in-house director attendance, board committees, board agenda handling, governance law/regulation

Division		MSCI	Refinitiv	KCGS 2022 ~	K-ESG
					violation
	Audit body	Business Ethics, Tax Transparency		Internal audit, external audit	Establishment of internal audit departments, expertise of audit organizations (accounting/financial experts in audit organizations), disclosure of violations of ethical norms, and compliance with laws/codes of conduct related to ethical management/anti-corruption, etc.
	Stakeholder Communication		CSR Strategy, ESG Reporting and Transparency	Direct communication with shareholders and stakeholders, disclosure of information	ESG information disclosure method, ESG information disclosure cycle, ESG information disclosure scope, ESG core issues and KPI, ESG information disclosure verification.

Data: ESG evaluation institutions' evaluation indicators were reconstructed by researchers by category.

1.4.3 Contributions of the K-ESG Guidelines

The contributions of the K-ESG guidelines are as follows. First, the K-ESG guidelines are an excellent guidebook for individual corporates to self-evaluate ESG. ESG evaluation indicators at home and abroad were not disclosed, so corporates could not self-diagnose themselves. Of course, The researcher needed to learn what was lacking and satisfying. Finding a solution was difficult because the researcher did not know the cause. However, the K-ESG guidelines guide individual corporates on what items to take for sustainable management. Second, the K-ESG guidelines can be an excellent guide to establishing environmental and social management goals for corporates that are running or intend to introduce ESG management. Third, the K-ESG guidelines provide individual corporates with mid- to long-term implementation guidance within five years, such as a one-year short-term plan and Compound Annual Growth Rate (CAGR), in comparing diagnostic items in governance, social and environmental pillars with industry averages. In other words, it allows individual corporates to compare their short-term performance with the industry average and set goals for improvement over the corporate's past performance.

1.4.4 What Needs to be Improved in the K-ESG Guidelines

The following are the improvements to the K-ESG guidelines. First, finding average industry statistics on sites guided by the K-ESG guidelines in the environmental domain takes much work. It is desirable for the government department that produced the K-ESG guidelines to organize the average industry statistics of the items and publish them on the website related to the K-ESG guidelines. Second, it is necessary to

promote or actively induce the disclosure of standardized information for stakeholders who have difficulty accessing information about individual corporates, such as corporate managers and institutional investors. For example, some corporates produce environmental figures required by the K-ESG guidelines due to differences in the methods described in the Sustainable Management Report. In contrast, others do not have them at all. Third, it is necessary to provide detailed guidance, such as application requirements and application exceptions among ESG diagnosis items by industry.

1.5 Implications and limitations

This study presents the following theoretical and practical implications. First of all, as a theoretical implication, it showed context's role in ESG evaluation and how important it is to consider that context. In other words, the K-ESG guidelines developed in the context of Korean corporates and regulatory environments by analyzing the evaluation methods of numerous global and Korean ESG evaluation institutions gave a higher ESG rating than MSCI. Similar results in the KCGS rating in 〈Table 1-10〉 suggest that ESG evaluation methods must be tailored to reflect the unique circumstances of different countries and regions. Second, the need for a standardized ESG evaluation method and examples of its successful application were suggested to the academic community. In other words, the significant gap between global and domestic evaluation institutions' ESG ratings suggests the need for a standardized ESG rating method that can provide reliable and comparable ESG ratings across various regions and evaluation institutions. As an example of such a standardized ESG evaluation method, the K-ESG guidelines established by the Korean government were suggested to the

academic community. Third, it implied that the government's role in promoting ESG evaluation is essential. In other words, the fact that the Korean government produced the K-ESG guidelines and used them in this study suggests the critical role of the government in promoting ESG evaluation and creating a standardized framework for evaluating corporate ESG performance. It has been demonstrated that governments can be essential in facilitating ESG evaluation and encouraging corporates to practice sustainability.

As for the remaining practical implications, first, it was the first paper to apply the K-ESG guidelines to actual corporates, showing the ease of applying the K-ESG guidelines. Second, it was shown that the K-ESG guidelines could narrow the large gap between global ESG evaluation ratings and ESG evaluation ratings in Korea. In other words, it is a paper that studies how to apply global ESG evaluation indicators. Third, difficulties and improvements in the K-ESG guidelines were proposed. Identifying these improvements will be helpful when revising the K-ESG guidelines in the future.

On the other hand, this paper has the following limitations. First, this study gave the same weight to governance, society, and the environment. However, since different weights need to be applied depending on the industry, if empirical weights are announced for each industry in the future, more sophisticated ESG evaluations should be made by applying optimized weights for each industry, such as financial, manufacturing, and distribution. Second, this study targeted three of the listed large corporates, but in the future, applying the K-ESG guidelines to mid-sized or small-sized corporates is necessary. Third, in this study, the K-ESG guidelines targeted three corporates in different industries. There needed to be more corporates covered. In future studies, it is necessary to simultaneously evaluate several corporates by industry to discover the

characteristics and insights of each industry when applying the K-ESG guidelines in practice.

1.6 Conclusion

This study aimed to compare ease of use and measurement results with existing ESG ratings by applying the K-ESG guidelines to three corporates. As a result of the study first provides clear and detailed criteria for setting ESG goals, which are the purpose of introducing the K-ESG guidelines and setting the direction of ESG practice. In particular, in environmental and social pillars that are challenging to understand, diagnostic items on the goal-setting and implementation system of environmental or social management provide a clear guide. Second, the K-ESG guidelines have 61 diagnostic items covering the evaluation indicators of leading global ESG evaluation institutions and KCGS in Korea and have 12 additional diagnostic items in line with global trends, which are suitable for domestic and international ESG evaluation standards. Third, the ESG evaluation rating of the K-ESG guidelines was lower than Refinitiv and higher than MSCI among global ESG evaluation institutions, and results were lower or similar to that of KCGS, a domestic ESG evaluation institution. Although it cannot be clearly said that the gap between domestic and international evaluation ratings, which was the research goal, is almost reflected in the global ESG evaluation index, it is believed to provide a direction to narrow the gap between domestic and international evaluation ratings. For example, the evaluation index of global ESG evaluation corporates, such as waste, pollutants, raw materials, greenhouse gases, and water in the environmental field, will be equipped to serve as a guide to corporates. Fourth, the ease of application of the K-ESG guidelines is considered high. It was easy to

measure because detailed descriptions of individual diagnostic items and methods to find data were described. However, detailed information can only be provided by the IR team of individual corporates if it is a professional evaluation institution for undisclosed information. Public relations and institutional mechanisms are needed so that information can be disclosed so that institutional investors can also evaluate themselves. Fifth, what needs to be improved in the K-ESG guidelines is. The government must compile average industrial statistics on diagnostic items in the K-ESG environment pillar and publish them on its ESG-only site. In addition, industry application weights of E, S, and G should be determined and disclosed.

This study studied that the K-ESG guidelines are easy to apply in practice, and ESG self-evaluation is possible only with published data. The K-ESG guidelines are considered a good guide to play a role as a lighthouse for corporates that have introduced or will introduce ESG when ESG information disclosure is mandatory and ESG-related regulatory bills are being pursued. Further studies on the K-ESG guidelines will likely continue, and a revised version of the K-ESG guidelines will be released to help domestic corporates achieve sustainable growth.

Appendix

〈Table 1-12〉 ESG Evaluation Table of the K-ESG guidelines_K Corporate

Pillar	Category	Diagnostic item	Score	Reason
P	Information Disclosure Format	ESG Information Disclosure Method	25	Distributed and disclosed ESG information in sustainability reports, the organization's website, other publications, and business reports
		ESG information disclosure cycle	100	In the case of publishing an annual report or disclosing ESG information
		Scope of ESG information disclosure	25	Disclosure of all or some ESG information of businesses legally directly owned by the corporate (ex. based on individual financial statements)
	Information Disclosure	ESG key issues and KPIs	100	Clearly define materiality evaluation results and core issues, and explain systems and procedures for managing core issues
	Information Disclosure Verification	ESG information disclosure verification	100	In the assurance statement, the third-party verification institution's verification information disclosure indicators are specified.
E	Environmental Management Goal	Establishment of environmental management goals	100	Establishment of mid- to long-term goals for the organization on key issues in the environmental sector, and preparation of tasks and performance check indicators to achieve mid- to long-term goals
		Environmental Management Promotion System	100	Satisfaction of 5 requirements for environmental management promotion
	Raw materials	Raw material consumption	0	Total consumption of raw and subsidiary materials by basic unit exceeded the average for the previous 3 years, trend of increase in total consumption of raw and subsidiary materials by basic unit for 4 years
		Percentage of recycled raw materials	0	There is no record of recycled raw materials on page 68 of the Sustainability Report.
	Green gas	Greenhouse gas emissions (Scope1 & Scope2)	0	Increase in GHG emissions per unit of intensity for the previous year compared to the average of the previous 3 years, increasing trend of GHG emissions per unit for the past 3 years
		Greenhouse gas emissions (Scope3)	0	Organization recognizes scope 3 category, measures emissions, has no third-party verification record
		Greenhouse Gas Emission Verification	100	Clarification of third-party verification institution's opinions on corporate GHG management
	Energy	Energy usage	0	Organizational past unit energy consumption exceeded the average of the previous 3 years, the trend of

Pillar	Category	Diagnostic item	Score	Reason
				increasing energy consumption in unit of unit over the past 4 years
		Ratio of renewable energy use	0	No data on renewable energy use in the Sustainability Report
	Water	Water consumption	0	The corporate's water consumption per basic unit has increased compared to the average of the previous three years, and the trend of increasing water consumption per basic unit over the past four years
		Percentage of reused water	50	Below the corporate's previous 3-year average, 4-year CAGR increase
	Waste	Waste emissions	0	Unit waste exceeds the average of the previous 3 years, increasing trend of unit waste over the past 4 years
		Waste recycling rate	100	The rate of waste recycling by basic unit exceeds the average of the previous three years, and the recycling rate of waste by basic unit is on the rise
	Pollutant	Air pollutant emissions	100	The average emission concentration of air pollutants in the previous year decreased compared to the average of the previous two years, and the average emission concentration of air pollutants in the three years decreased.
		Emissions of water pollutants	75	The average discharge concentration of water pollutants in the previous year was less than the average of the previous 3 years, and the average discharge concentration of water pollutants in the past 4 years was unchanged
	Violation of environmental laws and regulations	Violation of environmental laws/regulations	10	3 cases including environmental fines and fines in the past 5 years (-30 points * 3 = -90 points)
	Environmental labeling	Ratio of eco-friendly certified products and services	0	No related data disclosed
S	Target	Goal setting and disclosure	100	Set mid- to long-term goals related to core issues in the social sector of the corporate, including quantitative goals other than qualitative goals in the mid- to long-term goals
	Labor	Hiring and retaining employment	50	The new employment index in the previous year was less than the average of the previous three years, and the annual average employment

Pillar	Category	Diagnostic item	Score	Reason
				size increased over the previous four years
		Percentage of full-time employees	100	The percentage of full-time employees in the corporate exceeds 80%
		Voluntary turnover	0	No relevant data in published material
		Education and training expenses	25	Education and training costs for the previous year were less than the average for the previous 3 years, and there was no change in education and training costs for the past 4 years.
		Employee benefits	100	The per capita welfare cost in the previous year exceeded the average of the previous four years, and the trend of increasing per capita welfare cost in the past five years
		Guaranteed freedom of association	100	Labor union membership, establishment, collective bargaining, faithful implementation of collective agreements / Labor-management council held every 3 months, resolution (agreement)
	Diversity and Gender Equality	Percentage of female members	100	The difference between the ratio of female employees in the corporate and the ratio of females among non-registered executives is 20% or less
		Salary ratio for women (relative to average salary)	25	The ratio of the average wage per woman to the average wage per person in the corporate exceeds 60% to less than 80%
		Employment rate for people with disabilities	0	No relevant data in disclosure data
	Industrial safety	Safety and Health Implementation System	100	Satisfying 5 requirements of the safety and health promotion system
		Industrial accident rate	50	The industrial accident rate for the previous year was the same as the average for the previous three years, and there was no change in the industrial accident rate for the past four years.
	Human rights	Establishment of human rights policy	75	Explanation of 7~8 organizational policy approaches among issues related to human rights policy establishment
		Human Rights Risk Evaluation	100	Establishment of human rights risk evaluation system, non-face-to-face diagnosis and on-site inspection, improvement plans/improvement activities related to identified human rights risks

Pillar	Category	Diagnostic item	Score	Reason
	Shared growth	Supplier ESG Management	100	Establishment of ESG risk management system for suppliers, non-face-to-face diagnosis and on-site inspections, and promotion of identified risk improvement plans/improvement activities
		Supplier ESG Support	50	Confirm three requirements for ESG support for suppliers on pages 42-45 of the Sustainability Report
		Supplier ESG Agreement	0	No data related to promotion support among partner ESG agreements
	Community	Strategic Social Contribution	100	Satisfying 5 requirements for strategic social contribution
		Member Volunteer Participation	100	Introduced three or more employee volunteer participation incentive systems
	Information protection	Establishment of information protection system	0	No related information in the sustainability report
		Privacy Invasion and Remedy	100	No incidents or violations related to personal information infringement and remedy
	Violation of social laws and regulations	Violation of social laws and regulations	40	2 fines for violation of social laws/regulations (-30 points*2=-60 points)
G	Composition of the board of directors	Presenting ESG agenda within the board of directors	0	Currently, there is no ESG agenda presented by the board of directors or affiliated committees. ESG matters not specified in operating regulations of subcommittees
		Percentage of outside directors	75	Number of outside directors (3 or more), majority of outside directors, less than 70% to 80% outside directors ratio
		Separation of CEO and Chairman of the Board of Directors	0	CBD is CEO
		Board of Directors Gender Diversity	0	According to the 2020 business report, there are no female directors on the board of directors.
		Outside Director Expertise	50	At least one outside director with experience in the same industry
	Board activities	Attendance rate of all directors	100	Average attendance rate of all directors is 95% or higher

Pillar	Category	Diagnostic item	Score	Reason
		Inside director attendance rate	100	Average attendance rate of inside directors is 95% or higher
		Committees under the Board of Directors	50	Satisfying 3 requirements for committees under the Board of Directors
		Board agenda handling	0	There is no amendment, supplementation, or objection to the agenda.
	Shareholder rights	Announcement of convocation of meeting of shareholders	100	Using 4 or more additional methods in addition to notification methods in writing and electronic documents
		Held outside of the meeting of shareholders	50	Confirmation of 3 requirements related to avoiding the eeting of shareholders, other details unavailable
		Concentrated/ Electronic/ Written Voting System	0	Cumulative voting system, electronic voting system, and written voting system are all not introduced
		Dividend Policy and Implementation	100	Dividend policy and dividend plan notified to shareholders at least once a year, and dividends executed according to dividend policy and dividend plan
	Ethical management	Disclosure of violations of the Code of Ethics	100	Satisfying 5 requirements related to disclosure of violations of the Code of Ethics
	Audit body	Establishment of internal audit department	100	The internal audit department performs the role of supporting the audit committee independently of the organization
		Audit body expertise (accounting and finance experts within the audit body)	100	Appointment of at least one financial and accounting expert within the Audit Committee, exceeding 50% of all audit committee members
	Violation of governance laws and regulations	Governance Law/Regulation Violation	40	2 fines for violation of governance laws/regulations (−30 points * 2 cases = −60 points)
Pillar (4), category (27), basic diagnostic items (61)			55.2	BBB

Source: This is the result applied by the researcher to individual corporates according to the K-ESG guidelines v1.0 (2021.12)

〈Table 1-13〉 ESG Evaluation Table of the K-ESG guidelines_D Corporate

Pillar	Category	Diagnostic item	Score	Reason
P	Information Disclosure Format	ESG Information Disclosure Method	50	Integrated disclosure of ESG information on website, business report, sustainability report, and other publications
		ESG information disclosure cycle	100	Publication of annual reports, disclosure of ESG information
		Scope of ESG information disclosure	75	Disclosure of some ESG information, including those of subsidiaries within the corporate's sphere of influence/control. Presenting a plan to expand the scope of ESG information disclosure
	Information Disclosure	ESG key issues and KPIs	100	Materiality test results, definition of key issues and description of management system and procedures
	Information Disclosure Verification	ESG information disclosure verification	100	Timely disclosure of verification information by third-party verification institutions in the verification statement
E	Environmental Management Goal	Establishment of environmental management goals	100	Establish mid- to long-term goals related to key issues in the environmental field of the corporate, and prepare tasks and performance check indicators to achieve those goals
		Environmental Management Promotion System	100	Satisfaction of 5 requirements related to environmental management promotion
	Raw materials	Raw material consumption	100	Total consumption of raw and subsidiary materials by basic unit below the average for the previous 2 years, trend of decrease in total consumption of raw and subsidiary materials by basic unit for 3 years
		Percentage of recycled raw materials	100	Ratio of recycled raw and subsidiary materials use in the previous year Exceeded the average of the previous 2 years, increasing trend of use of recycled raw and subsidiary materials in the past 3 years
	Greenhouse gas	Greenhouse gas emissions (Scope1 & Scope2)	100	GHG emissions per unit of intensity in the previous year decreased compared to the average of the previous 2 years, trend of decrease in GHG emissions per unit of intensity over the past 3 years
		Greenhouse gas emissions (Scope3)	0	Recognition of organization's Scope 3 category, measurement of emissions, third-party verification None

Pillar	Category	Diagnostic item	Score	Reason
		Greenhouse Gas Emission Verification	100	Satisfying 5 requirements for verification of greenhouse gas emissions
	Energy	Energy usage	100	Organization's past unit energy consumption is less than the average of the previous two years, and the trend of decreasing energy consumption per unit for the past three years
		Ratio of renewable energy use	0	No data on renewable energy use rates
	Water	Water consumption	100	The corporate's water consumption per basic unit decreased compared to the average of the previous two years, and the trend of decreasing water consumption per basic unit over the past three years
		Percentage of reused water	75	Exceeds the corporate's previous 2-year average, no change in CAGR over the 3-year period
	Waste	Waste emissions	100	Unit waste is less than the average of the previous two years, and the trend of unit waste reduction over the past three years
		Waste recycling rate	0	Waste recycling rate by basic unit is below the average of the previous two years, and the recycling rate of waste by basic unit is decreasing
	Pollutant	Air pollutant emissions	0	The average emission concentration of air pollutants in the previous year has increased compared to the average of the previous two years, and the average emission concentration of air pollutants in the past three years has increased
		Emissions of water pollutants	25	The average discharge concentration of water pollutants in the previous year exceeded the average of the previous two years, and the average discharge concentration of water pollutants in the past three years remained unchanged
	Violation of environmental laws & regulations	Violation of environmental laws/regulations	100	No violations of environmental laws/regulations in the past 5 years.
	Environmental labeling	Ratio of eco-friendly certified products and services	0	No published data related to eco-certified products and services
S	Target	Goal setting and disclosure	100	Set mid- to long-term goals for key issues in the social domain of corporate, including qualitative /quantitative goals in those goals

Pillar	Category	Diagnostic item	Score	Reason
	Labor	Hiring and retaining employment	50	The new employment index in the previous year increased compared to the average of the previous three years, and the annual average employment size decreased in the previous four years
		Percentage of full-time employees	100	Percentage of full-time employees in the corporate exceeds 80%
		Voluntary turnover	100	The voluntary turnover rate in the previous year was below the average of the previous two years, and the voluntary turnover rate in the past three years was on the decline.
		Education and training expenses	0	Education and training costs for the previous year below the average for the previous two years, decreasing trend of education and training costs for the past three years
		Employee benefits	100	Welfare benefit expenses for the previous year Exceeded the average for the previous 2 years, increasing welfare benefit expenses for the past 3 years
		Guaranteed freedom of association	100	Collective bargaining, labor-management council, institutional improvement committee, concluded labor-management negotiations without disputes for 15 consecutive years
	Diversity and Gender Equality	Percentage of female members	100	Percentage of all female members of the organization - Percentage of non-registered female executives =< 20%
		Salary ratio for women (relative to average salary)	50	The ratio of the average wage per female to the average wage per person in the organization is between 60% and 80%
		Employment rate for people with disabilities	0	45% of the mandatory employment rate for the disabled in the previous year
	Industrial safety	Safety and Health Implementation System	100	Satisfying 5 safety and health promotion system requirements
		Industrial accident rate	0	The industrial accident rate in current year exceeded the industrial accident rate in previous 2 years, and the industrial accident rate has increased in the past 3 years
	Human rights	Establishment of human rights policy	100	The organization's policy approach is explained for at least 9 of the issues related to human rights policy establishment.

Pillar	Category	Diagnostic item	Score	Reason
		Human Rights Risk Evaluation	100	Establishment of human rights risk evaluation system, promotion of identified human rights risk improvement plans/improvement activities
	Shared growth	Supplier ESG Management	100	Establish a supplier ESG risk management system and promote identified risk improvement plans/improvement activities
		Supplier ESG Support	100	Satisfaction of 5 requirements for ESG support for suppliers
		Supplier ESG Agreement	100	Satisfaction of 5 requirements for ESG support for suppliers
	Community	Strategic Social Contribution	75	Satisfying 4 requirements related to strategic social contribution
		Member Volunteer Participation	100	Introduced three or more employee volunteer participation incentive systems
	Information protection	Establishment of information protection system	75	Satisfying 4 requirements related to information protection system establishment
		Privacy Invasion and Remedy	100	No incidents or violations related to personal information infringement and remedy
	Violation of social laws and regulations	Violation of social laws and regulations	100	No violations of social laws and regulations
G	Composition of the board of directors	Presenting ESG agenda within the board of directors	50	Currently, among ESG-related agendas for the past year, there are 'deliberation/decision' matters, and ESG cannot be confirmed in the operating regulations of the board of directors (subcommittee)
		Percentage of outside directors	50	3 or more outside directors, majority of total directors, 67% outside directors
		Separation of CEO and Chairman of the Board of Directors	0	CBD is CEO
		Board of Directors Gender Diversity	0	No female directors on the board
		Outside Director	0	No outside directors with experience in the same industry

Pillar	Category	Diagnostic item	Score	Reason
		Expertise		
	Board activities	Attendance rate of all directors	100	Average attendance rate of board members 95.4%
		Inside director attendance rate	75	Average attendance rate of inside directors 92.2%
		Committees under the Board of Directors	50	Satisfying the requirements of three committees under the board of directors
		Board agenda handling	0	No amendments, supplements, or objections to the agenda of the board of directors
	Shareholder rights	Announcement of convocation of meeting of shareholders	100	Using 4 or more additional methods other than written or electronic notification methods related to the convocation of the meeting of shareholders
		Held outside of the meeting of shareholders	50	Unable to confirm except for 3 holding requirements other than the meeting concentration day
		Concentrated/ Electronic/ Written Voting System	80	No cumulative voting system, introduction of electronic voting and written voting
		Dividend Policy and Implementation	100	Dividend policy and dividend plan Notification to shareholders of increase once a year, dividend execution according to dividend policy and dividend plan
	Ethical management	Disclosure of violations of the Code of Ethics	50	3 points related to the disclosure of violations of the Code of Ethics
	Audit body	Establishment of internal audit department	100	The internal audit department independently performs a supporting role for the audit committee. A separate dedicated department performs
		Audit body expertise(accounting & finance experts within the audit body)	50	Appointment of at least one accounting and finance expert within the audit committee, 50% or less of the audit committee members
	Violation of governance laws and regulations	Governance Law/Regulation Violation	0	2 fines and 2 fines related to governance law/regulation violation (−50*2, −30 points*2 = −160 points)
Pillar (4), category (27), basic diagnostic items (61)			67.7	A

Source: This is the result applied by the researcher to individual corporates according to the K-ESG guidelines v1.0 (2021.12)

〈Table 1-14〉 ESG Evaluation Table of the K-ESG guidelines_H Corporate

Pillar	Category	Diagnostic item	Score	Reason
P	Information Disclosure Format	ESG Information Disclosure Method	50	Integrated disclosure of ESG information on corporate websites, business reports, sustainability reports, and other publications
		ESG information disclosure cycle	100	Publication of annual reports, disclosure of ESG information
		Scope of ESG information disclosure	75	Scope of Organizational Influence/Control Disclosure of some ESG information of the corporate, proposal of expansion of the scope of ESG information disclosure
	Information Disclosure	ESG key issues and KPIs	100	Explanation of materiality test result/key issue management system and procedure
	Information Disclosure Verification	ESG information disclosure verification	100	According to the verification statement, the information disclosure indicators verified by the third verification institution are timely.
E	Environmental Management Goal	Establishment of environmental management goals	100	Set mid- to long-term goals for key issues in the organization's environmental field, prepare mid- to long-term goal achievement tasks/performance check indicators
		Environmental Management Promotion System	100	Satisfaction of 5 requirements of environmental management promotion system
	Raw materials	Raw material consumption	100	The consumption of raw and subsidiary materials by basic unit in the previous year was below the average of the previous 2 years, and the trend of decreasing raw and subsidiary material consumption by basic unit in the past 3 years
		Percentage of recycled raw materials	0	No data on recycled raw materials
	Green gas	Greenhouse gas emissions	100	GHG emissions per unit intensity for the previous year below the industry

Pillar	Category	Diagnostic item	Score	Reason
		(Scope1 & Scope2)		average for the current year, trend of decreasing GHG emissions per unit for the past 5 years
		Greenhouse gas emissions (Scope3)	100	Recognition of Scope 3 category of GHG emissions, emission calculation, fulfillment of 3 stages of emission verification
		Greenhouse Gas Emission Verification	100	Satisfying 5 GHG emissions verification requirements
	Energy	Energy usage	0	Organizational past unit energy consumption exceeded the average of the previous 3 years, and the unit energy consumption increased over the past 4 years
		Ratio of renewable energy use	0	No data
	Water	Water consumption	0	The corporate's water consumption per basic unit exceeds the average of the previous three years, and the increasing trend of water consumption per basic unit over the past four years
		Percentage of reused water	0	No data
	Waste	Waste emissions	50	The previous unit waste volume exceeded the average of 2 years ago, and the trend of unit waste reduction over the past 3 years
		Waste recycling rate	100	The rate of waste recycling by basic unit exceeds the average of the previous two years, and the recycling rate of waste by basic unit is on the rise
	Pollutant	Air pollutant emissions	100	The average emission concentration of air pollutants in the previous year decreased compared to the average of the previous two years, and the trend of decreasing emission concentration in the three years
		Emissions of water pollutants	0	No data on water pollutants
	Violation of environmental laws and regulations	Violation of environmental laws/regulations	100	No violations of environmental laws/regulations in the past 5 years.
	Environmental labeling	Ratio of eco-friendly certified	0	There is a ratio of eco-friendly vehicles, but there is no eco-certified product service data

Pillar	Category	Diagnostic item	Score	Reason
		products and services		
S	Target	Goal setting and disclosure	50	Set short-term goals for core issues in the social sector of the organization
	Labor	Hiring and retaining employment	50	The new employment index in the previous year was below the average of the previous two years, and the number of new hires increased in the previous three years
		Percentage of full-time employees	100	99.3% of full-time employees in the corporate
		Voluntary turnover	100	The voluntary turnover rate in the previous year was below the industry average for the year, and the voluntary turnover rate in the past four years has been on the decline.
		Education and training expenses	0	Education and training expenses for the previous year are below the average of the previous 3 years, and education and training expenses for the past 4 years are on the decline
		Employee benefits	0	Per capita welfare cost for the previous year was below the average for the previous three years, and the trend of decreasing per capita welfare cost for the past four years
		Guaranteed freedom of association	25	There are labor unions and collective agreements, but the details are not confirmed. Mentioned only slightly in the Sustainability Report
	Diversity and Gender Equality	Percentage of female members	75	Ratio of female employees - Ratio of female unregistered executives = 29%
		Salary ratio for women (relative to average salary)	75	Ratio of average wage per woman to average wage per person 82%
		Employment rate for people with disabilities	0	Employment rate for people with disabilities/ legally required employment rate = 42%
	Industrial safety	Safety and Health Implementation System	100	All 5 safety and health promotion system requirements
		Industrial accident rate	0	The industrial accident rate for the previous year was the same as the average for the previous three years, and the industrial accident rate for the past four years has increased
	Human rights	Establishment of human rights policy	100	Explaining the organizational policy approach direction for more than 9 of the human rights policy issues

Pillar	Category	Diagnostic item	Score	Reason
		Human Rights Risk Evaluation	100	Establishment of human rights risk evaluation system, promotion of identified human rights risk improvement plans/improvement activities
	Shared growth	Supplier ESG Management	0	Nothing related
		Supplier ESG Support	100	Creating an ecosystem for shared growth with SMEs, discovering/nurturing startups, supporting R&D for SMEs, etc.
		Supplier ESG Agreement	100	Creating an ecosystem for shared growth with SMEs, discovering/nurturing startups, supporting R&D for SMEs, etc.
	Community	Strategic Social Contribution	100	Satisfying 5 requirements for strategic social contribution
		Member Volunteer Participation	100	Introduced three or more volunteer activity participation incentives
	Information protection	Establishment of information protection system	0	The cyber security management system is strengthened, but other information cannot be confirmed
		Privacy Invasion and Remedy	100	No incidents or violations related to personal information infringement and remedy
	Violation of social laws and regulations	Violation of social laws and regulations	0	3 penalties for violation of social laws/regulations (-50 points*3=-150 points)
G	Composition of the board of directors	Presenting ESG agenda within the board of directors	75	Currently, there is a 'deliberation/decision'among ESG-related agendas for the past year, the contents of the ESG Committee's operating regulations have not been confirmed
		Percentage of outside directors	25	8 social directors, majority of outside directors, 53% outside directors ratio
		Separation of CEO and Chairman of the Board of Directors	100	An outside director is CBD
		Board of Directors Gender Diversity	50	2 female directors, 13%
		Outside Director Expertise	50	At least one outside director with experience in the same industry

Pillar	Category	Diagnostic item	Score	Reason
	Board activities	Attendance rate of all directors	100	Average attendance rate of board members 98.4%
		Inside director attendance rate	100	Average attendance rate of inside directors 100%
		Committees under the Board of Directors	100	Satisfying 5 requirements for committees under the Board of Directors
		Board agenda handling	0	Agenda amendment, supplementation, no dissenting opinion
	Shareholder rights	Announcement of convocation of meeting of shareholders	100	Use of 4 or more additional methods other than written or electronic documents for notice of convocation of shareholders' meeting
		Held outside of the meeting of shareholders	50	Unconfirmed other than 3 requirements related to holding other than the day of concentration of shareholders' meeting
		Concentrated/Electronic/Written Voting System	100	Cumulative voting, electronic voting, and written voting were all introduced.
		Dividend Policy and Implementation	100	Dividend policy and dividend plan notification to shareholders once a year, dividend execution based on dividend policy and dividend plan
	Ethical management	Disclosure of violations of the Code of Ethics	100	Satisfaction of 5 items related to disclosure of violations of the Code of Ethics
	Audit body	Establishment of internal audit department	100	The internal audit department supports the audit committee independently of the organization
		Audit body expertise (accounting and finance experts within the audit body)	50	Appointment of at least one accounting/financial expert within the audit committee, 50% or less of the audit committee members
	Violation of governance laws and regulations	Governance Law/Regulation Violation	100	Governance No violations of laws/regulations
Pillar (4), category (27), basic diagnostic items (61)			64.8	A

Source: This is the result applied by the researcher to individual corporates according to the K-ESG guidelines v1.0 (2021.12)

Chapter 2. Efficiency Comparison of ESG Management Corporates Using Meta-frontier: Focusing on TCFD Calculated from the K-ESG Guidelines*

ESG management to reduce greenhouse gases(GHG) is an essential strategy for corporate management. However, studies on TCFD scores and corporate efficiency on GHG were rare in Korea. Therefore, in this study, the level of GHG reduction implementation of 84 securities-listed corporates that released sustainability management reports were evaluated using the evaluation criteria of the K-ESG guidelines. In addition, the target corporates were divided into non-financial corporates, non-financial public corporates, and financial corporates, and the efficiency of each group was compared using a meta-frontier with TCFD scores and ESG scores set as input variables and output variables. As a result of the study, first, the GHG implementation rate is 57%. Second, the GHG implementation rate of financial corporates was 62%, which was relatively good compared to 56% of non-financial corporates. Third, the order of meta-frontier efficiency under VRS was financial corporates(99.5%), non-financial public corporates(96.2%), and non-financial corporates(95.0%). Fourth, as a cause of inefficiency, pure technological inefficiency was the main factor for three types of groups. As a contribution point of this study, first, an approach to measure TCFD scores using the K-ESG guidelines was introduced to corporates. Second, the efficiency of financial corporates with high TCFD scores was

* This essay was published in Cho & Lee (2023), Efficiency Comparison of ESG Management Corporates Using Meta-frontier: Focusing on TCFD calculated from the K-ESG Guidelines, Management Science and Financial Engineering 40(2)

higher than that of non-financial corporates, implying that non-financial corporates should be more active in reducing GHG emissions.

【Keywords】*ESG, TCFD, Greenhouse Gas, Meta-Frontier, K-ESG Guidelines*

2.1 Introduction

For five years from 2016, global carbon emissions have increased by 20% annually, with sea levels rising by more than 3.3mm. Global temperatures are also expected to increase by 3.4℃ by 2100(Demers & Metzner, 2021). Over the past 100 years, Korea's average temperature has increased by 1.8° C, higher than the global average temperature(0.8° C to 1.2° C), and the average annual precipitation has increased by about 160mm. The polarization of precipitation intensified, and the sudden rainfall aggravated the damage. In addition, summer has become longer, and winter has become shorter in the last 30 years(1988-2017) compared to the past 30 years(1912-1941)(IPCC, 2021). To prevent such a rise in global temperature, the international community adopted the Kyoto Protocol, which mandated developed countries, in 1997, and the Paris Agreement, in which both developing and developed countries participated, in 2015. The Paris Agreement decided to keep the global average temperature increase much lower than the 2° C increase compared to before industrialization and finally try to suppress it to 1.5° C.

Moreover, through the UN Climate Summit in 2019, 121 countries joined the Climate Goal Upward Alliance according to the '2050 Carbon Neutrality Global Agenda'. The G20 Financial Stability Board(FSB) formed a Taskforce on Climate-related Financial Disclosures(TCFD) based on the Paris Agreement, which advocated a scenario for achieving the 2° C goal. It was recommended that all corporates, including financial corporates, transparently disclose financial risk information related to climate change. The Ministry of Environment of the Republic of Korea supported TCFD in May 2020(The Government of Korea, 2020).

According to the Republic of Korea Policy Briefing(2022), the Korean government joined the above climate target upward alliance. In

2021, the 'Framework Act on Carbon Neutrality Green Growth to Response to the Climate Crisis (after this, referred to as the Framework Act on Carbon Neutrality)' was enacted. According to this law, by 2030, it aims to reduce 40 percent of national GHG emissions compared to 2018 and prepares and discloses an annual inspection report. Carbon neutrality equals the amount of carbon emitted and the amount of carbon absorbed so that the net amount of carbon emitted is zero, and carbon neutrality is called net zero(Korea Policy Briefing, 2021).

Meanwhile, the Financial Services Commission announced a schedule for mandatory disclosure of ESG reports in 2021. First, concerning the disclosure of the corporate governance report, from January 2021, KOSPI-listed corporates with assets of 2 trillion won or more must make mandatory disclosure, and from 2022, corporates with assets of 1 trillion won or more will be subject, and from 2024, corporates with assets of 50 billion won or more, and from 2026, all KOSPI-listed corporates are eligible. On the other hand, KOSPI-listed corporates are subject to voluntary disclosure of the Sustainable Management Report by 2024, and from 2025, KOSPI-listed corporates with assets of 2 trillion won or more must disclose Sustainable Management Report. From 2030, all KOSPI-listed corporates must disclose Sustainable Management Report(Financial Services Commission, 2021a). In this way, as the Carbon Neutral Framework Act was implemented and the disclosure obligation for sustainable management was institutionalized, corporates' response to carbon neutrality became a necessity rather than an option. However, even though TCFD activities related to GHG are activities that all corporates must introduce in the future according to the Framework Act on Carbon Neutrality and the schedule for mandatory disclosure of sustainability reports as described above. According to the Korea Standards Association's sustainability report statistics, as of 2020, only

138 corporates self-disclose sustainability reports for various reasons, such as entailing additional costs(Sustainability Report statistics, 2022).

Several recent studies have shown many research results using the TCFD framework related to GHG information disclosure, but they show different results. For example, Luo(2019) showed that there is a negative relationship between voluntary carbon information disclosure and carbon emission performance. On the other hand, Giannarakis et al.(2017) showed that high levels of climate information disclosure were associated with better carbon performance. Suortti(2021) found that using the TCFD framework had a negative relationship with the cost of equity in environmentally sensitive firms. Ding et al.(2022) studied that corporates with high carbon emissions, by TCFD principles, are fulfilling their corporate responsibility by increasing climate-related disclosure. Among the above studies related to the TCFD framework, it is judged that there are no studies on carbon emission performance and corporate efficiency, at least from the researcher's viewpoint.

Therefore, this study calculated the TCFD score, which indicates the level of GHG implementation, for corporates that have disclosed their sustainability reports among listed corporates in Korea, and used the value to compare and verify the efficiency of different industries. Efficiency refers to using the same resources to produce more or better results and using fewer resources for the same output(Seo, 2005). This study aims to evaluate TCFD's implementation level to reduce GHG emissions for 84 securities-listed corporates that disclose sustainability management reports and to compare the efficiency of each group through a meta-frontier. Looking at the purpose of the study in more detail, first, this study targeted Korean financial corporates, non-financial corporates, and non-financial public corporates that disclosed their sustainable management report. The division is divided into three groups because it is

necessary to distinguish between financial corporates that the Financial Supervisory Service supervises in addition to shareholders of financial corporates because of the public nature of protecting financial consumers and non-financial corporates.

Moreover, among non-financial corporates, it is necessary to distinguish public corporates that are subject to management and supervision by government-related organizations from corporates. In other words, regarding ESG's governance structure, corporates were distinguished according to differences in shareholders or stakeholders that could affect the corporate's unique ESG management. For these corporates, the level of TCFD implementation was checked using three evaluation indicators related to GHG in the K-ESG guidelines released by the Korean government in December 2021. Second, the Scope 1 & Scope 2 score, which measures direct GHG emissions, and the Scope 3 score, which measures indirect GHG emissions, were evaluated separately, and the level of third-party verification of GHG emissions was evaluated. Third, the TCFD score derived from the K-ESG guidelines was set as the input variable, the ESG rating score given by ESG evaluation institutions was set as the output variable, and the efficiency of the three groups was compared using a meta-frontier that can compare the efficiency of different industries. Therefore, it was verified how much the level difference was in the efficiency of the group with a relatively high TCFD score compared to the group that did not.

Compared to previous studies, this study has the following two academic contributions. First, among the TCFD indicators, the level of disclosure related to self-inspection and third-party verification, such as Scope1, Scope2, and Scope3, was evaluated, and the efficiency of each group was compared using the TCFD score as a meta-frontier variable. Activities to reduce GHG emissions can be regarded as a net increase in

costs rather than sales expansion, so it is meaningful to compare the difference in efficiency between groups with excellent GHG performance compared to groups with poor performance. In addition, this study is meaningful in comparing the efficiency and evaluation of GHG performance scores in non-financial and financial sectors, which are different industrial groups. As a basis for comparing the efficiency of different industries, the TCFD recommendation is a practical method that can be applied not only to the non-financial sector but also to the financial sector(TCFD, 2017). In addition, meta-frontiers can be used to compare the technological efficiency of different industries, regions, or countries(Kang & Kim, 2010). In other words, studies comparing the efficiency of different regions(Kang & Kim, 2010; Seo & Shin, 2015; Abid & Goaied, 2017; O'Donnell et al., 2008), studies comparing different financial industries(Cho, 2017; Johnes et al., 2014), and studies comparing the productivity of hydropower and thermal power generation(Wang et al., 2021).

SPSS 27 was used for descriptive statistics, correlation analysis, and Kruskal-Wallis analysis in this study. Also, MaxDea 8.0 was used for a meta-frontier analysis. The composition of this study is in the order of preceding research, research methodology, empirical analysis, discussion, implications and limitations, and conclusion.

2.2 Literature Review

2.2.1 Carbon Neutrality

Carbon Neutrality(Net Zero) refers to a state in which the amount of net emissions obtained by subtracting the amount of GHG absorption from the amount of GHG emitted or leaked into the atmosphere becomes zero(Framework Act on Carbon Neutrality and Green Growth

to Respond to the Climate Crisis, 2021). GHG refers to gaseous substances in the atmosphere that cause greenhouse effects by absorbing or re-emitting infrared radiant heat, such as carbon dioxide(CO2), nitrous oxide(N20), methane(CH4), and perfluorocarbons(PFC-S), hydrofluorocarbon(HFC-S), and sulfur hexafluoride(SF6). These GHG emissions measurements are made through Scope 1, Scope 2, and Scope 3. First, Scope1 GHG refers to direct GHG emissions from sources owned or controlled by corporations. Scope1 GHG emissions are calculated as the sum of GHG emissions generated through mobile combustion, fixed combustion, evasion, process emissions, and waste disposal. Scope 2 GHG refers to indirect GHG emissions generated during the production of heat or power, such as hot water steam used or purchased by a corporate, and the method of calculating the emissions is the sum of GHG generated through the purchase of heat or electricity. Finally, Scope 3 GHG refers to indirect GHG emissions from value chains outside the workplace that the organization does not manage or own. Although it is not subject to reduction obligations like Scope 1 and 2, the need to manage Scope 3 GHG is increasing. Scope 3 is also essential, especially for organizations that outsource most business operations(Ministry of Trade, Industry and Energy & Korea Productivity Center, 2021).

In response to carbon neutrality at home and abroad, some countries have legislated 'carbon neutrality' first. For example, Sweden enacted the legislation first in 2017, followed by the United Kingdom, France, Denmark, and New Zealand in 2019, Hungary in 2020, and the Republic of Korea in 2022. In addition, significant countries such as Europe, China, and Japan have declared carbon neutrality targets. On the other hand, the United States announced that it would be Carbon

Neutrality by 2050 after President Joe Biden rejoined the Paris Agreement(Joint Ministries, 2022).

2.2.2 TCFD(Taskforce on Climate-related Financial Disclosures)

In 2015, the Financial Stability Board, which serves as an international financial regulator and supervisor under the G20, established a consultative body called TCFD to help stakeholders make more complete decisions by disclosing financial information related to climate change by corporations. TCFD recommends quantitatively quantifying climate change-related risks and opportunity factors that may affect corporates, integrating them financially, and disclosing them(Achenbach, 2021).

The TCFD recommendation focuses on four key factors: Governance, Strategy, Risk Management, and Metrics and Targets, as shown in 〈Table 2-1〉, but recommends additional guidance to the financial sector in addition to disclosure guidelines on climate change for non-financial sectors. The TCFD Implementation Guidance presents practical methods for the financial sector to implement the TCFD recommendations and methods for implementing the TCFD recommendations in the non-financial sector(TCFD, 2017). The main contents of the TCFD on the disclosure of financial information related to climate change are as follows. As a first factor, the board of directors should manage and supervise climate-related opportunities and risks as necessary disclosures related to governance and disclose management's role in assessing and managing climate-related opportunities and risks. As a second factor, a strategy should disclose opportunities and risks associated with climate change by a period in the short, medium, and long term and the Impact of climate-related opportunities and risks on sales, strategy, and financial planning. Finally, the Impact of various climate-related scenarios on sales,

strategy, and financial planning should be disclosed. As a third factor, risk management should identify, assess, and disclose procedures for managing climate-related risks. It should also disclose how to integrate risk management systems, such as identifying, assessing, and managing climate-related risks. As the final fourth factor, metrics and targets should disclose metrics for assessing or managing climate-related opportunities and risks. In addition, risks related to GHG emission information, such as Scope1, Scope2, and Scope3, should be disclosed. Finally, targets and achievements for climate-related opportunity and risk management should be disclosed.

〈Table 2-1〉 TCFD Highlights

Division	Key Disclosures
Governance	·The board of directors manages and supervises climate-related opportunities/risk ·The role of management in evaluating and managing climate-related opportunities/risk
Strategy	· Opportunities and risks related to climate change by period (short/medium/long) · Impact of climate-related opportunities/risk on sales/strategy/financial planning · Impact of various climate-related scenarios on sales/strategy/financial planning
Risk Management	·Climate risk identification/evaluation/management procedures ·How to integrate the risk management system for climate risk identification/evaluation/management
Metrics & Targets	·Indicators for evaluating/managing climate-related opportunities/risk ·Risk related to GHG emission information(Scope 1, 2, 3) ·Targets and achievements for climate-related opportunities/risk management

Source: Financial Services Commission(2021a)

2.2.3 Previous Study on TCFD

Previous studies on TCFD were conducted in four types: TCFD evaluation, TCFD and corporate management, TCFD, and information disclosure, and GHG reduction measures.

First, as a TCFD evaluation, Eccles & Krzus(2019) assessed the difficulty of implementing the TCFD recommendations. However, it is possible for corporates in individual sectors interested in reducing GHG emissions to realize the recommendations of the TCFD. Carney(2019) conducted a study to provide the necessary foundation for the role of financial institutions in achieving zero GHG emissions. He said that the quantity and quality of disclosure should be increased by sharing best practices as a foundation. TCFD disclosure recommendations should be improved to be the most valuable recommendations for investors' decision-making. R. Siew(2020) conducted a study on TCFD in the real estate and construction industries and argued that a network should be set up so that the industry can share the best practices of TCFD. In addition, several researchers have studied the outlines and drivers of TCFD practices or practical practices in Finland, Norway, Sweden, and Malaysia(Dyakova, 2021; Middleton, 2020; Siew, 2021).

Moreover, as for TCFD and corporate management, Staker et al. (2017) stated that compliance with TCFD recommendations provides commercial benefits to corporations and their board of directors, and non-disclosure of information will likely expose them to greater liability. Bouma(2021) examined the relationship between voluntary disclosure of climate-related financial information and corporate capital costs for US corporates between 2015 and 2020, saying that the increase in voluntary climate-related financial disclosure did not affect debt costs and that

TCFD signatures increase corporate equity costs for non-ESG-run corporates. Nag et al.(2021) stated that investors are introducing a carbon conversion risk premium into the stocks of corporates that have reduced their carbon footprint. Suortti(2021) studied the relationship between the TCFD framework and the cost of equity capital of corporates listed on the Australian Stock Exchange and found that using the TCFD framework showed a significant reduction in the cost of equity capital.

In addition, as TCFD and information disclosure, Achenbach(2021) studied the determinants affecting the information disclosure level by TCFD recommendations. Policies, legislative reform, the goals of adapting the strategy, the availability of data, and TCFD recommendations were identified as determinants. Demers & Metzner(2021) studied the initial disclosure of TCFD, saying market participants needed to understand TCFD and pay more attention to corporate TCFD reporting, so they did not fully consider disclosure. Lastly, as a GHG reduction plan, Choi et al.(2012) studied a response plan to the GHG reduction policy of power generation corporates, suggesting that fossil fuels should be reduced in the power generation sector and an eco-friendly fuel mix should be established. Noh(2014) studied GHG reduction measures in the household sector and analyzed the emission structure in which energy consumption factors in the household sector affect GHG emissions. Cho(2017) studied the change factors of carbon dioxide emissions in electricity generation in Korea from 1990 to 2016 and said that during that period, carbon dioxide increased, and the primary fuel was thermal power generation.

2.2.4 Previous Study on Meta-frontier

Previous researchers conducted various studies using meta-frontiers. Lee & Yoon(2019) studied the efficiency of private colleges by region.

Seo & Shin(2015) compared the productivity of tourist hotels for foreign tourists by region. Choi(2016) studied the operational efficiency of the local culture and tourism festival. In addition, Song & Ha(2017) examined the efficiency of food materials distribution and logistics corporates, and Park(2019) studied the efficiency of each coffee shop franchise headquarters. In addition, Park(2016) analyzed port clustering, and Oh et al.(2019) examined the marketing efficiency of global car brands. In addition, Bos & Schmiedel(2003) and Abid & Goaied(2017) studied the efficiency of financial institutions in a group.

2.3 Research Methodology

2.3.1 TCFD Evaluation with the K-ESG Guidelines

On December 1, 2021, the Ministry of Trade, Industry, and Energy created the K-ESG guidelines to help Korean corporates' ESG management by integrating ministries. The diagnosis item system of the K-ESG guidelines consists of 27 categories and 61 diagnosis items in the four pillars of information disclosure(P), environment(E), social(S), and governance(G)(Ministry of Trade, Industry and Energy & Korea Productivity Center, 2021). This study used three GHG-related evaluation items among the environmental pillars of the K-ESG guidelines to diagnose the TCFD GHG score. The first evaluation method considers whether the current GHG emission level of Scope 1 & Scope 2, which checks whether or not to reduce GHG emissions within the boundaries of the organization, increases or decreases compared to the past by 50%(Equation 2-1) GHG emissions were evaluated considering the degree of increase or decrease of the average annual growth rate as 50%. The Compound Annual Growth Rate (CAGR) is the compound annual growth rate for the target period. The CAGR formula is (Equation

2-1)(Ministry of Trade, Industry and Energy & Korea Productivity Center, 2021).

$$CAGR(t_0,t_n) = (\frac{V(t_n)}{V(t_0)})^{\frac{1}{t_n - t_0}} - 1 \quad (Equation\,2-1)$$

$V(t_n)$ is the last year's value & $V(t_0)$ is the first year's value.

The second evaluation method is Scope3, which checks whether GHG emissions occurring outside the organization's boundaries are reduced. The sum of applying 1/3 of whether Scope 3 was not recognized, calculated, or verified at all, partially, or the whole evaluated. For example, the evaluation score for Scope 3 is 100 out of 100. However, since the highest score of the three items above is 100 points, adding each item together gives 300 points, so the value calculated as 1/3 of each item score was added to create a Scope3 score.

The third evaluation method evaluated whether or not a GHG verification statement was prepared to confirm that the GHG data's reliability, validity, and transparency were secured. As shown in 〈Table 2-2〉, the K-ESG guidelines recommend using five years of data. According to the recommendation to use five years of data, securing sustainability reports disclosed for three consecutive years is necessary. However, corporates' recently published sustainability reports have disclosed only three-year data. Therefore, this study used a three-year CAGR to check the TCFD implementation of a few more corporates.

〈Table 2-2〉 Evaluation Index of GHG Category in Environment Pillar of the K-ESG guidelines

Item	Item Description	Inspection criteria	Application method
GHG emissions (Scope1 &	·Check whether greenhouse gas emissions are reduced within	·Current level (1/2): Stage 1 (the previous year exceeds the average of the past	Calculate the weighted average score for each stage of 2 areas

Item	Item Description	Inspection criteria	Application method
Scope2)	the boundaries of organization ownership, management, and control ·Check greenhouse gas emissions with the concept of 'unit' for relative comparison	year), Stage 2 (the same as the previous year), and Stage 3 (less than the previous year) ·Trend (1/2): Stage 1 (5-year average annual growth rate) +%), Stage 2 (CAGR 0), Stage 3 (CAGR -%)	(1st stage 0 points, 2nd stage 50 points, 3rd stage 100 points) = Current level check base score*1/2 + Trend check base score*1/2
GHG emissions (Scope3)	·Check for reduction of greenhouse gas emissions from outside the organization ·Check the level of effort to manage Scope3 recognition/calculation/verification performance	·Category recognition (1/3): Stage 1 (recognition X), Stage 2 (partial recognition), Stage 3 (all recognition) ·Emission calculation (1/3): Stage 1 (measurement X), Stage 2 (measurement of some workplaces), Stage 3 (measurement of all workplaces) ·Emission verification (1/3) Stage 1 (third party verification X), Stage 2 (some measurement values verification), Stage 3 (all measurement values verification)	Results of application of inspection criteria (1st stage 0 points, 2nd stage 50 points, 3rd stage 100 points) Applied 1/3 each = (category recognition score + emission calculation score + emission verification score) *1/3
GHG emissions verification	·Check whether greenhouse gas data is reliable, valid, and transparent · Inspection of the formal requirements of third-party verification opinions	·Specify the verification institution ·Presentation of verification standards ·Revealing ESG information verification levels ·Specify the scope of verification of greenhouse gas emissions ·Specify opinions of third-party verification institutions	Points are assigned to the number of items that meet the selection requirements (0 points or less, 25 points for 2 points, 50 points for 3 points, 75 points for 4 points, 100 points for 5 points)

Source: Ministry of Trade, Industry and Energy & Korea Productivity Center(2021).

2.3.2 Meta-frontier Analysis

Meta frontier means the efficiency that covers the efficiency of each group by composing decision-making units(DMUs) that use the same production function in the same group and obtain the efficiency for the same group(Park, 2016; Kim et al., 2011). After Hayami(1969) presented the theory, Battese & Rao(2002) embodied the meta frontier with DEA (Data Envelopment Analysis) and SFA(Stochastics Frontier Approach) methods. Through the group frontier, meta-frontier efficiency within the group, technological efficiency within the group, and technology gap ratio were separated. This meta-frontier has the advantage of being able to compare different production functions(Seo & Shin, 2015). After grouping DMUs that use technologies of similar nature into one group, Meta Frontier derives production frontiers(T1, T2, T3,???, Tn) within each group. Then, create a meta-frontier production function (T*) that envelops the production frontiers of the corresponding group at various points in time. Using the derived meta-frontier production function, researcher can compare the efficiency between groups by comparing the production function of different groups with different technologies to measure the position of efficiency within the group by individual DMUs(Kang & Kim, 2010; Kang & Choi, 2018; Choi, 2017; Cho et al., 2021).

In the existing probability change approach, comparing technical efficiency(TE) between groups with different production functions was impossible, but Meta Frontier enables efficiency comparison in business groups with different production functions(Choi et al., 2012; Oh et al., 2013). Referring to previous studies, the researcher cites the process of deriving the meta frontier and explaining the mathematical approach through the necessary formulas. Assuming that groups with different production functions exist, the simple probability change model of the

k-th group is shown in Equation (2-2) below. $y_{i(k)}$ in Equation (2-2) is the calculation vector of the i-th DMU in the k-th group and means the natural logarithm of the operating profit and the natural logarithm of the ESG score in this study. $x_{i(k)}$ is the input vector, which is the natural logarithm of the selling and administrative expenses and the natural logarithm of the TCFD score in this study. Also, β_k is a measured unknown parameter related to the k-th group.

$$y_{i(k)} = e^{x_{i(k)}\beta_{k+}v_{i(k)} - u_{i(k)}} \quad (2-2)$$

In addition, the total error term is divided into an arbitrary probability error term $v_{i(k)}$ and a technical inefficiency error term $u_{i(k)}$. $v_{i(k)}$ is an independent probability distribution with the same distribution of $N(0,\sigma_{v(k)}^{2})$ as a normal error term. $u_{i(k)}$ is a non-negative probability variable that describes the technical inefficiency error associated with production, assuming an independent distribution cut at 0 of $N(u_{i(k)},\sigma_{u(k)}^{2})$. Each parameter is measured with the Maximum Likelihood Estimation, and the technical efficiency value is derived from the Combined Error Term(Oh et al., 2013, Choi, 2017; Choi, 1997). Here, if there is no error term in the technology efficiency, the group frontier considering the arbitrary error term on the frontier curve is shown in Equation (2-3) below(Assaf et al., 2010; Oh et al., 2013).

$$y_{i(k)}^{*} = e^{x_{i(k)}\beta_{k+}v_{i(k)}} \quad (2-3)$$

Here, when the actual output of the k-th group and the group frontier output are defined, the technical efficiency(TE) of the individual production unit is shown in Equation (2-4) below(Battese et al., 2004; Oh et al., 2013; Seo et al., 2015).

$$TE_{i(k)} = \frac{y_{i(k)}}{y_{i(k)}^{*}} = \frac{e^{x_{i(k)}\beta_k + v_{i(k)} - u_{i(k)}}}{e^{x_{i(k)}\beta_k + v_{i(k)}}} = e^{-u_{i(k)}} \quad (2-4)$$

O'Donnell et al.(2008) defines the probability frontier production function as in Equation (2-5), where y_i^* is the output of the meta frontier. β^* is the metafrontier variable vector(Oh et al., 2013).

$$y_i^* = f(x_{1i}, x_{2i}, \cdots, x_{Ni}; \beta^*) e^{v_{i(k)}} = e^{x_{i(k)}\beta^* + v_{i(k)}} \quad (2-5)$$

In Equation (2-5), since the meta-frontier includes the group frontier, it has the same relationship as Equation (2-6) and Equation (2-7). Equation (2-5) means that the meta-frontier always envelops individual group frontiers and exists on them.

$$y_i^* = e^{x_{i(k)}\beta^* + v_{i(k)}} \geq y_{i(k)}^* = e^{x_{i(k)}\beta_k + v_{i(k)}} \quad (2-6)$$

$$x_{i(k)}\beta^* \geq x_{i(k)}\beta \quad (2-7)$$

Meanwhile, meta technical efficiency can be derived by comparing the output located in the meta-frontier with the actual output. Meta-technical efficiency is defined as the actual output divided by the meta-frontier. It can be expressed as Equation (2-8).

$$TE_i^* = \frac{y_{i(k)}}{y_i^*} = \frac{y_{i(k)}}{y_{i(k)}^*} \cdot \frac{y_{i(k)}^*}{y_i^*} = e^{-u_{i(k)}} \times \frac{e^{x_{i(k)}\beta_k}}{e^{x_{i(k)}\beta^*}} \times e^{x_{i(k)}\beta^* + v_{i(k)}} \quad (2-8)$$

In Equation (2-8), meta-technology efficiency can be divided into group technology efficiency in the first term and technology gap ratio (TGR) in the second term. O'Donnell et al.(2008) refers to the technology gap ratio (group frontier ratio to potential meta frontiers) related to the i-th observation of the k-th group as shown in Equation (2-9), and the value is expressed as the meta technology ratio with a value between 0 and 1(Song & Ha, 2017; Oh et al., 2013).

$$TGR_{i(k)} = \frac{e^{x_{i(k)}\beta_k}}{e^{x_{i(k)}\beta^*}} \quad (2-9)$$

Therefore, the technological efficiency of Meta Frontier(TE_i^*) is as shown in Equation (2-10). Meta Frontier's technological efficiency is decomposed into group efficiency($TE_{i(k)}$) and technology gap ratio($TGR_{i(k)}$).

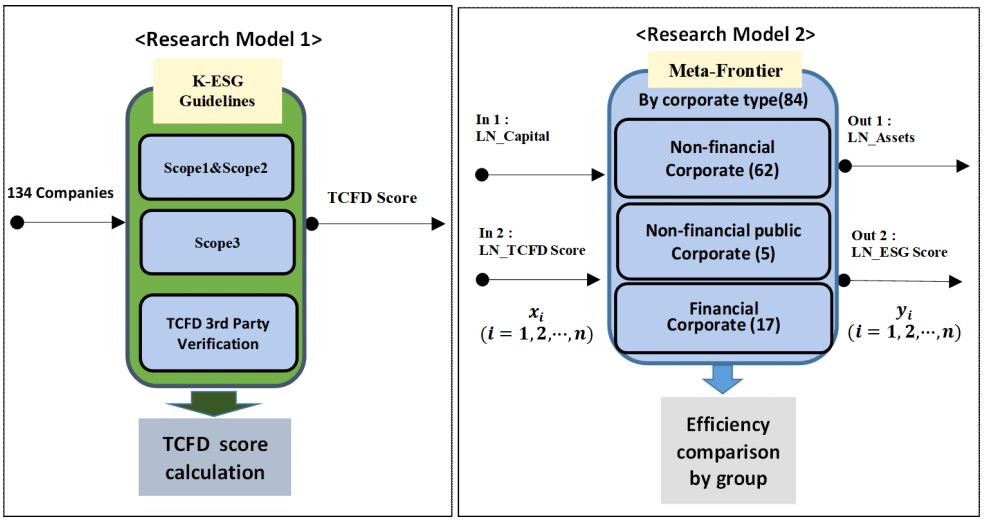
$$TE_{i(k)}^* = TE_{i(k)} \times TGR_{i(k)} \qquad (2-10)$$

The meta-frontier as described above may be measured by meta-efficiency, group efficiency, and technology gap ratio for individual DMUs. In other words, meta-frontier is a methodology developed to compare the efficiency between two or more groups with different production functions. It is a kind of DEA methodology that can identify the causes of variation through its efficiency figures(O'Donnell et al., 2008; Kang & Kim, 2010; Kang & Choi, 2018; Oh et al., 2013; Song & Ha, 2017).

2.3.3 Research Model

TCFD Evaluation with the K-ESG Guidelines and the research model planned using the meta-frontier analysis method is shown in 〈Figure 2-1〉. First, in 〈Research Model 1〉, the TCFD scores of a total of 134 corporates were calculated using the GHG evaluation items of the K-ESG guidelines. In 〈Research Model 2〉, the researcher divided 84 corporates into three groups. The efficiency of each group was compared by setting the natural log values of equity capital and TCFD score calculated in 〈Research Model 1〉 as an input variable and the natural log values of total assets and ESG score as output variables.

〈Figure 2-1〉 Research Model



2.4 Empirical Analysis

2.4.1 Analysis Data

2.4.1.1 Analysis Data

The researcher obtained TCFD evaluation data through the Sustainability Report Statistics website of the Korean Standards Association. According to the statistics of this site, there are 138 corporates publishing sustainability reports in 2020, 120 cumulatively publishing corporates, and 18 first publications. This study downloaded the sustainability reports of individual corporates from the sustainability report DB of this site, excluded non-profit foundations, and then analyzed 92 non-financial corporates such as Kia Motors, 22 non-financial public corporates such as Korea South-East Power, and 20 non-financial corporates such as BNK Financial Group. A total of 134 corporates, including financial corporates, were selected as corporates subject to TCFD evaluation. For the above 134 corporates, the researcher

calculated TCFD scores related to the evaluation of GHG emissions based on the three evaluation indicators for the GHG category among the environmental pillars of the K-ESG guidelines, as shown in 〈Table 2-2〉.

The researcher extracted Financial data from 2020 to 2022 from FnGuide's DataGuide for input and output variables of meta-frontier analysis and used ESG environment ratings of the Korea Institute of Corporate Governance and Sustainability(KCGS) from 2020 to 2022 as ESG scores. Among the input and output variables for meta-frontier analysis, 134 corporates were reduced to 84 before the data preprocessing work by removing unlisted corporates without ESG ratings and corporates with negative numbers.

In order to compare efficiency by corporate type in 〈Research Model 1-2〉, the researcher used data from 2020 as input variables and average values of three years from 2020 to 2022 as output variables. The reason for doing so is to minimize the possibility that external factors not included in this study's analysis model can significantly affect corporate performance in a specific year, reducing the reliability of the analysis results by reflecting the time difference in which input variables affect output variables. For example, it is a case where corporate performance suddenly deteriorates due to external circumstances such as Covid-19(Meyer & Gupta, 1994; Oster, 1990; Yoo & Kim, 2008).

2.4.1.2 Selection of Variables

In this study, 'CAPITAL' and 'TCFD SCORE' were set as input variables as shown in 〈Table 2-3〉 for the 〈Figure 2-1〉 research model, and 'ASSETS' and 'ESG SCORE' were selected as output variables. According to previous studies, 'CAPITAL' was selected to analyze corporate efficiency among input and output variables. In addition, the

'TCFD SCORE' used as an explanatory variable in previous studies was selected as an input variable, and 'ASSETS' and 'ESG score' used as a dependent variables in previous studies were set as an output variable.

〈Table 2-3〉 Operational Definition of Variables

Variables		Operational definition	Relevant literature
Input	CAPITAL	Equity Capital in Balance Sheet	Kim et al.(2014), Baek(2011)
	TCFD Score	The greenhouse gas performance score calculated based on the K-ESG guidelines greenhouse gas evaluation criteria for Scope 1, 2 and 3 set by TCFD	Ding et al.(2022), Suortti(2021)
Output	ASSETS	Total Assets in Balance Sheet	Jeong & Jung(2019)
	ESG Score	The KCSG's ESG Environment rating is converted into a score. (S→7, A+→6, A→5, B+→4, B→3, C→2, D→1).	Baek & Choi(2021), Berg et al.(2020), Del Giudice & Rigamonti(2020)

All data of the input variable and output variables data were processed as natural logs, and basic statistics of the related data are shown in 〈Table 2-4〉. First, the reason for natural log processing of data is that the number of units of 'CAPITAL' and 'ASSETS' is relatively large compared to the number of units of 'TCFD SCORE' or 'ESG SCORE', so the result distortion may be severe. In addition, log conversion spreads the data shapes of "TCFD SCORE" and "ESG SCORE," which are concentrated in relatively small values, making nonlinear relationships linear.

In addition, the correlation between the related input and output variables is shown in 〈Table 2-5〉. Looking at the correlation analysis, the researcher analyzed all four variables significantly. In particular,

'LN_ASSETS' highly correlates with 'LN_CAPITAL', 'LN_ESG SCORE', and 'LN_ESG SCORE' with 'LN_CAPITAL'.

〈Table 2-4〉 Descriptive Statistical Characteristics of Input/Output Variables

Variable		Obs	Min	Max	Mean	S. D.	Skew	Kurtosis
Input	LN_CAPITAL	84	18.8	26.3	22.2	1.5	0.137	-0.189
	LN_TCFD SCORE	84	-16.1	5.7	4.5	3.3	-6.015	36.417
Output	LN_ESG SCORE	84	0.7	1.8	1.5	0.2	-1.812	3.883
	LN_ASSETS	84	19.5	27.1	23.4	1.7	0.164	-0.403

〈Table 2-5〉 Correlation between Input/Output variables

Variable	Sub Variable	①	②	③	④
Input	① LN_CAPITAL	1			
	② LN_TCFD SCORE	.316** (.003)	1		
Output	③ LN_ESG SCORE	.420** (.000)	.227* (.038)	1	
	④ LN_ASSETS	.906** (.000)	.336** (.002)	.401** (.000)	1

** Correlation is significant at 0.01 level (both sides).

* Correlation is significant at 0.05 level (both sides).

2.4.2 Analysis Results

2.4.2.1 TCFD Evaluation Results

〈Table 2-6〉 shows the TCFD evaluation results of corporates measured by GHG evaluation items in the K-ESG guidelines. Individual corporate names were anonymized using DMU(Cho et al., 2021). GHG evaluation targets were evaluated based on three indicators related to GHG emissions in the K-ESG guidelines for 134 corporates that disclosed

sustainable management reports. In order to compare productivity by a group with meta-frontier, the results of the analysis are as follows for 84 corporates, excluding unlisted corporates that are difficult to obtain financial information from FnGuide and listed corporates that are difficult to analyze due to operating losses. First, 171 points out of a total of 300 points were obtained in the GHG implementation evaluation. This can be interpreted as corporates achieving more than average performance to reduce GHG emissions. Second, the level of implementation for Scope1 & Scope2, GHG emitted within boundaries directly managed, owned, and controlled by the organization, was 69 out of 100.

Third, Scope 3, which measures GHG emissions outside the organization, performed poorly, with 41 out of 100. Corporations should make more efforts to measure and reduce GHG outside of organizational boundaries. Fourth, in the third-party verification of GHG emissions, non-financial public enterprises showed the lowest level of 40% in specifying verification agencies or disclosing the level of ESG information verification. Efforts are needed to enhance the planning and implementation of GHG by public corporations. Fifth, by industry, financial corporates were more active in reducing GHG emissions than non-financial corporates. Looking closely at the results, the average GHG implementation rate of the highest financial corporates was 62%, the average GHG implementation rate of non-financial corporates was 56%, and the average GHG implementation rate of non-financial public corporates was 53%. Financial corporates performed better than non-financial businesses in all three evaluation indicators, especially Scope1 & Scope2 evaluation results with 82 points, 16 points superior to 66 in non-financial businesses.

〈Table 2-6〉 TCFD Evaluation Results

Division		Non-financial			Financial Corp	Totality
		Corp	Public	Subtotal		
The first DMU 134	DMU No.	92	22	114	20	134
	Total GHG Score **	150	139	148	174	152
	Scope1 & 2***	60	80	64	80	66
	Scope3***	34	14	30	38	31
	GHG Verification***	56	45	54	56	54
	Rate of fulfillment****	50%	46%	49%	58%	51%
Change DMU 84*	DMU No.	62	5	67	17	84
	Total GHG Score**	167	160	167	187	171
	Scope1 & 2***	63	100	66	82	69
	Scope3***	42	20	41	44	41
	GHG Verification***	62	40	60	60	60
	Rate of fulfillment****	56%	53%	56%	62%	57%

* For meta-frontier analysis, unlisted corporates, excluding DMUs with negative (-) input/output variables.

** The total score for GHG is 300 points.

*** GHG emissions (Scope 1 & Scope 2), GHG emissions (Scope 3), and GHG emissions verification are 100 points each.

**** The implementation rate is the ratio of the total greenhouse gas score of individual DMUs to the total score of 300 points.

2.4.2.2 Meta-frontier Analysis Results

Among listed corporates, corporates that disclosed sustainability reports were grouped into 'non-financial corporates', 'non-financial public corporates', and 'financial corporates', and a meta-frontier analysis was conducted. Individual corporate names were indicated as DMU and numbered from 001 to 084. DMUs belonging to the above three groups are classified into a constant return to scale(CRS), increasing return to scale(IRS), and decreasing return to scale(DRS) according to the propensity for economies of scale(RTS: Return to Scale) was categorized(Oh et al., 2013; Lee et al., 2015). The result table was displayed as in 〈Table 2-7〉. The CCR model assumes a production possibility set in this table with constant economies of scale. Since this assumes the increase and decrease of the total DMU being observed, the measured value of the CCR model is called technical efficiency(TE)(Moon & Min, 2015). Since the BCC model assumes a convex combination of the producible sets composed of DMUs, the measured value of the BCC model is called pure technical efficiency(PTE)(Seo & Park, 2006). Scale inefficiency can be inferred through the difference in technical efficiency between these two models, and this difference is called efficiency scale(SE). If there is scale inefficiency, it is possible to analyze the increase in returns to scale or the decrease in returns to scale. Finally, whether the cause of inefficiency was purely technical or scale efficiency was confirmed.

First, comparing the efficiency of the CCR model assuming a constant return to scale(CRS), the meta-frontier value of financial corporates(0.991) was higher than those of non-financial public corporates(0.941) and non-financial corporates(0.940). In addition, Group Frontier was followed by financial corporates(0.994), non-financial public

corporates(0.987), and non-financial corporates(0.945). On the other hand, when looking at the efficiency of the BCC model assuming a variable return to scale(VRS), the meta-frontier value of financial corporates(0.995) was higher than those of non-financial public corporates(0.962) and non-financial corporates(0.950). In addition, group frontiers were found in the order of non-financial public corporates(1.000), financial corporates(0.997), and non-financial corporates(0.967). In each meta-frontier, non-financial and non-financial public corporations were less efficient than financial corporations. Therefore, non-financial corporates must establish various ESG strategies to overcome GHG and ESG-related inefficiencies and improve efficiency.

The average value of the Technology Gap Ratio(TGR) of financial corporates assuming CRS or VRS(CRS-based=0.997, VRS-based=0.998) is relatively close to 1 compared to those of the other two groups. It is interpreted that there is no difference between group frontiers and meta-frontiers.

In addition, when analyzing the causes of inefficiency under CRS or VRS, 88% of DMUs among non-financial corporates, 80% of DMUs among non-financial public corporates, and 53% of DMUs among financial corporates showed pure technological inefficiency(SE>PTE). Each corporate should take a strategic approach to reduce pure technological inefficiency by improving its technologies.

In addition, regarding economies of scale(RTS), 50% of non-financial corporates, 60% of non-financial public corporates, and 76% of financial corporates fall under diminishing returns to scale(DRS) and are in non-economies of scale. This phenomenon occurs because management inefficiency occurs due to the complexity of the decision-making system or decision-making as the production scale increases. Reduce scale to increase efficiency.

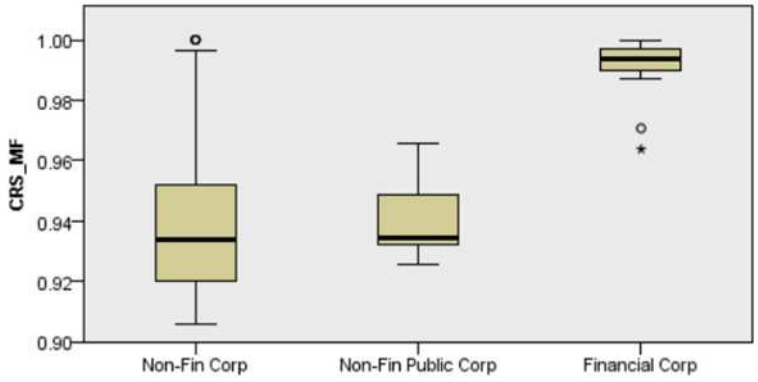
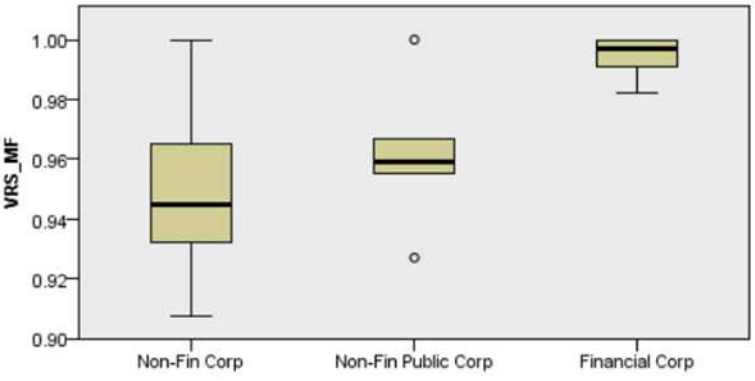
Finally, the Kruskal-Wallis test was conducted to analyze whether the average PTE and TE values for each type were statistically different, and the results are shown in 〈Figure 2-2〉. The average rank of meta-efficiency by type under the assumption of CRS or VRS was insignificant at the 1% significance level. Therefore, the alternative hypothesis that there would be a difference in the average value of each group was accepted, and it was found that there was a difference in the average value of each group.

〈Table 2-7〉 Meta-Efficiency Comparison by Type

Cluster	DMU	CCR(CRS-Based)			BCC(VRS-Based)			SE	RTS	Inefficiency	
		MF (TE)	GF	TGR	MF (PTE)	GF	TGR			PTE	SE
Non-Fin Corp	045 & 2	1.000	1.000	1.000	1.000	1.000	1.000	1.000	CRS		
	018 & 2	0.922	0.925	0.997	0.980	0.994	0.986	0.942	DRS		√
	003 & 26	0.925	0.931	0.994	0.934	0.966	0.967	0.991	DRS	√	
	005 & 3	0.980	0.982	0.998	0.998	0.998	1.000	0.982	IRS		√
	001 & 24	0.943	0.949	0.994	0.949	0.955	0.994	0.993	IRS	√	
62	AVG	0.940	0.945	0.994	0.950	0.967	0.983	0.989		88 %	12 %
Non-Fin Public Corp	063 & 2	0.942	0.989	0.952	0.951	1.000	0.951	0.991	DRS	√	
	067	0.932	0.968	0.963	1.000	1.000	1.000	0.932	IRS		√
	065	0.949	1.000	0.949	0.955	1.000	0.955	0.993	IRS	√	
5	AVG	0.941	0.987	0.954	0.962	1.000	0.962	0.980		80 %	20 %
Fin Corp	069 & 1	1.000	1.000	1.000	1.000	1.000	1.000	1.000	CRS		
	071 & 4	0.989	0.996	0.993	0.998	1.000	0.998	0.991	DRS		√

Cluster	DMU	CCR(CRS-Based)			BCC(VRS-Based)			SE	RTS	Inefficiency	
		MF (TE)	GF	TGR	MF (PTE)	GF	TGR			PTE	SE
	068 & 7	0.989	0.990	0.999	0.991	0.993	0.997	0.998	DRS	√	
	073 & 1	0.997	1.000	0.997	1.000	1.000	1.000	0.997	IRS		√
17	AVG	0.991	0.994	0.997	0.995	0.997	0.998	0.996		53 %	47 %

〈Figure 2-2〉 Meta-Efficiency Kruskal-Wallis Test Results by Industry

	Independent Sample Kruskal-Wallis Comparison
CRS Meta Efficiency (CRS Meta Frontier)	 Test statistics 30.810, asymptotic significance level (both tests) .000
VRS Meta Efficiency (VRS Meta Frontier)	 Test Statistics 27.809, asymptotic significance level (both tests) .000

2.5. Discussion, Implications, and Limitations

2.5.1 Discussion

The interpretation of the analysis results of this study is as follows. First, the GHG compliance rate of financial corporates is 62%, which is higher than that of non-financial corporates, which is 56%. Financial corporates' performance is better because financial holding corporates, which are mainly included in financial corporates, are paying more attention to raising the value of ESG management than corporates to recruit large global institutional investors as investors. For example, BlackRock, the world's most extensive asset management corporate, expanded its stake in Hana Financial Group(6.10% stake), KB Financial Group(6.02% stake), and Shinhan Financial Group(5.63% stake), which are actively engaged in ESG management as of October 2022. Moreover, global pension funds invest in these corporates with ESG as their primary investment criterion(The Bell, 2022). This shows the same result as Middleton's previous study(Middleton, 2020). According to him, corporates in carbon-intensive industries, such as oil and gas, rarely adopt TCFD because it is voluntary. Just as Korean financial corporates actively managed ESG to receive investment, the most vital driver of TCFD adoption is the financial sector of Scandinavian countries represented by asset management corporates and pension funds. Because latecomers who fail to disclose climate risks under TCFD recommendations may be less attractive to investors and may have difficulty securing loans or insurance(Staker et al., 2017), boards or CEOs of non-financial firms need to adopt TCFD recommendations to reduce GHG emissions for sustainable management.

Second, when comparing meta-frontier efficiency under variable returns to scale (VRS), the efficiency of financial corporates(99.5%) was higher than that of non-financial public corporates(96.2%) and non-financial corporates(95.0%). Significantly, financial corporates have higher efficiency than non-financial corporates despite their higher GHG compliance rates. It is worth noting that strengthening activities to reduce GHG emissions does not necessarily lead to cost expansion and efficiency reduction. These findings were consistent with Giannarakis et al.(2017)'s study that showed that a high level of climate information disclosure was related to better carbon performance and was also the same as Suortti(2021)'s study that showed the use of the TCFD framework in Australian listed corporates has a negative relationship to environmentally sensitive equity costs. The research results in which groups with high TCFD scores related to GHG have high efficiency will contribute to active ESG management by Korean corporates to reduce GHG.

2.5.2 Implications

This study, which measured the level of TCFD implementation related to GHG emission reduction, has the following academic and practical implications.

First of all, the theoretical implications are as follows. First, the relationship between TCFD scores and corporate efficiency was studied using meta-frontiers. TCFD scores could be calculated using sustainability reports and the K-ESG guidelines that corporates voluntarily disclose, and the calculated values were applied to meta-frontier analysis to compare corporate efficiency. At least, as researchers know, no research analyzed TCFD and corporate efficiency in Korea. Hopefully, it will be priming water for more research on TCFD and corporate efficiency. Second, when analyzing the meta-frontier, this study used the TCFD score as an input

variable and the ESG score as an output variable. This is distinct from the previous studies that used only financial data as input or output variables. Through this study, research attempts on more diverse input and output variables will likely continue. Third, this study followed the TCFD recommendation that it could be applied to non-financial and financial industries and compared the efficiency of non-financial and financial corporates using a meta-frontier that can compare the efficiency of different industries. Previous studies on TCFD and corporate performance or ESG activities and corporate performance differ from those conducted only in the same industry group. The researcher thinks it will be a part of further development in future follow-up studies by other researchers.

Moreover, as a practical implication, first, the degree of TCFD implementation was identified by measuring the level of corporates related to GHG emission reductions to the 2050 Carbon Neutrality scenario, such as net zero and the Korean government, which needs to reduce carbon emissions by 40% in 2030 compared to 2018. This study will inform the government of the need to provide GHG statistics by industry and provide individual corporates with insights on their plans and inspections for GHG reduction. Second, it will give awareness and implications of GHG emissions within the boundary(Scope 1 & Scope 2) and outside the boundary(Scope 3) for TCFD implementation to corporates that disclose sustainability reports. In particular, 134 corporates were divided into financial and non-financial industries. The non-financial industries were divided into corporate and public corporates, and GHG emission statistics for each group were provided. It was possible to judge the degree of GHG reduction efforts by group. Third, some corporates wish to reduce GHG emissions, but the approach through the K-ESG guidelines was introduced to corporates and

managers who needed to be made aware of the method. The K-ESG guidelines were prepared by analyzing 13 major domestic and international evaluation indicators and disclosure standards, such as DJSI and MSCI, to present the evaluation items most frequently handled by ESG evaluation institutions(Ministry of Trade, Industry and Energy & Korea Productivity Center, 2021). Therefore, if individual corporates appropriately utilize this standard, they can quickly introduce ESG management and settle it into their organizational culture.

2.5.3 Limitations

On the other hand, this study has the following limitations. First, there were few subjects in this study. This study calculated TCFD scores for 134 corporates voluntarily disclosed sustainability management reports and compared efficiency through meta-frontier analysis for 84 listed corporates. Therefore, it was impossible to determine the level of GHG emissions of corporates closely related to GHG emissions that do not disclose sustainable management reports. From 2025, KOSPI-listed corporates with assets of 2 trillion won, or more must disclose sustainable management reports. In future studies, it is necessary to examine the level of TCFD implementation on GHG emissions for more corporates. Second, due to a lack of disclosure information, this study failed to use some evaluation criteria of the K-ESG guidelines for evaluating TCFD. For example, since the quota or target value was not disclosed compared to the quota by the 'Act on Allocation and Trade of GHG Emissions' or the target value by the 'Greenhouse Gas and Energy Target Management System', Evaluated based on emissions in the past year. In future studies, it is necessary to evaluate based on the statistics related to GHG compiled and announced by the government. Third, this study compared the efficiency of non-financial corporations,

non-financial public corporations, and financial corporation groups through the TCFD recommendation, which can be applied to both the financial and non-financial industries and the meta frontier, which can compare the efficiency of different industry groups. In future studies, it is necessary to compare the efficiency of each sector within the industry when more corporates disclose their sustainability reports. In addition, it is necessary to compare the level and efficiency of TCFD implementation by country through comparison with other countries.

2.6 Conclusion

Looking at the results of this study, which evaluated the TCFD implementation level of Korean corporates disclosing sustainability reports based on the K-ESG guidelines, first, the GHG compliance rate, which is the TCFD score, of 84 corporates that are listed on stock exchanges and have disclosed sustainability reports is 57%. This result shows above-average GHG reduction sensitivity, but more efforts are needed. Second, the implementation level of Scope 1 & Scope 2, which measures GHG emissions within the corporate boundary, is 69%, and Scope 3, which measures GHG emissions generated outside the corporate, is 41%. Corporations should be more proactive in planning and implementing measures to measure and reduce GHG emissions outside the corporate. Third, the overall percentage of third-party verification of GHG emission measurements was 60%, but the third-party verification of non-financial public enterprises was low at 40%. In particular, non-financial public corporates need to be more active in reducing GHG led by the government than corporates. Fourth, the GHG implementation rate of financial corporates was 62% higher than that of non-financial corporates, which was relatively good. This result is because financial holding corporates are paying more attention to increasing the value of ESG management than ordinary corporates in order to recruit large

global institutional investors as investors. On the other hand, non-financial corporates have relatively less interest in GHG reduction. The board of directors or CEOs of non-financial corporates need to make more efforts to reduce GHG emissions. Fifth, under Variable Return to Scale(VRS), the order of meta-frontier efficiency was financial corporates(99.5%), non-financial public corporates(94%), and non-financial corporates(94.9%). It is significant to suggest that financial corporates are highly efficient despite their superior TCFD scores compared to non-financial corporates. It is worth noting that strengthening activities to reduce GHG does not necessarily lead to increased costs and reduced efficiency. Sixth, as a cause of inefficiency, pure technological inefficiency was the main factor for the three groups. Therefore, each corporate should find and reduce the cause of inefficiency in the corporate's unique technology. Seventh, 50% of non-financial corporates, 60% of non-financial public corporates, and 76% of financial corporates fall under diminishing returns to scale(DRS), meaning they were in a state of diseconomies of scale. This result is because the increase rate of output factors(Δoutput) was smaller than the increase rate of input factors(Δinput), so the return to scale decreased. Despite the production scale's expansion, improving the complexity of communication or decision-making systems is necessary.

In summary, by analyzing corporates listed on securities in Korea that have disclosed their sustainability reports and comparing TCFD GHG reduction activities and corporate efficiency, the TCFD score of financial corporates was higher than that of non-financial corporates. However, efficiency was somewhat. It was confirmed that it was not lower than that of non-financial corporates. This study's results on comparing GHG emission reduction efforts and corporate efficiency will provide awareness

and insights for GHG reduction to the Korean government and businesses.

Chaper 3. Evaluation of Corporate Performance Using Difference-in-Differences and Malmquist Productivity Index: Focusing on CEO Non-Duality

CEO Non-Duality is one of the essential activities for transparent governance for corporate sustainability management. However, previous studies have shown inconsistent research results on the relationship between CEO Non-Duality and corporate performance. This study investigated whether CEO Non-Duality improves the corporate performance of Korean securities listed corporates. In particular, a treatment group and a control group were formed using propensity score matching, and the effect of CEO Non-Duality on corporate performance was analyzed using the difference-in-differences method. In addition, the change in productivity by year was measured through the Malmquist Productivity Index. As a result of this study, first, PSM-DID analysis did not prove a direct causal relationship between CEO Non-Duality and corporate performance improvement. However, it showed the possibility that appointing an outside director as the chairman of the board of directors(CBD) could positively impact corporate performance. Therefore, Korean companies need to increase management efficiency through good cooperation between CEO and CBD, like companies in advanced countries, rather than just having the appearance of improving governance. Second, it was impossible to verify that the annual productivity of the company improved through CEO Non-Duality. During this study, the number of companies implementing CEO Non-Duality was relatively small, at 20. In the future, more and more

companies will execute CEO Non-Duality, and it is necessary to closely study the relationship between CEO Non-Duality and corporate performance through follow-up studies that set a more extended research period.

【Keywords】*CEO Non-Duality, Propensity Score Matching, Difference-in-Differences, Malmquist Productivity Index*

3.1 Introduction

Over the past 30 years, the phenomenon of CEO Non-Duality between Chief Executive Officer(after this referred to as "CEO") and Chairman of Board of Directors(after this referred to as "CBD") has been one of the critical discussions and the most widely controversial issues of corporate governance among scholars and market regulators(de Sousa Guimaraes & Trevisan, 2022). In particular, the shockwaves of governance collapse, such as Enron, Worldcom, and Tyco, have sparked a longstanding debate about the relationship between CEO Non-Duality and corporate performance(Braun & Sharma, 2007). If CEO Non-Duality had become CEO in such an enormous accounting scandal, CBD would have had a strong influence, and the board would have smoothly performed the monitoring function of adequately checking the CEO and suppressing the CEO's tyranny(Park et al., 2016). One of the causes of the IMF financial crisis in Korea was the backwardness of the governance structure that allowed the arbitrary management of significant shareholders or CEOs. If there was transparency and responsibility in the governance structure, management problems such as excessive borrowing or investment could be checked in advance(Cho, 2007).

Looking at the actual situation of CEO Non-Duality, in the United States, more than half of the S&P 500 global corporates in 2019 prohibited the concurrent position of CEO and CBD(Lee, 2019). On the other hand, 27 percent of the 101 listed corporates in the top 10 business groups are obligated to disclose corporate governance reports in Korea, nearly doubling from 15 percent five years ago. However, there is still a long way to go, with five of the top 10 business groups needing to be appointed a separate CBD(Kim, 2021).

CEO is at the top of corporate and leads decision-making on key management issues such as investment in new technologies and new products, entry or exit of the market, and M&A (Sanders & Carpenter, 1998; Kassinis & Vafeas, 2002; Kim & An, 2018). CEO is the subject of commission from the board of directors when making routine management decisions (Mintzberg, 1983; Kim et al., 2015). On the other hand, CBD leads the corporate's board of directors and sets the corporate's main agenda. Furthermore, it strives to communicate efficiently with shareholders and supports and advises the CEO to develop the corporate's strategy.

Although CBD maintains a steady relationship with the corporate's management, it should not violate CEO's domain, and efforts should be made to form a smooth communication relationship between outside directors and management (Kim, 2013). In addition, instead of delegating operations to CEO, the board also provides the ability to perform monitoring and supervisory functions or advise the CEO to make effective management decisions(Forbes & Milliken, 1999). Since decision-makers' characteristics are reflected in corporate decision-making and corporate performance, CBD occupies a large proportion of corporate decision-making(Hambrick & Mason, 1984; Kim et al., 2015). Research on CEO Duality and CEO Non-Duality has been studied in various ways.

First, CEO Duality promotes organizational effectiveness in implementing management initiatives that contribute to corporate performance by enhancing a clear focus on objectives and operations(Anderson & Anthony, 1986; Stoeberl & Sherony, 1985; Kim, 2012b), it can give CEO unity of command and a broader power base(Donaldson, 1990) and clarify decision-making authority(Finkelstein & D'aveni, 1994). However, in order to maintain their fame and

reputation as a representative of shareholders, CEOs have incentives to pursue their private profits rather than corporate performance, such as focusing on short-term performance rather than long-term performance or avoiding active investment opportunities(Fama & Jensen, 1983; Kim et al., 2020). In addition, CEO, which makes the final decision on various management-related issues within the corporate, abuses discretion(Jenson & Meckling, 1976; Kim & An, 2018) or loses objectivity in the decision-making process with excessive confidence(Park et al., 2013), or it is highly likely that the internal control system does not operate effectively(Tsui et al., 2001; Kim & An, 2018). In other words, in the case of CEO duality, the difference in power between the CEO and the board of directors is so significant that it may be difficult for the board of directors to effectively monitor and control the CEO's pursuit of private profits(Neville et al., 2019; Kim et al., 2020). Many studies have also found that CEO duality harms corporate performance(Rechner & Dalton, 1991; Pi & Timme, 1993; Daily & Dalton, 1994; Simpson & Gleason, 1999; Judge et al., 2003; Rahman & Haniffa, 2005).

Therefore, securing independence to exclude CBD from participating in management is more advantageous because choosing CBD as CEO or outside director affects the board of directors' independence (Cho, 2007). In addition, the harmonious relationship between the CEO and the board of directors is essential in improving corporate performance (Pearce & Robinson Jr, 1987; Vance, 1983; Stewart, 1991; Roberts & Stiles, 1999; Kim & Yoo, 2015). CEO Non-Duality also undermines corporate governance effectiveness by reducing the board of directors' ability to perform adequate monitoring functions(Dayton, 1984; Levy, 1981; Kim, 2012b). As such, a study confirmed inconsistent results by concluding no relationship between CEO Non-Duality and corporate performance(Dalton et al., 1998).

Prior research on the relationship between CEO Non-Duality and corporate performance mainly used hierarchical regression analysis. However, it is necessary to analyze corporate performance before and after CEO Non-Duality implementation or to analyze CEO Non-Duality effects in time series by tracking changes in productivity by year. Through the above discussion, this study has two primary research purposes. First, this study uses Propensity Score Matching (PSM) and Difference-in-Differences (DID) to check whether corporate performance has changed since the implementation of CEO Non-Duality policy. In other words, among the corporates listed on the Korean stock market, corporates with CEO Non-Duality were divided into Treatment Group and Control Group using PSM, and corporate performance changes due to policy implementation were analyzed using DID. Second, another purpose of this study is to check the annual productivity change during the five years before and after CEO Non-Duality was implemented using the Malmquist Productivity Index (MPI) to determine whether the policy implementation improved the corporate's productivity.

A more detailed study purpose is as follows. First, the researcher will check whether CEO Non-Duality improves corporate performance. Second, the researcher will check whether CEO Non-Duality improves return on assets. Third, this study aims to determine whether the policy implementation improved corporate productivity by checking the annual productivity change for five years before and after CEO Non-Duality implementation using MPI. Stata 17.0 was used for PSM-DID analysis, and MaxDEA 8.0 was used for MPI analysis.

This study was organized as follows. The background and purpose of the study were described in the introduction of 3.1, and the theoretical background of CEO Non-Duality, domestic and foreign prior studies, and research hypotheses was introduced in 3.2. In 3.3 research design,

the research model, analysis data, and variable settings are explained, and in 3.4, the PSM-DID and MPI results are described. In 3.5, discussions, implications, and limitations were presented, and the conclusion in 3.6 was concluded.

3.2 Literature Review

3.2.1 Theoretical Basis of CEO Non-Duality

3.2.1.1 Agency Theory

The problem of corporate governance is an agent problem that arises from the process of coordinating interests between corporate managers and related stakeholders. From a corporate governance perspective, the agency issue refers to the conflicts of interest and gaps between the corporate's shareholders and managers, and resolving them is the core of the governance system and operation(Kim et al., 2015). The move to ban CEO Duality begins with agency theory, likened to the theory of sinful nature that claims that human nature is evil(Kim, 2013). Agency theorists argue based on an inevitable conflict between shareholders who delegate and CEOs who execute(Jenson & Meckling, 1976; Braun & Sharma, 2007). Regarding this conflict, agent problems arise when owners try to align CEO interests with shareholders' interests in light of different goals and risk preferences (Villalonga & Amit, 2006), and as the difference between CEO interests and shareholders grows, agency costs of organizing, monitoring, and binding contracts to resolve fundamental conflicts. Ultimately, shareholders bear losses because governance costs are higher than CEO Duality(John, 1993). In other words, due to CEO duality, shareholders' decision-making management and control are not separated, which increases the corporate's agency costs(Fama & Jensen, 1983; Rechner & Dalton, 1991). In agency theory,

CEOs are incentivized to adopt unprofitable investment options to expand their private interests(Jenson & Meckling, 1976; Jensen, 1986; Kang & Byun, 2021). In response to the ongoing cost of agency problems, agency theorists propose controls that inhibit CEO selfishness and align goals between the CEO and shareholders(Fama & Jensen, 1983; Jenson & Meckling, 1976; Braun & Sharma, 2007). Agency theorists say that CEO Non-Duality can control the CEO. This CEO Non-Duality allows the board of directors, the primary means of representing shareholder rights, to effectively monitor and control CEO's behavior, which is presumed to destroy shareholder value. In other words, decision-making power is given to CEO, and the board retains decision-making control to maintain the power to ratify and monitor decisions made by CEO(Boyd, 1995). Therefore, agency theory emphasizes that CEOs should be monitored excessively and non-self-disciplined (Kim, 2013).

3.2.1.2 Stewardship Theory

Stewardship theory starts from the ethical doctrine that human nature is fundamentally sound, which is the opposite premise of the agency theory. In other words, a CEO is not a selfish being who only pursues self-interest at the expense of the interests of shareholders, but rather a person who finds satisfaction in the act of honesty and service to the investors who trusted him and entrusted him with asset management. In other words, since a successful CEO achieves self-realization through self-fulfillment, it is said that CEO Duality instead leads to efficient corporate management and business performance increase(Kim, 2013). From the stewardship theory perspective, the CEO is considered to act rationally and economically selfishly. In self-actualizing CEOs, the human need for achievement, responsibility, and recognition offsets selfish intentions so that working for the organization's benefit is

more remarkable than working against the organization(Argyris, 1973; Braun & Sharma, 2007). According to stewardship theory, CEOs are inherently good stewards of corporate assets, not opportunistic avoiders, and want to do a good job. Thus, stewardship theory argues that no general problems are inherent in motivating executives. However, there is also the question of how far CEOs can achieve superior corporate performance, given that CEOs do not have intrinsic motivation problems(Donaldson & Davis, 1991).

Nevertheless, because stewardship's utility function is maximized, CEOs who are considered stewards protect and maximize shareholder wealth through actual performance(Davis et al., 1997; Braun & Sharma, 2007). In addition, stewardship theorists say CEO Non-Duality hinders executives' autonomy in forming and implementing organizational strategies, and the lack of authoritative decision-making will likely harm organizational performance(Corbetta & Salvato, 2004; Davis et al., 1997). Stewardship theory does not focus on CEO's motivation but rather on a facilitative and empowering structure, and the fusion of the roles of CBD and CEO improves efficiency and consequently provides more value to shareholders than CEO Non-Duality. Claims it will bring corporate better returns. Policy discussions so far have tended to approach the problem of CEO duality from a perspective similar to agency theory(Kesner & Dalton, 1986; Donaldson & Davis, 1991). However, the stewardship theory may neglect shareholder protection(Kim, 2013).

3.2.1.3 Contingency Theory

Contingency theory is a behavioral theory that presupposes no clear path when forming a corporation's management organization or making management decisions(Tribbett, 2012; Kim, 2013). Contingency theory approach assumes that it can serve as a theoretical foundation that can provide the possibility of social consensus by avoiding conflicting or

confrontational discussion structures(Jung, 2006). Scott(2005) stated that the best way to structure an organization depends on the nature of the environment in which it is concerned. When applied to individual corporates, contingency theory denies drawing uniform conclusions as one theory overwhelms another. Rather than selecting one of several theories, it is said that an optimal combination should be created by considering various factors(Kim, 2013). Therefore, CEO Duality or CEO Non-Duality should be determined according to the circumstances of each corporate.

3.2.2 CEO Non-Duality and Corporate Performance

Previous studies on CEO Non-Duality have been studied in two types: the relationship between CEO Non-Duality and corporate performance and the relationship between CEO Non-Duality and various corporate management activities.

First, a study found a positive relationship between CEO Non-Duality and corporate performance. Jeon & Lee(2013) found that the number of sub-committees on the board significantly affected corporate performance and said CEO Duality harmed corporate performance. Braun & Sharma(2007) studied the relationship between CEO Duality and corporate performance in owner-controlled public enterprises. He said CEO Duality does not affect the corporate performance of owner-controlled public corporations. In addition, it was studied that CEO Non-Duality is advantageous regarding shareholder income when the owner's family's stake is low. Krause & Semadeni(2013) stated that CEO Non-Duality positively affects future corporate performance when current performance is terrible and harms future corporate performance when current performance is high.

On the other hand, as a study that found no significant relationship between CEO Non-Duality and corporate performance, Kim(2012b), based on the agency theory and stewardship theory, studied the effect of

CEO duality on corporate performance depending on the external environment of the corporate. He studied that CEO Duality harms corporate performance for corporates experiencing extreme changes in the external competitive environment. Kim(2013) explained the relationship between CEO Non-Duality and corporate performance through agency, stewardship, and situation theories but concluded that no single structure applies to all corporates. Kim & Yoo(2015) conducted an empirical study on how to build relationship characteristics between the CEO and the board according to the tenure of the CEO and found that CEO Duality did not have a significant adverse effect on corporate performance. Yoo & Kim(2008) verified that CEO Non-Duality does not affect corporate performance in a CEO Non-Duality study on the interaction effect of a CEO's career within the corporate.

Next, when examining the relationship between CEO Non-Duality and various corporate management activities, many studies showed the effect of improving the governance structure of CEO Non-Duality. Yu(2013) studied CEO Non-Duality of public corporations and found that CEOs whose political independence was undermined had a significant adverse effect on customer satisfaction. In addition, it was said that CEO Non-Duality of public corporations had a significant positive effect on customer satisfaction of public corporations. Kim et al.(2020) studied that CEO Non-Duality positively affects CEO checks, focusing on the power difference between the CEO and the board of directors. In other words, it proved that opposition to the board of directors' agenda decreased under CEO Duality. Bae et al.(2020) studied that CEO Duality had a significant adverse effect on the possibility of replacement and replacement type of managers. Kim & Jung(2018) argued that the more management rights were concentrated on CEO Duality, the lower the credit rating. Park et al.(2016) studied the size of profit adjustment in the

state of CEO Duality, and it was verified that the size of profit adjustment of the corporate was smaller than CEO Non-Duality corporates. Krause et al.(2016) stated that CEO Non-Duality is an important classification condition for the effect of social capital. Therefore, CEO Non-Duality is recognized as social capital, but when CEO Duality, CBD argued that the possibility of being regarded as a resource decreases.

On the other hand, Kim et al.(2015) stated that CEO Non-Duality harms corporate mergers and acquisitions performance.

3.2.3 Research Method

3.2.3.1 Propensity Score Matching (PSM)

This study used PSM to compare corporates with similar characteristics of CEO Non-Duality. PSM is a non-experimental approach that can respond to the problem of not being able to observe the results when the treatment group is not treated by comparing how corporates with similar characteristics show different results depending on the treatment. When constructing a control group in which individual factors match in order to find a similar comparison group, PSM is a score obtained by deriving the probability that each case belongs to the treatment group by setting several factors as independent variables. If the potential outcome is independent of treatment when individual factors are presented, then the potential outcome is independent of treatment even when propensity scores are given(Rosenbaum & Rubin, 1983). Data to be used for PSM must be tested for validity before and after matching to ensure that matching is appropriate (Austin & Mamdani, 2006). When the matching is completed, the treatment group and the control group are compared to estimate the average effect of treatment (ATT), which is the net effect of treatment. In other words, ATT shows how much the

treatment group is superior to the control group with similar characteristics or propensity in the dependent variable. If the treatment group is defined as D=1, the control group is defined as D=0, the pre-treatment is defined as a, the post-treatment is b, and the performance difference before and after support of the treatment group is expressed as $Y(1) = E(P_{1b} - P_{1a})$, and the performance difference before and after support of the control group can be expressed as $Y(0) = E(P_{0b} - P_{0a})$(Jung & Lee, 2021). Here, measuring the effect of policy implementation of corporates with policies implemented compared to corporates with no policies implemented is called the average treatment effect (ATE)(Caliendo & Kopeinig, 2008). The formula is as shown in Equation (3-1).

$$\tau ATE = E(\tau) = E[Y(1) - Y(0)] \quad (3-1)$$

On the other hand, the ATT described earlier is an additional effect that explicitly focuses on the effect on the corporates in which the policy is implemented(Imbens, 2004). The formula is as shown in Equation (3-2).

$$\tau ATT = E(\tau|D=1) = E[Y(1)|D=1] - E[Y(0)|D=1] \quad (3-2)$$

The expected value of ATT is defined as the difference in the expected outcome value with or without treatment for the corporates in which the policy is actually implemented. An appropriate replacement must be selected to estimate ATT, and using the untreated mean result $E[Y(0)|D=0]$ is not a good idea in non-experimental studies. This is because the components that determine the treatment are likely to determine the outcome variables of interest. Thus, the individual results of the treatment group and the control group may differ even in the absence of treatment leading to selection bias(Heckman et al., 1999). Therefore, Equation (3-2) can be expressed as Equation (3-3).

$$E[Y(1)|D=1]-E[Y(0)|D=0]=\tau ATT+E[Y(0)|D=1]-E[Y(0)|D=0] \quad (3-3)$$

The difference between the left side of equation (3-3) and τATT is so-called 'selection bias'. The actual parameter τATT is identified only if $E[Y(0)|D=1]-E[Y(0)|D=0]=0$. Therefore, two important basic assumptions are needed to estimate ATTs that have eliminated selection bias in PSM. The first assumption is conditional independence assistance. The second assumption is the Common Support Condition. This means that the propensity scores of the two groups conducting the comparison must have some overlapping distributions(Shah et al., 2005; Weitzen et al., 2004; Jung & Lee, 2021).

3.2.3.2 Difference-in-Differences(DID)

This study used DID to find out the effect of CEO Non-Duality's policy implementation. DID dates back to the analysis of the London cholera outbreak(Snow, 1855), the most common and oldest similar experimental study design. DID estimate is the difference between the change in outcome before and after treatment(difference 1) in the treatment group versus control group(difference 2): $(\bar{y}_{TREAT}^{POST}-\bar{y}_{TREAT}^{PRE})-(\bar{y}_{CONTROL}^{POST}-\bar{y}_{CONTROL}^{PRE})$. This simple quantity is also equivalent to the estimated coefficient for the interaction between the treatment group dummy and the post-treatment period dummy in the following regression equation(Goodman-Bacon, 2021).

$$y_{it}=\gamma+\gamma_i TREAT_i+\gamma_t POST_t+\beta^{2*2} TREAT_i\times POST_t+u_{it} \quad (3-4)$$

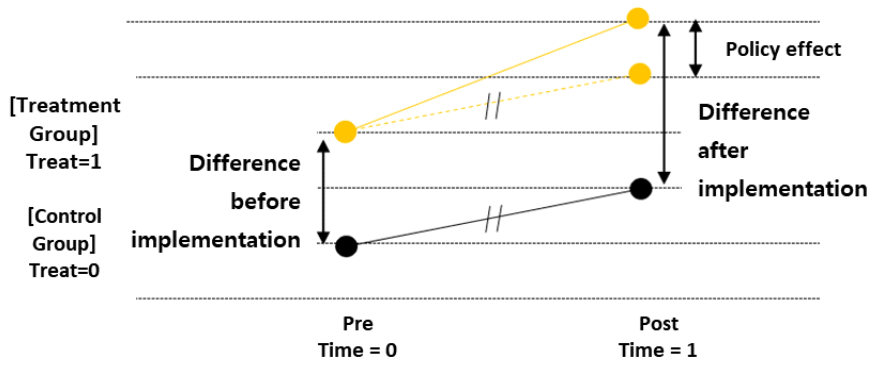
DID is excellent because it clarifies which comparisons generate estimates, what causes bias, and how to test the design. The representation of the sample mean links regression to potential outcomes and shows the identification of the mean treatment effect for the

treatment target by 2 groups and 2 periods (2×2)DD under the general trend assumption. Here, the group that received the policy implementation was usedas the treatment group, and the group that was not treated was used as the control group. Individual economic actors can be affected by macroeconomic policies, climate change, and resource dependence at the same time, so using DID can control before and after differences between research subjects and effectively separate the actual results of policies(Chai et al., 2022). The structure of DID is shown in 〈Table 3-1〉. In addition, a schematic diagram of the estimated amount of DID is shown in 〈Figure 3-1〉.

〈Table 3-1〉 The Structure of DID

Y	*Treat*=0 (C.G.)	*Treat*=1 (T.G.)	Difference 2
Post=0 (Duality)	γ	$\gamma+\gamma_i$	γ_i
Post=1 (Non-Duality)	$\gamma+\gamma_t$	$\gamma+\gamma_i+\gamma_t+\beta^{2*2}$	$\gamma_i+\beta^{2*2}$
Difference 1	γ_t	$\gamma_t+\beta^{2*2}$	β^{2*2}

〈Figure 3-1〉 Calculating DID estimators



※ Modify and quote the figure of Kim & Oh(2022).

3.2.3.3 Malmquist Productivity Index(MPI)

MPI does not assume a specific production function but refers to the index of the output variable for the input calculated based on the distance function. In other words, it refers to measuring the change in productivity between the two points by calculating the ratio of distances to each data point concerning a standard technology (Kwon, 2010). When analyzing the efficiency at a specific time, the CCR model compares the relative ratio of input to output between several observation points in a similar situation. On the other hand, when there is time series data at different points, tracking the increase or decrease in the ratio of output to input over time is called Productivity Growth Analysis. MPI is a productivity analysis using data envelope analysis(DEA)(Kang & Choi, 2015).

MPI indicates how much productivity has changed between the two points. It is expressed as the ratio of productivity at the current time to productivity at the previous time. If MPI is greater than 1, the ratio of output to input at the time t+1 increased compared to the time t, and total factor productivity is considered to have increased. Since it is not necessarily right to express the productivity index based on a set of production possibilities at a specific point in time, it is reasonable to use MPI by geometrically averaging MPI obtained based on each point in Equation (3-5)(Lim, 2008; Kang & Choi, 2015).

$$M_0^{t,t+1}(x^t, y^t, x^{t+1}, y^{t+1}) = [M_0^t \cdot M_0^{t+1}]^{1/2}$$
$$= [[\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)}] \cdot [\frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)}]]^{1/2} \quad (3-5)$$

In Equation (3-5), MPI presents the time-series change in productivity by calculating the ratio through the distance of individual data points at different points in time for a common technology. In

addition, the calculation standard geometric mean MPI is converted into the rate of efficiency change(EC) and rate of technical change(TC) as shown in Equation (3-6) to analyze the cause of change after time-series comparison of productivity. EC, the rate of efficiency change, is a value that expresses whether any DMU is further or closer to the production change line between time t and time t+1, and refers to the Catching-up Effect. That is, EC>1 means that it is further away from the production change line at the time t+1 than at the time t. On the other hand, TC, the rate of technical change, can be calculated more at the same input when the production change line is expanded, which means technological progress (TC>1) and vice versa (TC<1)(Hong, 2002; Lee & Hong, 2012).

$$M^{t,t+1}_0(x^t,y^t,x^{t+1},y^{t+1}) = [[\frac{D^t_0(x^{t+1},y^{t+1})}{D^t_0(x^t,y^t)}] \cdot [\frac{D^{t+1}_0(x^{t+1},y^{t+1})}{D^{t+1}_0(x^t,y^t)}]]^{1/2}$$
$$= \frac{D^t_0(x^{t+1},y^{t+1})}{D^t_0(x^t,y^t)} \times [\frac{D^t_0(x^t,y^t)}{D^{t+1}_0(x^t,y^t)} \cdot \frac{D^t_0(x^{t+1},y^{t+1})}{D^{t+1}_0(x^{t+1},y^{t+1})}]^{1/2} = EC \times TC \quad (3-6)$$

If EC is further subdivided in Equation (3-6), it can be divided into the Pure Efficiency Change Index(PECI) and the Scale Efficiency Change Index(SECI).

$$M^{t,t+1}_0 = \frac{V^{t+1}_0(x^{t+1},y^{t+1})}{V^t_0(x^t,y^t)} \times [\frac{V^t_0(x^t,y^t)}{D^t_0(x^t,y^t)} \cdot \frac{V^{t+1}_0(x^{t+1},y^{t+1})}{D^{t+1}_0(x^{t+1},y^{t+1})}]$$
$$\times [\frac{D^t_0(x^t,y^t)}{D^{t+1}_0(x^t,y^t)} \cdot \frac{D^t_0(x^{t+1},y^{t+1})}{D^{t+1}_0(x^{t+1},y^{t+1})}]^{1/2} = PECI \times SECI \times TCI \quad (3-7)$$

Here, V represents the output distance function under Variable Return to Scale(VRS). When the input and output data of a specific DMU are given for periods t and t+1, six distance functions of equation (3-7) are measured. These six distance functions are

$D_0^t(x^t, y^t)$, $D_0^t(x^{t+1}, y^{t+1})$, $D_0^{t+1}(x^t, y^t)$, $D_0^{t+1}(x^{t+1}, y^{t+1})$, $V_0^t(x^t, y^t)$, $V_0^{t+1}(x^{t+1}, y^{t+1})$.

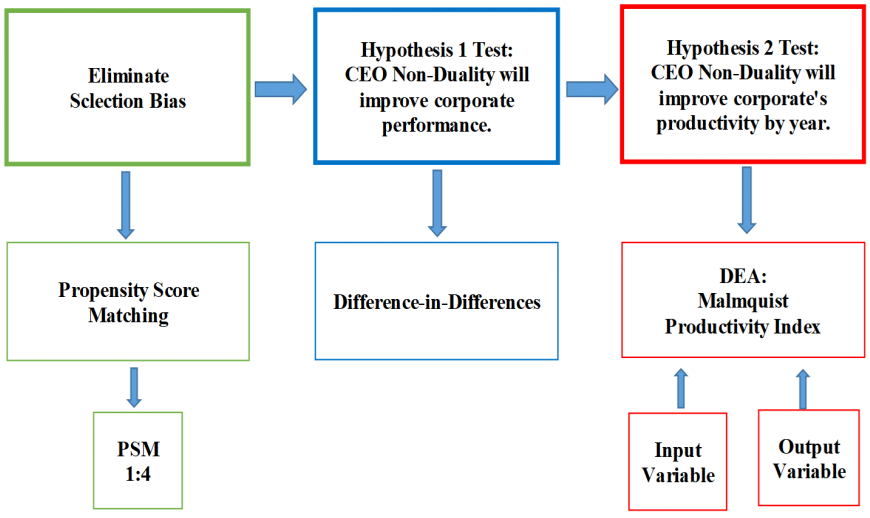
By measuring six distance functions and substituting them into Equation (3-7), PECI, SECI, TCI and MPI can be obtained. PECI, the self-efficiency of DMU, is an indicator that indicates the degree to which DMUhas been efficiently operated and managed to contribute to the transformation of input variables into output variables. SECI is an indicator that can identify the degree to which the scale of DMU has approached economies of scale for efficient management. TCI is an indicator that measures productivity changes by reflecting innovation potential such as external shocks or new management techniques.

3.3. Research Methodology

3.3.1 Research Model and Hypothesis Setting

This study verified whether corporates implementing CEO Non-Duality among securities-listed corporates improved their performance using PSM and DID and studied whether their annual productivity improved using MPI. In order to conduct the above research, a research model such as 〈Figure 3-2〉 was presented.

〈Figure 3-2〉 Research Model



3.3.1.1 Hypotheses on CEO Non-Duality and Corporate Performance

In European and US capital markets, it is common to pursue long-term investment returns by investing in ESG, a non-financial factor that affects corporate sustainability (Oh, 2021). Corporations are carrying out numerous management activities to generate profits. Corporate sustainability results in the probability that the corporate will continue its management activities (Lee & Rhee, 2020). Therefore, this study aims to check whether the corporate performance of corporates with CEO Non-Duality is improved, as mentioned in the introduction.

Studies have shown that CEO Duality weakens the board control mechanism and ultimately negatively affects corporate performance (Boyd, 1995; Mallette & Fowler, 1992; Kim, 2012a). It was also predicted that CEO Duality would negatively affect corporate performance by creating a situation where CEOs could act outside the organization's interests (Kim & Prescott, 2005). CEO Duality removes market constraints, increasing environmental uncertainty, giving CEOs more opportunities for discretionary actions that are blamed for agency problems (Finkelstein & Boyd, 1998; Hambrick & Finkelstein, 1987). According to these previous studies, this study was expected to improve corporate performance by CEO Non-Duality. Therefore, the following hypotheses were established to confirm whether these research results were measured the same way in this study sample listed on the Korean securities market.

Hypothesis 1: CEO Non-Duality will improve a corporate's performance.
Hypothesis 1-1: CEO Non-Duality will improve return on assets (ROA).
Hypothesis 1-2: CEO Non-Duality will improve return on equity (ROE).

3.3.1.2 Hypotheses on CEO Non-Duality and Change in Productivity by Year

In addition, the researcher will verify through MPI whether the management performance of corporates that have implemented CEO Non-Duality improves year by year. ESG is based on the philosophy that environmental, social, and governance pillars can affect a corporation's success and market returns. It has also been shown that corporates with strong ESG performance tend to remain sustainable over many years by successfully managing business objectives(Senadheera et al., 2021).

The link between sound governance and strengthened CSR leads to an increase in corporate value, which expands through an increase in foreign ownership, providing a foundation for smooth financing in the capital market(Ko et al., 2012; Kim et al., 2013; La Porta et al., 1999). In other words, increasing foreign ownership leads to efficient monitoring of management activities, increasing corporate value(Kim & Kim, 2009; Park et al., 2004). A governance system that prevents the management from being arbitrary increases the stability of management activities and consequently improves management performance. In other words, excellent corporate governance leads to stable sales growth and cost reduction, making profit flexible and increasing profit stability(Suh et al., 2013; Kim & Park, 2013). As in previous studies, corporates that have implemented CEO Non-Duality are expected to improve their performance year by year due to improved decision-making efficiency. Therefore, it was confirmed that the treatment group that implemented the above PSM-DID analysis with CEO Non-Duality improved corporate performance after the implementation compared to before the implementation. For double verification, MPI was used to examine how productivity changes by year. To confirm, the researcher established the following hypotheses.

Hypothesis 2: CEO Non-Duality will improve a corporate's annual productivity.
Hypothesis 2-1: CEO Non-Duality will improve productivity by year.
Hypothesis 2-2: The treatment group that implemented CEO Non-Duality will improve productivity by year compared to the control group that did not.

3.3.2 Research Subjects

This study downloaded the executive status of securities-listed companies from 2018 to 2021 from OpenDART, which can download important information from the Financial Supervisory Service's electronic disclosure system, and extracted 20 CEO Non-Duality companies as shown in 〈Table 3-2〉. In this way, after downloading financial information from FnGuide for PSM analysis of the treatment group with CEO Non-Duality and the control group that did not, the final analysis target samples were collected, excluding 1) settlement corporations other than December, 2) financial institutions, and 3) corporates with missing values. In addition, the analysis period was set as shown in 〈Table 3-3〉 to conduct PSM-DID analysis of companies that implemented CEO Non-Duality in these different years. In other words, for DID analysis, the year the policy was implemented was called t (post), the year before it was set to t-1 (pre), and the year before implementation was compared with the average value of three years after implementation. The reason is to minimize external factors that are not included in the analysis model of this study but have a significant impact on corporate performance in a specific year and to reflect inputs that increase the reliability of the output variable analysis results. For example, it is a case where corporate performance suddenly deteriorates due to external circumstances such as Covid-19(Meyer & Gupta, 1994; Oster, 1990;

Yoo & Kim, 2008). In the panel data for MPI measurement, total assets, equity capital, and sales variables were divided into each year's producer price index, a GDP deflator released by the National Statistical Office, to eliminate inflation. Therefore, inflation by variable in five years was eliminated, eliminating data distortion caused by price changes.

〈Table 3-2〉 Analysis on Target Corporates

Year	No.	Name of Corporates
2018	8	DL, Samsung Electronics, Samsung C&T, Dongwon Fisheries, Hyundai Doosan Infracore, Fila Holdings, HSD Engine, KSS Shipping
2019	4	SK Innovation, DI Dongil, Able C&C, District Heating Corporation
2020	8	AJ Networks, Keyang Electric, DY Power, Samsung Biologics, Saeha, Sindoh, Coway, Hanjin KAL

〈Table 3-3〉 Setting Analysis Period

	Treatment Year(t)	Period	Note
DID	2018, 2019, 2020	Pre(t_{-1}), Post(AVG(t_1, t_2, t_3))	Comparison of average values 3 years after implementation with values 1 year before implementation
MPI	2018, 2019, 2020	t_{-2}, t_{-1}, t_1, t_2, t_3	Comparison of 5 years including policy implementation year

* CEO Non-Duality Treatment year: t

〈Table 3-4〉 shows the operational definitions of variables for performing PSM, DID, and MPI in the 〈Figure 3-2〉 research model.

〈Table 3-4〉 Operational Definition of Variables

	Variable	Variable Name	Operational Definition
PSM	Performance Variable	ROA_{it}	Return on Assets(Net Income/Total Assets)
	Treatment Variable	*CEO Non-Duality*	CEO Non-Duality, Y=1, N=0
	Covaiate	*LN_AGE*	The natural logarithm of days after listing
		LN_CAPITAL	The natural logarithm of equity in financial statements
		LN_SALES	The natural logarithm of equity in income statements
		LN_ASSETS	The natural logarithm of total assets in financial statements
		LEV	Total liabilities / Total equity * 100
		OPEPRFR	Operating Profit Rate: Operating Profit/Sales * 100
DID	Dependent Variable	ROA_{it}	Return on Assets(Net Income/Total Assets)
		ROE_{it}	Return on Equity(Net Income/Equity)
	Independent Variable	$D_{1,t} * D_{2,t}$	Interactive variables of CEO Non-Duality and dummy variables pre and post implementation
		$D_{1,t}$	Dummy Variables of CEO Non-Duality, Y=1, N=0
		$D_{2,t}$	Dummy Variables pre and post. Post=1, Pre=0
	Control Variable	*LN_CAPITAL*	The natural logarithm of equity in financial statements
		LN_SALES	The natural logarithm of equity in income statements
		LN_ASSETS	The natural logarithm of total assets in financial statements
		LEV	Total liabilities / Total equity * 100
		OPEPRFR	Operating Profit Rate: Operating Profit/Sales * 100
		LN_AGE	The natural logarithm of days after listing
MPI	Input	*LN_EMPL*	The natural logarithm of the total

	Variable	Variable Name	Operational Definition
	Variable		number of employees
		LN_CAPITAL	The natural logarithm of total assets in financial statements
		LN_ASSETS	The natural logarithm of total assets in financial statements
	Output Variable	*LN_SALES*	The natural logarithm of equity in income statements

As shown in 〈Table 3-3〉, CEO Non-Duality DID analysis was divided into before (t-1) and after (AVG(t1,t2,t3)) the implementation of the policy, and compared and analyzed the management performance before and after. The analysis subjects were divided into 40 treatment groups, and 154 control groups matched 1:4. The basic statistics of the sample are shown in 〈Table 3-5〉. The mean and standard deviation of ROA, the dependent variable of Hypothesis 1-1, showed values of 2.55 and 5.54, and the mean and standard deviation of ROE, the dependent variable of Hypothesis 1-2, showed values of 4.76 and 15.03. Other control variables are as shown.

〈Table 3-5〉 Summary of Variables Using DID(N=194)

Variable	No.	Mean	S.D.	Min	Max
ROA	194	2.55	5.54	-33.05	27.42
ROE	194	4.76	15.03	-145.11	36.80
LN_CAPITAL	194	20.79	1.92	16.46	26.26
LN_SALES	194	21.25	1.92	16.68	26.19
LN_ASSETS	194	21.58	1.97	17.62	26.56
LEV	194	139.30	100.51	7.67	560.16
OPEPRFR	194	4.85	9.22	-72.73	45.57
LN_AGE	194	8.73	0.92	5.38	10.70

〈Table 3-6〉 shows the descriptive statistics and correlations of three input variables and one output variable for MPI analysis, and it was confirmed that all variables were significantly correlated at the 1% significance level.

〈Table 3-6〉 Summary of Variables, Correlation Using MPI(N=194)

Variable	obs	Mean	S.D.	Min	Max	①	②	③	④
① LN_EMPL	194	6.54	1.90	1.79	11.27	1			
② LN_CAPITAL	194	20.79	1.92	16.46	26.26	0.623***	1		
③ LN_ASSETS	194	21.58	1.97	17.62	26.56	0.646***	0.980***	1	
④ LN_SALES	194	21.25	1.92	16.68	26.19	0.660***	0.910***	0.938***	1

*** p〈0.01, ** p〈0.05, * p〈0.1

3.3.3 Matching of Treatment Group and Control Group

In this study, Stata 17.0 was used to conduct PSM. Logistic regression analysis was conducted for PSM, and a control group of 4 was matched to treatment group 1 during the k-Nearest neighbor as a matching method. k-NN is a method of matching the control group corporate with the propensity score closest to the treatment group corporate propensity score. In other words, it is a method of calculating the average of one treatment group corporate by matching

one control group corporate or multiple control group corporates in the order of high similarity. Looking at the value of t before matching in 〈Table 3-7〉, the significance probability P〈0.01 in the LN_CAPITAL, LN_SALES, and LN_ASSETS variables is significant, indicating that the two groups of the treatment group and the control group are different in some variables. However, in the t-value after matching, all variables are not significant at the significance level of 1%, so the alternative hypothesis that there is an average difference between the treatment group and the control group is rejected, and the two groups can be regarded as the same group after matching.

〈Table 3-7〉 Statistical Analysis of Mean Difference between Treatment Group and Control Group Before and After Matching

Variable	Before matching				After matching			
	T.G. (n=40)	C.G. (n= 4,016)	t-value	Pr〉|t|	T.G. (n=40)	C.G. (n=154)	t-value	Pr〉|t|
ROA	2.638	1.519	-0.764	0.445	2.638	2.530	-0.110	0.912
LN_AGE	8.550	8.873	2.310	0.021	8.550	8.777	1.401	0.163
LN_CAPITAL	20.808	19.628	-4.747	0.000	20.808	20.783	-0.073	0.942
LN_SALES	21.141	19.989	-4.505	0.000	21.141	21.278	0.400	0.689
LN_ASSETS	21.587	20.430	-4.171	0.000	21.587	21.582	-0.016	0.988
LEV	138.022	200.621	0.523	0.601	138.022	139.638	0.090	0.928
OPEPRFR	5.898	3.118	-1.397	0.163	5.898	4.579	-0.805	0.422

3.4. Empirical Analysis

3.4.1 Average Treatment Effect Analysis for the Treatment Group

The Average Effect of Treatment on the Treated (ATT) is Y^1-Y^0, which is the difference between the Average Treatment Effect (ATE) Y^1 of the treatment group and the Average Difference Effect (ATE) Y^0 of the control group. This can be referred to as DID (Difference-in-Differences) effect, a net effect. As shown in 〈Table 3-8〉, the net effect of implementing CEO Non-Duality policy was more significant in the net growth effect of the treated group than the control group in two variables, LN_AGE and LEV. On the other hand, LN_CAPITAL, LN_SALES, LN_ASSETS, and OPEPRFR showed negative growth compared to the control group. Four out of six variables had negative values, so the treatment group that implemented CEO Non-Duality had no net growth effect on corporate performance due to CEO Non-Duality compared to the control group that did not. This result is different result from the previous CEO Non-Duality research results. In other words, previous studies found that CEO Non-Duality positively affected corporate performance, and other research results showed mixed positive or adverse effects.

〈Table 3-8〉 Average Effect of Treatment on the Treated (ATT)

Variable	Comparison before and after implementation after matching						
	T.G.(n=40)			C.G.(n=154)			DID (Y^1-Y^0)
	Pre	Post	ATE(Y^1)	Pre	Post	ATE(Y^0)	
LN_AGE	8.453	8.646	0.193	8.687	8.868	0.181	0.012
LN_CAPITAL	20.790	20.826	0.036	20.758	20.808	0.050	-0.014
LN_SALES	21.217	21.065	-0.152	21.254	21.302	0.048	-0.200
LN_ASSETS	21.591	21.583	-0.008	21.554	21.610	0.055	-0.063
LEV	146.058	129.986	-16.072	139.816	139.459	-0.357	-15.715

Variable	Comparison before and after implementation after matching						
	T.G.(n=40)			C.G.(n=154)			DID (Y^1-Y^0)
	Pre	Post	ATE(Y^1)	Pre	Post	ATE(Y^0)	
OPEPRFR	6.533	5.264	−1.269	4.534	4.625	0.091	−1.360

3.4.2 Performance Analysis of Difference-in-Differences

This study used the DID model for multiple regression analysis of Hypothesis 1-1 (CEO Non-Duality will improve ROA) and Hypothesis 1-2 (CEO Non-Duality will improve ROE), and the formula is as shown in the following formula (3-8).

$$y_i = \beta_0 + \beta_1 D_{1,i} + \beta_2 D_{2,i} + \beta_3 D_{1,i} \times D_{2,i} + \beta_4 X_{4,i} \cdots \beta_n X_{n,i} + \epsilon_i \quad (3-8)$$

$$y_i = Corporate\ Performance\ (H_1 : ROA, H_2 : ROE)$$

$$D_{1,i} = D_1 : Treatment\ (Treatment : i = 1, Control : i = 0)$$

$$D_{2,i} = D_2 : \mathrm{Pre\ or}\ Post\ (Post : i = 1, \mathrm{Pre} : i = 0)$$

$$X_{n,i} = other\ control\ variables$$

y_i is ROA and ROE among corporate performance. D_1 is a dummy variable(treatment = 1, control = 0) about whether CEO Non-Duality policy is treated or not. D_2 is a dummy variable before and after policy implementation(pre = 0, post = 1). $D_1 \times D_2$ is an interaction term, and the value of the coefficient value becomes DID estimator. Here, has a positive value and if it is statistically significant, it can be interpreted as having a treatment effect(Lee et al., 2018). DID estimators for Hypothesis 1-1(ROA) and Hypothesis 1-2(ROE) through the regression model are shown in 〈Table 3-9〉. In Hypothesis 1-1, LN_CAPITAL, LN_SALES, LN_ASSETS, and OPERPFR were statistically significant in the dependent variable ROA in the 95% confidence interval. However, the $D_1 \times D_2$

estimator, which is the effect after the implementation of CEO Non-Duality, was 1.112, which had a statistically insignificant positive effect on ROA. In addition, in Hypothesis 1-2(ROE), LN_SALES and OPERPFR were statistically significant in the dependent variable ROE in the 95% confidence interval, but the estimated amount of $D_1 \times D_2$, which is the effect after the CEO Non-Duality is 2.610, showing a positive value that is not statistically significant.

〈Table 3-9〉 Financial Performance Measurement

Variables	ROA		ROE	
	(1)	(2)	(3)	(4)
D1	-0.140	-0.832	1.292	-0.330
D2	-0.800	-0.878	-2.910	-3.069
D1 * D2	0.497	1.112	0.810	2.610
LN_AGE		0.408		0.508
LN_CAPITAL		6.441 **		4.543
LN_SALES		1.031 **		2.869 **
LN_ASSETS		-7.239 **		-6.743
LEV		0.015		0.023
OPERPFR		0.396 ***		0.902 ***
constant	2.929 ***	-4.124	5.863 ***	-15.846
Adj R^2	-0.011	0.526	-0.005	0.333
F	0.280	24.770	0.567	11.690

*** p<.01, ** p<.05, * p<.10

However, the CBD of a corporate that implemented CEO Non-Duality was appointed as an inside director or an outside director. In particular, the appointment of inside directors such as shareholders, chairpersons of conglomerates, former CEO, and CFO as CBD makes it

difficult to change management strategies or organizational culture compared to outside directors becoming CBD. In other words, the CBD of the inside director is closer to CEO Duality than the CBD of the outside director. Therefore, in 〈Table 3-10〉, this researcher examined how the corporate's corporate performance with the CBD of the outside director differs from the corporate's corporate performance with the CBD of the inside director. Regarding the dependent variable ROA, the estimated DID of corporates with an outside director serving as CBD was 2.734, which increased ROA compared to the estimated estimator of -0.194 for corporates with an inside director serving as CBD. Also, regarding the dependent variable ROE, the estimated DID for corporates with an outside director serving as CBD is 7.178, which is more ROE than the DID estimator of -1.098 for corporates with an inside director serving as CBD. In other words, among the corporates that implemented CEO Non-Duality, the effect of corporates whose inside directors became CBD was superior to that of corporates whose outside directors became CBD. Even if it is not a statistically significant result, appointing an outside director as CBD is more likely to create a new management strategy or organizational culture than appointing an inside director as CBD.

〈Table 3-10〉 Comparison of DID Values of Outside Director CBD and Inside Director CBD

Variables	ROA			ROE		
	T.G. (N=40)	Out_Dir. CBD (N=8)	In_Dir. CBD (N=32)	T.G. (N=40)	Out_Dir. CBD (N=8)	In_Dir. CBD (N=32)
D_1	-0.140	-4.387	1.093	1.292	-9.003	4.119
D_2	-0.800	-0.810	-0.665	-2.910	-3.039	-2.562
D_1*D_2	0.497	2.734	-0.194	0.810	7.178	-1.098

Variables	ROA			ROE		
	T.G. (N=40)	Out_Dir. CBD (N=8)	In_Dir. CBD (N=32)	T.G. (N=40)	Out_Dir. CBD (N=8)	In_Dir. CBD (N=32)
constant	2.929 ***	3.082 ***	2.720 ***	5.863 ***	6.501 ***	5.450 ***
Adj R^2	-0.011	0.003	-0.007	-0.005	0.000	0.001
F	0.280	1.170	0.540	0.567	1.020	1.050

*** p<.01, ** p<.05, * p<.10

D_1: Treatment Group Yes=1, No=0

D_2: Post Yes=1, No=0

3.4.3 Performance Analysis of Malmquist Productivity Index

In 〈Table 3-11〉, the change in average productivity by period was examined. Since each productivity index value is a rate of change, the average value of productivity change was calculated using the geometric mean. t-2 to t-1 were divided into the first period, t-1 to t1 into the second period, t1 to t2 into the third period, and t1 to t2 into the fourth period. Looking at MPI by period, productivity increased by 0.6% overall and by 3.1% in the second period, which had a before and after the implementation of CEO Non-Duality. The productivity of the treatment group decreased by 0.1% over the entire period, and the productivity of the control group increased by 0.8%. Therefore, the productivity of the treatment group decreased by a narrow margin. The PECI(Pure Efficiency Change Index) remained unchanged, while the TCI(Technical Change Index) rose 0.6% over five years. In the PECI that appears when the DMU operates efficiently on its own, the treatment group's PECI(0.999) is lower than the control group's PECI(1.000), so the treatment group cannot be considered to be operated efficiently. When the treatment group rose 0.1% in the TCI, which reflects innovation potential such as external shocks and new management techniques, the control group rose 0.7%. Through MPI, the treatment group's annual

productivity was lower than the control group's. In addition, low productivity made it inferior to the control group in its efficient operation. Although the implementation of CEO Non-Duality positively affected corporate performance through DID analysis, it was not statistically significant, and MPI confirmed that productivity did not improve year by year.

〈Table 3-11〉 Average Rate of Change in MPI

Period	Group	MPI	TCI	TECI	PECI	SECI
t_{-2}~t_{-1} (1st)	T.G.	1.004	1.004	1.000	1.001	0.998
	C.G.	0.999	1.005	0.994	0.996	0.998
	Mean	1.000	1.004	0.995	0.997	0.998
t_{-1}~t_1 (2nd)	T.G.	0.996	1.012	0.985	0.989	0.996
	C.G.	1.040	1.043	0.992	0.995	0.997
	Mean	1.031	1.037	0.990	0.994	0.996
t_1~t_2 (3rd)	T.G.	0.997	0.983	1.014	1.007	1.007
	C.G.	0.993	0.976	1.017	1.010	1.007
	Mean	0.994	0.977	1.016	1.010	1.007
t_2~t_3 (4th)	T.G.	0.999	1.006	0.993	1.000	0.993
	C.G.	1.000	1.006	0.994	0.999	0.995
	Mean	1.000	1.006	0.994	0.999	0.995
Mean Total Period	T.G.	0.999	1.001	0.998	0.999	0.998
	C.G.	1.008	1.007	0.999	1.000	0.999
	Mean	1.006	1.006	0.999	1.000	0.999

MPI: Malmquist Productivity Index
TCI: Technical Change Index
TECI: Technical Efficiency Change Index
PECI: Pure Efficiency Change Index
SECI: Scale Efficiency Change Index

3.5. Discussion, Implications, and Limitations

3.5.1 Discussion

The analysis results of this study are summarized and interpreted as follows. First, the study results of Hypothesis 1, that the corporate performance of corporates that conducted CEO Non-Duality would improve showed a DID estimator of 1.112 for the dependent variable ROA. However, it was not statistically significant, and a DID estimator of 2.610 for the dependent variable ROE was also not statistically significant. However, 80% of the corporates implementing CEO Non-Duality have appointed inside directors such as shareholders, chairpersons of conglomerates, and former CEOs as CBD. Therefore, the neutrality of CBD may only be guaranteed partially for most corporates implementing CEO Non-Duality. CEO Non-Duality estimates for the dependent variable ROA and ROE of a company that an inside director is CBD are 2.734 and 7.178, respectively, indicating the possibility can have a positive effect on corporate performance compared to the estimates of -0.194 and -1.098 for a company that an outside director is CBD. As such, the results of research on corporates where outside directors became CBD showed the possibility to be consistent with studies by Boyd(1995), Mallette & Fowler(1992), and Kim & Prescott(2005) that CEO Duality negatively affects corporate performance. In addition, CEO Non-Duality showed the possibility to be consistent with Kim(2013)'s research that leads to efficient corporate management and increased corporate performance. However, the results of this study confirmed that the corporate governance improvement activities of Korean-listed corporates that implemented CEO Non-Duality did not substantially impact corporate performance. The reason for this is that first, 80% of corporates that conducted CEO Non-Duality only showed the possibility

that they could change externally without changing their organizational culture or management strategy by appointing an inside director as CBD. In addition, this is because the research subject period of this study is short. In other words, the fact that the four-year short-term PSM-DID analysis and the five-year period for MPI analysis were short-term may be why this study showed different results from previous studies. In future research, it is necessary to expand the research period further.

In addition, it was confirmed that the second hypothesis that CEO Non-Duality will improve the company's productivity by year also did not improve productivity by year. In addition, the productivity improvement of the treatment group was not superior to that of the control group and could have been better. Instead, the change in productivity of the control group by year was slightly different, but it was superior to the change in productivity of the treatment group by year. This result differed from a study by Senadheera et al. (2021), in which companies with strong ESG performance tend to remain sustainable for many years by successfully managing their business goals. In addition, it was different from Suh et al. (2013) and Kim & Park(2013)'s research that excellent corporate governance leads to stable sales growth and cost reduction, making profits flexible and increasing profit stability. Through CEO Non-Duality, it was verified that the research results that CBD from outside directors plays a role in checking CEO to streamline decision-making have yet to be applied to listed companies in Korea. In other words, it can be interpreted that while companies in advanced Western countries such as the U.S. have practical effects by introducing CEO Non-Duality to control the CEO's arbitrary management efficiently, Korean CEO Non-Duality can only be an external publicity effect of improving governance in large business groups.

3.5.2 Implications

This study shows the following theoretical and practical implications. First, the theoretical implications are as follows. First, this study analyzed the effect of policy implementation on corporate performance through advanced DID compare to the existing hierarchical regression analysis method on CEO Non-Duality. Second, PSM-DID analysis usually compares the effects before and after policy implementation in a single year. At the same time, this study conducted DID analysis by grouping corporates that implemented policies in different years. This method can be used when analyzing corporates that implemented policies at different points over the years in the same group. Third, in addition to verifying the effectiveness of policy implementation through DID, the change in productivity by year was once again verified through MPI. This study has the theoretical significance that the previous measure of simple productivity changes through MPI was used as a means for complementary verification of DID.

Next, the following practical implications can be stated. First, the impact of CEO Non-Duality on corporate performance in listed corporates in Korea was verified. As a result, more than 50% of corporates in the U.S. are implementing CEO Non-Duality, while only a small number of corporates in Korea, which account for less than 20% of the five listed corporates, are doing CEO Non-Duality. As such, it was possible to determine whether CEO Non-Duality has a practical effect or is only ESG washing at a time when Korean corporates are passive in CEO Non-Duality. Second, although it was found that CEO non-duality is not directly related to corporate performance improvement, it was found that improving the corporate structure externally by appointing an inside director as CBD may not bring about practical effects. It is significant to confirm the possibility that appointing an outside director as CBD can positively impact corporate performance.

Therefore, the form of board members is essential to achieve corporate restructuring. In addition, it is necessary to take an approach that considers various aspects such as organizational culture and management strategy by executives such as CEO or CBD. Third, CEO Non-Duality of Korea is still at the level of the introduction period. In other words, it was analyzed that not only the number of corporates introducing CEO Non-Duality is small, but also there is no positive effect of CEO Non-Duality on corporate performance. Through this study, it is expected that CEO Non-Duality in Korea will be substantially expanded, and the introduction effect will be an opportunity to affect corporate performance positively.

3.5.3 Limitations

Despite the above theoretical and practical implications, this study has limitations. First, only 20% of the corporates that implemented CEO Non-Duality practice true CEO Non-Duality, and 80% only practice CEO Non-Duality, making it difficult to verify the exact implementation effect. It is necessary to study the relationship between CEO Non-Duality and corporate performance in the future when the proportion of companies that have appointed outside directors as CBD increases. Second, the amount of analysis data was not significant. The reason for the small number of data is that among the securities listed companies that implemented CEO Non-Duality, financial firms and companies that were not settled in December were excluded. However, 35 companies implemented CEO Non-Duality in 2021, up 438% from 8 companies in 2020. More companies are expected to implement CEO Non-Duality in the future, so research needs to be conducted through increased corporate data. Since the target period of this study is three years, from 2018 to 2020, only 20 companies were studied. In the future, it is necessary to

establish a mid-to-long-term research plan and secure more data from companies that have implemented CEO Non-Duality for about ten years. Third, the corporate performance of this study was analyzed only for the previous year of CEO Non-Duality and the average value three years after implementation. For similar reasons to the second above, the policy implementation effect may have yet to be clearly shown because the mid-to-long-term performance from 5 to 10 years after the policy implementation was not collected. Therefore, in the future, it is necessary to analyze corporate performance within five years or more and ten years after the policy implementation year. This study is because after implementing the policy, the management strategy takes a long time to permeate the organizational culture or members and exert an effect.

3.6. Conclusion

ESG management, such as CEO Non-Duality, is widely required by corporates to improve corporate governance in developed capital markets, led by the United States. In this study, through PSM-DID analysis, we studied whether the treatment group, which implemented CEO Non-Duality for Korean securities-listed companies, improved corporate performance compared to the control group and before policy implementation of the corporate. In addition, through MPI, annual productivity changes over a more expanded five-year period were measured. As a result, an empirical analysis was conducted on how CEO Non-Duality affected corporate performance.

In this study, only 20% of companies implementing CEO Non-Duality appointed outside directors as CBD. 80% of companies implementing CEO Non-Duality appointed inside directors as CBD. This result cannot be considered to have genuinely improved corporate

governance. In other words, it was a structure in which corporate management philosophy or strategy could not be changed, mainly through CEO Non-Duality. The study did not prove a causal relationship between CEO Non-Duality and corporate performance improvement through PSM-DID analysis. However, it showed the possibility that appointing an outside director as CBD could positively impact corporate performance. This result suggests that it is necessary to properly adjust the company's management strategy and organizational culture and further strengthen outside directors' role in electing a board of directors.

In addition, the annual productivity of corporates that implemented CEO Non-Duality through MPI was inferior to that of the control group that did not implement the policy. One reason for this may be that Korean securities listed corporates belong to large corporate groups, so inside directors such as shareholders, chairman or vice chairman of conglomerate, former CEO, and CFO are appointed as CBD.

Although the hypothesis established by this researcher, according to previous studies, has been rejected, it is hoped that further ESG activity research will continue to improve the governance structure of Korean corporates based on this study.

References

References_Chapter 1

Alareeni, B. A., & Hamdan, A. (2020). ESG impact on performance of US S&P 500-listed firms. Corporate Governance: The International Journal of Business in Society.

Amel-Zadeh, A., & Serafeim, G. (2018). Why and how investors use ESG information: Evidence from a global survey. *Financial Analysts Journal*, 74(3), 87-103.

Bae, C. H., Kim, T., & Shin, S.-C. (2021). The Trend of Studies Using Non-financial Measures in the Field of Accounting and ESG Issue. *Korean Accounting Journal*, 30(2), 235-276.

Baik, S., & Choi, J. (2021). ESG Rating and Firm Characteristics. *KOREAN INTERNATIONAL ACCOUNTING REVIEW*, 99, 147-169.

Billio, M., Costola, M., Hristova, I., Latino, C., & Pelizzon, L. (2021). Inside the ESG Ratings:(Dis) agreement and performance. *Corporate Social Responsibility and Environmental Management*, 28(5), 1426-1445.

Buallay, A. (2019). Is sustainability reporting (ESG) associated with performance? Evidence from the European banking sector. Management of Environmental Quality: An International Journal.

Choe, K., & Kim, D. (2021). Earnings Management of High ESG-Scored Companies: For Companies Evaluated by the Korea Corporate Governance Service. Productivity Research: *An International Interdisciplinary Journal*, 35(4), 187-210.

Chun, S., & Park, H. (2021). Comparative Analysis Study of ESG Evaluation Indicators from the Perspective of HRM. *Journal of Human Resource Management Research*, 28(5), 133－148.

Do, Y. W., & Kim, S. (2019). The Effects of Changes in ESG Ratings on Firms'Stock Price Volatility and Excess Return: Focusing on Asymmetric Signal Effects by Detailed Evaluation Factors. *Korean Finance Association Conference*, 821－850.

Dorfleitner, G., Halbritter, G., & Nguyen, M. (2015). Measuring the level and risk of corporate responsibility－An empirical comparison of different ESG rating approaches. *Journal of Asset Management*, 16(7), 450－466.

Gillan, S., Hartzell, J. C., Koch, A., & Starks, L. T. (2010). Firms'environmental, social and governance (ESG) choices, performance and managerial motivation. Unpublished working paper, 10.

Hughes, A., Urban, M. A., & Wójcik, D. (2021). Alternative ESG Ratings: How Technological Innovation Is Reshaping Sustainable Investment. *Sustainability*, 13(6), 3551.

Jang, Y. (2021). Status and Problems of Korean ESG Rating Agencies and Regulatory Direction. *COMMERCIAL CASES REVIEW*, 34(3), 423－472.

Jin, J., & Seong, Y. (2020). A Study on the Evaluation Model of Corporate Social Responsibility. *KBM Journal(K Business Management Journal)*, 4(2), 69－88.

Kang, W., & Jung, M. (2020). Non-financial Index and Market Performance of Firm: Analysis of Events Used for Developing ESG Index. *Yonsei Business Review*, 57(2), 1－22.

Kim, D. Y. (2020). The Effect of ESG Rating on Free Cash Flow. *The Journal of Business Education*, 34(4), 153－177.

Kim, K., & Lee, H. (2021). The Effect of ESG rates on Corporate Value and Cost of Debt, Credit rating. *Research Institute of Industry and Economy*, 11－19.

Kim, Y., & Park, J. (2021). ESG·CSR and Corporate Financial Performance: What Have We Learned, and Where Do We Go from Here? *Journal of Strategic Management*, 24(2), 75－114.

Korea Corporate Governance Service. (2021). ESG Best Practices. Korea Corporate Governance Service.

Kotsantonis, S., Pinney, C., & Serafeim, G. (2016). ESG integration in investment management: Myths and realities. *Journal of Applied Corporate Finance*, 28(2), 10－16.

Lee, I. (2020). ESG evaluation system status and characteristics analysis. *Korea Capital Market Institute*, 21(09).

Lee, J., & Rhee, J. H. (2020). Current Status and Future Directions of Research on "Sustainable Management": Focusing on the ESG Measurement Index. *Journal of Strategic Management*, 23(2), 65－92.

Lee, Y., & Kim, O. (2021). Searching ways for improving reliability of ESG through standardization. *Public Policy Review*, 35(4), 37－64.

Leem, W. B. (2019). Effect of Non－Financial Information on Firm Performance: Focusing on ESG Score. *KOREAN INTERNATIONAL ACCOUNTING REVIEW*, 86, 119－144.

Maeil Economic Daily ESG Team. (2021). This is ESG. Maekyung Publishing Co., Ltd.

Ministry of Trade, Industry and Energy, Korea Productivity Center. (2021). K-ESG Guidelines v1.0. Collaboration of related ministries.

MSCI ESG Research. (2020). MSCI ESG Ratings Methodology. MSCI.

National Federation of Entrepreneurs. (2021). Domestic and international ESG evaluation trends and implications.

Oh, S. (2021). A Study on theEffect of Agency Rating and ESG Rating on Corporate Value. *Tax Accounting Research*, 69(0), 125－144.

Oh, S., & Lee, S. (2019). A Study on the Relationship between ESG Evaluation Factors and Corporate Value. *Korean Computers and Accounting Review*, 17(2), 205－223.

Park, S. R., & Jang, J. Y. (2021). The Impact of ESG Management on Investment Decision: Institutional Investors'Perceptions of Country-Specific ESG Criteria. *International Journal of Financial Studies*, 9(3), 48.

Refinitiv. (2021). Environmental, social and governance scores from Refinitiv. Refinitiv.

Senadheera, S. S., Withana, P. A., Dissanayake, P. D., Sarkar, B., Chopra, S. S., Rhee, J. H., & Ok, Y. S. (2021). Scoring environment pillar in environmental, social, and governance (ESG) assessment. *Sustainable Environment*, 7(1), 1960097.

Social Responsibility Management Quality Institute ·ESG Management Research Institute. (2021). ESG management strategy for sustainable growth. Freedom Academy.

Specialized reporter for Korea Economic Daily and Korea Economic Magazine. (2021). Hankyung Mook: ESG K-Corporate Survival Plan. Korea Economic Daily.

Zhao, C., Guo, Y., Yuan, J., Wu, M., Li, D., Zhou, Y., & Kang, J. (2018). ESG and corporate financial performance: Empirical evidence from China's listed power generation companies. *Sustainability*, 10(8), 2607.

References_Chapter 2

Abid, I., & Goaied, M. (2017). A meta-frontier assessment of bank efficiency in Middle East and North Africa countries. *International Journal of Productivity and Performance Management*, 66(2), 266-296

Achenbach, M. (2021). Transparency of Climate-Related Risks and Opportunities: Determinants Influencing the Disclosure in Line with the Task Force on Climate-Related Financial Disclosures. Glocality,

Assaf, A., Barros, C. P., & Josiassen, A. (2010). Hotelefficiency: A bootstrapped metafrontier approach. *International Journal of Hospitality Management*, 29(3), 468-475.

Baek, J.-W. (2011). An Efficiency Analysis of Korean Thrift Institutions through DEA. *Journal of Industrial Economics and Business*, 24(3), 1363-1378.

Baik, S., & Choi, J. (2021). ESG Rating and Firm Characteristics. *KOREAN INTERNATIONAL ACCOUNTING REVIEW*, 99, 147-169.

Battese, G. E., & Rao, D. P. (2002). Technology gap, efficiency, and a stochastic metafrontier function. *International Journal of Business and Economics*, 1(2), 87.

Battese, G. E., Rao, D. P., & O'donnell, C. J. (2004). A metafrontierproduction function for estimation of technical efficiencies and technology gaps for firms operating under different technologies.

Berg, F., Fabisik, K., & Sautner, Z. (2020). Rewriting history II: The (un) predictable past of ESG ratings. *European Corporate*

Governance Institute-Finance Working Paper, 708(2020), 10-2139.

Bos, J. W. B., & Schmiedel, H. (2003). Comparing Efficiency in European Banking: A Meta Frontier Approach (SSRN Scholarly Paper ID 460060). Social Science Research Network.

Bouma, D. (2021). Voluntary Climate-related Financial Disclosure and the Cost of Capital [PhD Thesis]. University of Groningen.

Carney, M. (2019). TCFD: strengthening the foundations of sustainable finance. Proceedings of the TCFD Summit.

Cho, C., Lee, S., & Lee, H.-Y. (2021). A Comparison on Efficiency of Specialized Credit Finance Companies Using a Meta-Frontier. *Knowledge Management Research*, 22(3), 151-172.

Cho, Y. (2017). Decomposition Analysis of CO2 Emissions of the Electricity Generation Sector in Korea using a Logarithmic Mean Divisia Index Method. *Journal of Climate Change Research*, 8(4), 357-367.

Choi, D.-C., Han, S.-M., & Kim, B. (2012). A Study on the GENCO Adaptive Strategy for the Greenhouse Gas Mitigation Policy. *The Transactions of the Korean Institute of Electrical Engineers*, 61(4), 522-533.

Choi, K.-H. (2016). A Comparison on Efficiency of Regional Festival Using a Meta-Frontier. *Journal of Tourism Studies*, 31(6), 27-46.

Choi, K.-H. (2017). An Efficiency Comparison among Airlines Group by Meta-Frontier Analysis. *Journal of the Aviation Management Society of Korea*, 15(1), 3-17.

Choi, M.-K. (1997). A Study on Measuring the Operating Efficiency and the Profitability of Domestic Banks: An Application of DEA. *Ride Journal of Economics and Business*, 2, 117-143.

Del Giudice, A., & Rigamonti, S. (2020). Does audit improve the quality of ESG scores? Evidence from corporate misconduct. *Sustainability*, 12(14), 5670.

Demers, E., & Metzner, M. (2021). TCFD Climate Risk Disclosures: Early Evidence on the "Gold Standard."

Ding, D., Liu, B., & Chang, M. (2022). Carbon Emissions and TCFD Aligned Climate-Related Information Disclosures. *Journal of Business Ethics*, 1-35.

Dyakova, J. (2021). An Analysis of Finnish Companies TCFD reporting.

Eccles, R. G., & Krzus, M. P. (2019). Implementing the task force on climate-related financial disclosures recommendations: An assessment of corporate readiness. *Schmalenbach Business Review*, 71(2), 2

Financial Services Commission. (2021a). Declaration of support for TCFD and the 1st Green Finance Council. https://www.fsc.go.kr/no010101/75955?srchCtgry=&curPage=2&srchKey=&srchText=&srchBeginDt=&srchEndDt=%0A

Framework Act on Carbon Neutrality and Green Growth to Respond to the Climate Crisis, (2021). https://www.law.go.kr/LSW/lsSc.do?dt=20201211&subMenuId=15&menuId=1&query=%ED%83%84%EC%86%8C%EC%A4%91%EB%A6%BD#undefined

Giannarakis, G., Zafeiriou, E., & Sariannidis, N. (2017). The impact of carbon performance on climate change disclosure. *Business Strategy and the Environment*, 26(8), 1078-1094.

Hayami, Y. (1969). Sources of agricultural productivity gap among selected countries. *American Journal of Agricultural Economics*, 51(3), 564-575.

IPCC. (2021). Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Cambridge University Press. In Press. http://www.climate.go.kr/home/bbs/view.php?code=94&bname=climaterepor

Jeong, K., & Jung, S. (2019). A Study on the Impact of Government Technical Support for the Performance of SMEs. *The Korean Journal of Financial Management*, 36(2), 83-105.

Johnes, J., Izzeldin, M., & Pappas, V. (2014). A comparison of performance of Islamic and conventional banks 2004-2009. *Journal of Economic Behavior & Organization*, 103, S93-S107.

Joint ministries, (2022). http://www.climate.go.kr/home/bbs/view.php?code=93&bname=abnormal&vcode=6609&cpage=1&vNum=Notice&skind=&sword=&category1=&category2=

Kang, D.-H., & Choi, K. (2018). Measuring the Meta-Efficiency and Its Determinants on Efficiency in "L" Hotel.*Journal of Tourism and Leisure Research*,30(4),135-154.

Kang, S. M., & Kim, M.-H. (2010). Analysis of Technical Efficiency and Productivity Using the Meta-frontier -Manufacturing Industries in Korea and China-.*Journal of the Economic Geographical Society of Korea.*,13(1),126-146.

Kim, B., Kim, M. S., & Min, J. H. (2011). Evaluating Stock Value using Data Envelopment Analysis. *KOREAN MANAGEMENT SCIENCE REVIEW*, 28(3), 61-72.

Kim, J., Cho, Y., & Park, S. (2014). Managerial Efficiency of Local Credit Unions Using Bootstrap DEA. *Journal of Finance*, 13(1), 101-127.

Korea Policy Briefing. (2021). 2050 Carbon Neutral. https://www.korea.kr/special/policyCurationView.do?newsId=148881562

Korea Policy Briefing. (2022). Enforcement of the Carbon Neutral Framework Act. https://www.korea.kr/news/pressReleaseView.do?newsId=156500253

Lee, B., & Yun, W. Y. (2019). Efficiency Analysis of Private Colleges: Using Meta-Frontier. *Tax Accounting Research*, 62, 1-21.

Lee, S., Kim, T., & Lee, H. (2015). Measuring the Dynamic Efficiency of Government Research Institutes in R&D and Commercialization by DEA Window Analysis. *KOREAN MANAGEMENT SCIENCE REVIEW*, 32(4), 193-207.

Luo, L. (2019). The influence of institutional contexts on the relationship between voluntary carbon disclosure and carbon emission performance. *Accounting & Finance*, 59(2), 1235-1264.

Meyer M. and V. Gupta(1994), "The Performance Paradox,"in B.M. Staw and L.L. Cummings (Eds.), Research in Organizational Behavior, Vol.16, Greenwich, CT: *JAI Press*, 161-213.

Middleton, A. (2020). Climate Change Accountability, Including TCFD in the Nordic Arctic Countries. Arctic Yearbook.

Ministry of Trade, Industry and Energy & Korea Productivity Center. (2021). K-ESG Guidelines v1.0.

Moon, H., & Min, D. (2015). The Energy-efficiency Analysis of Companies in Korea Using DEA. *KOREAN MANAGEMENT SCIENCE REVIEW*, 32(3), 37-54.

Nag, S., Chakrabarty, S. P., & Basu, S. (2021). From Carbon-transition Premium to Carbon-transition Risk. ArXiv Preprint ArXiv:2107.06518.

Noh, S. (2014). Analysis of Energy Consumption and CO2 Emissions Structure in Household Sector. *The Korea Spatial Planning Review*, 81, 157－183.

O'Donnell, C. J., Rao, D. S. P., & Battese, G. E. (2008). Metafrontier frameworks for the study of firm-level efficiencies and technology ratios. *Empirical Economics*, 34(2), 231－255.

Oh, B. S., Kim, K.-J., & Choi, K. (2019). Marketing Efficiency of Global Automobile Brands Using the Meta-frontier Analysis. *Journal of the Korean Operations Research and Management Science Society*, 44(4), 1－17.

Oh, S. J., Kim, H. J., & Kim, S. W. (2013). Analysis of the SCQM Efficiency of a Parent Company and Its Partner Companies Using DEA. *KOREAN MANAGEMENT SCIENCE REVIEW*, 30(2), 43－61.

Oster S.(1990), Modern Competitive Analysis, Oxford University Press, New York

Park, D. Y. (2019). The Efficiency and Productivity Analysis of Coffee Franchisor Using Meta-frontier [Hansung University The Graduate School].

Park, R.-K. (2016). A Brief Empirical Investigation of Seaport Clustering by Using Meta-Frontier and Cross-efficiency Models. *Korea Trade Review*, 41(3), 27－42.

Seo, C.-W., & Shin, Y.-S. (2015). An Empirical Study onRegional Differences in the Efficiency of Tourist Hotels Using a Metafrontier Model. *Korea Trade Review*, 40(4), 195－215.

Seo, C.-W., Shin, Y., & Lee, H. (2015). Efficiency of Commercial Bank among Korea, China, and Japan. *The Journal of International Trade & Commerce*, 11(6), 333－348.

Seo, S., & Park, M. (2006). The Performance Evaluation on Service Organization using the Priority-Constrained DEA Model. *KOREAN MANAGEMENT SCIENCE REVIEW*, 23(2), 93-107.

Seo, Y. A. (2005). Efficiency Measurement in Korean Restaurant Franchise Business by Data Envelopment Analysis [Kyonggi University Graduate School of Tourism & Hospitality]. http://www.riss.kr/link?id=T10309350

Siew, R. (2020). Briefing: Task force for climate financial disclosures (TCFD) for the property and construction industry. *Sustainable Buildings*, 5, 3.

Siew, R. Y. (2021). Task Force for Climate Financial Disclosures (TCFD): The Malaysian Case Study. Perceptions of Energy Resources Efficiency for Sustainable Development in the Developing Context of N

Song, G., & Ha, H.-K. (2017). Analysis of the Management Efficiency of Food Material Distribution and Logistics Companies with Meta-frontier SBM Model. *Journal of Creativity and Innovation*, 10(1), 97-126.

Song, K.-S., & Jung, N.-W. (2017). Performance Evaluation of Local Banking Service—Integrated Analysis Using Malmquist & Servqual Index -. *Korean Policy Sciences Review*, 21(1), 53-78.

Staker, A., Garton, A., & Barker, S. (2017). Concerns misplaced: Will compliance with the TCFD recommendations really expose companies and directors to liability risk? Rep., Commonw. Clim. Law Initiat

Suortti, J. (2021). TCFD-framework disclosure and its effect on cost of equity capital.

Sustainability report statistics. (n.d.). Korean Standards Association. Retrieved April 4, 2022, from http://www.ksa.or.kr

TCFD. (2017). Implementing the Recommendations of the Task Force on Climate-related Financial Disclosures.

The Bell. (2022). [Financial Holdings ESG Review] The reason why financial holdings go all-in on the trendy ESG. The Bell News. http://www.thebell.co.kr/free/content/ArticleView.asp?key=20221017134916996010651 9&lcode=00

The Government of the Republic of Korea. (2020). Korea 2050 Carbon Neutral Strategy for Realizing a Sustainable Green Society. The Government of the Republic of Korea.

Wang, R.-M., Tian, Z., & Ren, F. (2021). Energy efficiency in China: Optimization and comparison between hydropower and thermal power. Energy, *Sustainability and Society*, 11(1), 1－21.

Yoo, J. W., & Kim, K. S. (2008). Effect of Board Independence on Performance: Interaction Effect with CEO's Firm Specific Experience. *Management & Information Systems Review*, 24, 1-24.

References_Chapter 3

Anderson, C. A., & Anthony, R. N. (1986). *The corporate director*. Wiley Publication New York.

Argyris, C. (1973). Some limits of rational man organizational theory. *Public Administration Review*, 253－267.

Austin, P. C., & Mamdani, M. M. (2006). A comparison of propensity score methods: A case-study estimating the effectiveness of post-AMI statin use. *Statistics in Medicine*, *25*(12), 2084－2106. https://doi.org/10.1002/sim.2328

Bae, J. H., Choi, J. W., & Jo, E. H. (2020). The Effect of Board Independence on CEO Turnover. *KOREAN JOURNAL OF MANAGEMENT ACCOUNTING RESEARCH*, *20*(3), 37-67. DBpia. https://doi.org/10.31507/KJMAR.2020.12.20.3.37

Boyd, B. K. (1995). CEO duality and firm performance: A contingency model. *Strategic Management Journal*, *16*(4), 301-312.

Braun, M., & Sharma, A. (2007). Should the CEO also be chair of the board? An empirical examination of family-controlled public firms. *Family Business Review*, *20*(2), 111-126.

Caliendo, M., & Kopeinig, S. (2008). Some Practical Guidance for the Implementation of Propensity Score Matching. *Journal of Economic Surveys*, *22*(1), 31-72. https://doi.org/10.1111/j.1467-6419.2007.00527.x

Chai, S., Sun, R., Zhang, K., Ding, Y., & Wei, W. (2022). Is Emissions Trading Scheme (ETS) an Effective Market-Incentivized Environmental Regulation Policy? Evidence from China's Eight ETS Pilots. *International Journal of Environmental Research and Public Health*, *19*(6), 3177.

Cho, T. (2007). A Study on the Corporate Governance of Public Bodies in Korea. *korean policy sciences review*, *11*(4), 251-274.

Corbetta, G., & Salvato, C. (2004). Self-Serving or Self-Actualizing? Models of Man and Agency Costs in Different Types of Family Firms: A Commentary on "Comparing the Agency Costs of Family and Non-family Firms: Conceptual Issues and Exploratory Evidence." *Entrepreneurship Theory and Practice*, *28*(4), 355-362. https://doi.org/10.1111/j.1540-6520.2004.00050.x

Daily, C. M., & Dalton, D. R. (1994). Bankruptcy and corporate governance: The impact of board composition and structure. *Academy of Management Journal*, *37*(6), 1603–1617.

Dalton, D. R., Daily, C. M., Ellstrand, A. E., & Johnson, J. L. (1998). Meta-analytic reviews of board composition, leadership structure, and financial performance. *Strategic Management Journal*, *19*(3), 269–290.

Davis, J. H., Schoorman, F. D., & Donaldson, L. (1997). Toward a stewardship theory of management. *Academy of Management Review*, *22*(1), 20–47.

Dayton, K. N. (1984). Corporate governance-the other side of the coin. *Harvard Business Review*, *62*(1), 34–37.

de Sousa Guimaraes, R., & Trevisan, G. (2022). *Mandatory CEO Non-Duality, Agency Risk, and Shareholder Value*.

Donaldson, L. (1990). The ethereal hand: Organizational economics and management theory. *Academy of Management Review*, *15*(3), 369–381.

Donaldson, L., & Davis, J. H. (1991). Stewardship theory or agency theory: CEO governance and shareholder returns. *Australian Journal of Management*, *16*(1), 49–64.

Fama, E. F., & Jensen, M. C. (1983). Agency problems and residual claims. *The Journal of Law and Economics*, *26*(2), 327–349.

Finkelstein, S., & Boyd, B. K. (1998). How much does the CEO matter? The role of managerial discretion in the setting of CEO compensation. *Academy of Management Journal*, *41*(2), 179–199.

Finkelstein, S., & D'aveni, R. A. (1994). CEO duality as a double-edged sword: How boards of directors balance entrenchment avoidance and unity of command. *Academy of Management Journal*, *37*(5), 1079–1108.

Forbes, D. P., & Milliken, F. J. (1999). Cognition and corporate governance: Understanding boards of directors as strategic decision-making groups. *Academy of Management Review*, *24*(3), 489 – 505.

Goodman-Bacon, A. (2021). Difference-in-differences with variation in treatment timing. *Journal of Econometrics*, *225*(2), 254 – 277.

Hambrick, D. C., & Finkelstein, S. (1987). Managerial discretion: A bridge between polar views of organizational outcomes. *Research in Organizational Behavior*.

Hambrick, D. C., & Mason, P. A. (1984). Upper echelons: The organization as a reflection of its top managers. *Academy of Management Review*, *9*(2), 193 – 206.

Heckman, J. J., LaLonde, R. J., & Smith, J. A. (1999). The economics and econometrics of active labor market programs. In *Handbook of labor economics* (Vol. 3, pp. 1865 – 2097). Elsevier.

Hong, B. Y. (2002). Productivity Change in Korean Banks After the Financial Crisis—1997 ~ 2000. *The Korean Journal Of Financial Management*, *19*(1), 133 – 151.

Imbens, G. W. (2004). Nonparametric estimation of average treatment effects under exogeneity: A review. *Review of Economics and Statistics*, *86*(1), 4 – 29.

Jensen, M. C. (1986). Agency costs of free cash flow, corporate finance, and takeovers. *The American Economic Review*, *76*(2), 323 – 329.

Jenson, M. C., & Meckling, W. H. (1976). Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of Financial Economics*, *3*(4), 305 – 360.

Jeon, M., & Lee, K. (2013). An Empirical Study on the Influences of Board Structure and Independence on Corporate Performance. *Korean Corporation Management Review*, *20*(2), 235 – 250.

John, T. A. (1993). Optimality of spin-offs and allocation of debt. *Journal of Financial and Quantitative Analysis*, *28*(1), 139-160.

Judge, T. A., Erez, A., Bono, J. E., & Thoresen, C. J. (2003). The core self-evaluations scale: Development of a measure. *Personnel Psychology*, *56*(2), 303-331.

Jung, H., & Lee, S. (2021). Analysis of the Effectiveness of Government-sponsored Management Consulting Projects Using Propensity Score Matching(PSM) and Difference in Difference(DID). *Review of Accounting and Policy Studies*, *26*(2), 237-260.

Jung, I. (2006). An Analysis of IPTV Policy Process in Korea Based on Contingency Theory. *Journal of communication research*, *42*(2), 67-97.

Kang, H. C., & Byun, H. S. (2021). Do Corporate Social Responsibility Activities Alleviate Agency Problems? Focusing on Conflicts of Interest between Controlling Shareholders and Creditors. *Journal of Money & Finance*, *35*(1), 1-43.

Kang, S., & Choi, K. (2015). Analyzing Management Efficiency of Cosmetics Industry Using Data Envelopment Analysis and Malmquist Productivity Index. *Journal of the Korean Production and Operations Management Society*, *26*(1), 41-56.

Kassinis, G., & Vafeas, N. (2002). Corporate boards and outside stakeholders as determinants of environmental litigation. *Strategic Management Journal*, *23*(5), 399-415.

Kesner, I. F., & Dalton, D. R. (1986). Boards of directors and the checks and (Im)balances of corporate governance. *Business Horizons*, *29*(5), 17-23. https://doi.org/10.1016/0007-6813(86)90046-7

Kim, B. (2012a). CEO Duality Leadership and Firm Performance. *Asia Pacific Journal of Small Business*, *34*(2), 67-80.

Kim, B. (2012b). The Effects of Board Characteristics on the Development of Shared Mental Model and Effectiveness of the Board. *Journal of Social Science*, *38*(2), 101－126.

Kim, B., & Prescott, J. E. (2005). Deregulatory forms, variations in the speed of governance adaptation, and firm performance. *Academy of Management Review*, *30*(2), 414－425.

Kim, B.-G., & Kim, D.-W. (2009). Affect of Corporate Governance and Capital Structure on Corporate Value: 2SLS Analysis using Panel Data. *Journal of Industrial Economics and Business*, *22*(4), 1593－1620.

Kim, D., Kim, D., Lee, H., & Kim, S. (2015). A Case Study on Naver's Corporate Governance. *Korean Journal of Broadcasting and Telecommunication Studies*, *29*(1), 5－34.

Kim, D.-S., & Park, D. (2013). An Empirical Study On the Relations among Corporate Governance Strength, its Effectiveness, and Earnings Quality. *Korean Corporation Management Review*, *20*(2), 125－149.

Kim, E., & Oh, M. (2022). Analysis of the Effect of Shortening Working Hours on Quality of Life. *Ordo Economics Journal*, *25*(1), 19－45.

Kim, J., Cho, M.-H., & Kim, Y.-K. (2020). Independent Directors'Dissents on Strategic Issues: The Power Difference between CEO and Board of Director. *Journal of Strategic Management*, *23*(3), 143－163.

Kim, J., & Yoo, J. (2015). An Empirical Study on the Strategy of Building the Effective CEO-Board Relational Characteristics over CEO Tenure. *Korean Jouranl of Business Administration*, *28*(8), 1985－2003.

Kim, J.-H. (2013). CEO Duality—A Legal Study on the Issue of Splitting or Combining the CEO & Chairman Roles –. *The Korean Academy of Business Law*, *24*(1), 97–128.

Kim, P.-S., Park, Y.-R., & Choe, S. (2015). The Interaction Effects of Outside Director Ratio and CEO Duality on Acquisition Performance. *Asia-Pacific Journal of Business Venturing and Entrepreneurship*, *10*(3), 85–97.

Kim, S., Lee, K., & Lee, M. (2013). The Effects of CSR to Foreign Institutional Investors' Ownership and Firm Value. *Productivity Review*, *27*(3), 429–456.

Kim, T.-H. (2021). Chairman of the board of directors of a large company is 'the abdicated king'? *The Kyunghyang Shinmun*. https://m.khan.co.kr/article/202107251321001

Kim, Y. J., & An, J. I. (2018). AStudy ofManagerial Centrality andCredit Ratings. *Korean Accounting Journal*, *27*(6), 95–120.

Ko, D., Baek, E., & Kang, A. M. (2012). The Effect of Corporate Governance on Foreign Investor Ownership. *Accounting Information Review*, *30*(1), 29–59.

Krause, R., & Semadeni, M. (2013). Apprentice, departure, and demotion: An examination of the three types of CEO–board chair separation. *Academy of Management Journal*, *56*(3), 805–826.

Krause, R., Semadeni, M., & Withers, M. C. (2016). That special someone: When the board views its chair as a resource. *Strategic Management Journal*, *37*(9), 1990–2002.

Kwon, Y.-W. (2010). *A Study on the Efficiency and Productivity of Quality Management of Small & Medium-sized Enterprises Evaluated by DEA(Data Envelopment Analysis) Model: Cases of the Single PPM Quality Certification Companies* [Soongsil

University Gruduate School]. http://www.riss.kr/link?id=T12114736

La Porta, R., Lopez-de-Silanes, F., & Shleifer, A. (1999). Corporate ownership around the world. *The Journal of Finance*, *54*(2), 471－517.

Lee, J., & Rhee, J. H. (2020). Current Status and Future Directions of Research on "Sustainable Management": Focusing on the ESG Measurement Index. *Journal of Strategic Management*, *23*(2), 65－92.

Lee, K. M., & Hong, J.-B. (2012). Analysis Efficiency of Regional Fisheries Cooperative Operating Office according to Province with Data Envelopment Analysis. *The Journal of Industrial Innovation*, *28*(2), 35－57.

Lee, S., Jung, Y., & Kim, D. (2018). A Study of the Policy Effect of Governmental Financial Support: For Technology Development and Enterprise Support Programs under Chung-Nam Local Industries Support Plan. *The Journal of Korean Public Policy*, *20*(3), 111－131.

Lee, S.-S. (2019). More than half of S&P 500 global companies ban CEO Duality. *Opinionnews*. http://www.opinionnews.co.kr/news/articleView.html?idxno=25317

Levy, L. (1981). Reforming board reform. *Harvard Business Review*, *59*(1), 166－172.

Lim, H. (2008). Analysis on Efficiency and Productivity of Korean Industry using DEA and Malmquist Indices. *The Journal of Business Education.*, *20*, 305－318.

Mallette, P., & Fowler, K. L. (1992). Effects of board composition and stock ownership on the adoption of "poison pills." *Academy of Management Journal*, *35*(5), 1010－1035.

Mintzberg, H. (1983). *Power in and around organizations*.

Neville, F., Byron, K., Post, C., & Ward, A. (2019). Board independence and corporate misconduct: A cross-national meta-analysis. *Journal of Management*, *45*(6), 2538-2569.

Oh, S.-H. (2021). A Study on the Effect of Agency Rating and ESG Rating on Corporate Value. *Tax and Accounting Review*, *69*, 125-144.

Park, H. J., Shin, H. H., & Choi, W. S. (2004). The Korean Firms` Agency Costs and Firm Value: Role of Foreign Investors` Equity Ownership. *korean management review*, *33*(2), 655-682.

Park, H. Y., Lee, A. Y., & Kang, Y. S. (2016). Board Leadership and Earnings Management: Focusing on Existence of Independent Outside Director and CEO-Board Chair Separation. *Korean Accounting Journal*, *25*(5), 243-275.

Park, J. H., Sung, Y. D., & Kim, C. S. (2013). The CEO hubris and firm performance: The moderating role of board independence and chaebol affiliation. *korean management review*, *42*(3), 673-697.

Pearce, J. A., & Robinson Jr, R. B. (1987). A measure of ceo social power in strategic decision-making. *Strategic Management Journal*, *8*(3), 297-304.

Pi, L., & Timme, S. G. (1993). Corporate control and bank efficiency. *Journal of Banking & Finance*, *17*(2-3), 515-530.

Rahman, R. A., & Haniffa, R. M. (2005). The effect of role duality on corporate performance in Malaysia. *Corporate Ownership and Control*, *2*(2), 40-47.

Rechner, P. L., & Dalton, D. R. (1991). CEO duality and organizational performance: A longitudinal analysis. *Strategic Management Journal*, *12*(2), 155-160.

Roberts, J., & Stiles, P. (1999). The Relationship between Chairmen and ChiefExecutives: Competitive or Complementary Roles? *Long Range Planning*, *32*(1), 36－48.

Rosenbaum, P. R., & Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika*, *70*(1), 41－55. https://doi.org/10.1093/biomet/70.1.41

Sanders, W. G., & Carpenter, M. A. (1998). Internationalization and firm governance: The roles of CEO compensation, top team composition, and board structure. *Academy of Management Journal*, *41*(2), 158－178.

Scott, W. R. (2005). Institutional theory: Contributing to a theoretical research program. *Great Minds in Management: The Process of Theory Development*, *37*(2), 460－484.

Senadheera, S. S., Withana, P. A., Dissanayake, P. D., Sarkar, B., Chopra, S. S., Rhee,J. H., & Ok, Y. S. (2021). Scoring environment pillar in environmental, social, and governance (ESG) assessment. *Sustainable Environment*, *7*(1), 1960097.

Shah, B. R., Laupacis, A., Hux, J. E., & Austin, P. C. (2005). Propensity score methods gave similar results to traditional regression modeling in observational studies: A systematic review. *Journal of Clinical Epidemiology*, *58*(6), 550－559.

Simpson, W. G., & Gleason, A. E. (1999). Board structure, ownership, and financial distress in banking firms. *International Review of Economics & Finance*, *8*(3), 281－292.

Snow, J. (1855). On the comparative mortality of large towns and rural districts, and the causes by which it is influenced. *Journal of Public Health, and Sanitary Review*, *1*(4), T16.

Stewart, R. (1991). Chairmen and chief executives: An exploration of their relationship. *Journal of Management Studies*, *28*(5), 511－528.

Stoeberl, P. A., & Sherony, B. C. (1985). Board efficiency and effectiveness. *Handbook for Corporate Directors*, *12*(1).

Suh, C., Park, J., & Shin, J. (2013). Corporate Governance and Income Smoothing. *Korean Accounting Review*, *38*(3), 41－79.

Tribbett, C. (2012). SPLITTING THE CEO AND CHAIRMAN ROLES—YES OR NO?-Let company needs rather than activist pressures guide your decision. *Corporate Board-Okemos*, *33*(197), 11.

Tsui, J. S., Jaggi, B., & Gul, F. A. (2001). CEO domination, growth opportunities, and their impact on audit fees. *Journal of Accounting, Auditing & Finance*, *16*(3), 189－208.

Vance, S. C. (1983). *Corporate leadership: Boards, directors, and strategy*. McGraw-Hill College.

Villalonga, B., & Amit, R. (2006). How do family ownership, control and management affect firm value? *Journal of Financial Economics*, *80*(2), 385－417.

Weitzen, S., Lapane, K. L., Toledano, A. Y., Hume, A. L., & Mor, V. (2004). Principles for modeling propensity scores in medical research: A systematic literature review. *Pharmacoepidemiology and Drug Safety*, *13*(12), 841－853.

Yoo, J., & Kim, K. (2008). Effect of Board Independence on Performance: Interaction Effect with CEO's Firm Specific Experience. *Management Information Systems Review*, *24*, 1－24.

Yu, S. (2013). Independence, Board Chair Separation, Executive's Expertise, and Performance in State-Owned Enterprises. *[KDI] Journal of Economic Policy*, *35*(2).

국 문 초 록

ESG와 기업경영에 관한 세 가지 소논문

한 성 대 학 교 대 학 원
지 식 서 비 스 & 컨 설 팅 학 과
매 니 지 먼 트 컨 설 팅 전 공
조 찬 희

본 학위논문은 기업경영 관련 ESG컨설팅 분야에서 ESG와 기업경영에 대하여 다루고 있다. 즉, ESG 평가방법 비교, TCFD와 기업의 효율성 그리고 CEO Non-Duality에 관한 3편의 소논문으로 구성되어 있다.

첫 번째 소논문은 K-ESG 가이드라인을 통해 국내외 ESG 평가방법을 비교한 논문으로서, 기존 연구에서 다루지 않았던 ESG 진단항목을 직접 기업에 적용하여 K-ESG 가이드라인의 적용 용이성을 측정하고, 그 평가 결과를 회사가 보유하고 있는 국내외 ESG 등급들과 비교하여 K-ESG 가이드라인의 적정성 및 위치를 연구하고자 한다. 그 결과 K-ESG 가이드라인의 ESG 평가등급은 글로벌 ESG 평가기관 중 Refinitiv보다 낮았고 MSCI보다 높았으며 국내 ESG 평가기관인 KCGS의 등급보다 낮거나 유사한 결과가 나왔다. 또한, K-ESG 가이드라인의 적용 용이성은 높았다. 두 번째 소논문은 TCFD점수와 ESG 등급을 투입 및 산출변수로 사용한 메타프론티어를 이용하여 ESG 경영을 하는 기업의 그룹별 효율성을 비교한 논문이다. 온실가스(GHG) 주제에 대한 국내의 TCFD 점수와 기업 효율성에 대한 연구가 드물었지만 본 연

구는 금융기업, 비금융일반기업 그리고 비금융공기업 같은 서로 다른 산업별 효율성을 메타프론티어를 활용하여 비교하였다. 가변규모수익(VRS)하에서의 메타프론티어 효율성의 순서는 금융회사(99.5%), 비금융공기업(96.2%) 그리고 비금융일반기업(95.0%) 순이었다. 비효율성의 원인은 세 그룹 모두 순수기술효율성이었다. 세 번째 소논문은 CEO와 이사회의장의 겸직 분리(CEO Non-Duality)를 시행한 기업의 실적이 개선되는지를 알아본 논문이다. 성향점수매칭(PSM)과 이중차분법(DID)을 이용하여 정책시행 전 1년과 후 3년 평균의 기업실적을 비교하였고, 맘퀴스트생산성지수(MPI)를 이용하여 5개 연도의 생산성 변화를 측정하였다. 연구결과 PSM-DID분석을 통해 CEO Non-Duality와 기업실적 개선 간의 직접적인 인과관계를 증명하지는 못했으나, 사외이사를 이사회의장으로 선임하는 것이 기업실적에 긍정적인 영향을 미칠 수 있다는 가능성을 보여주었다. 이는 기업의 경영전략과 조직문화를 적절히 조정하고, 이사회 구성원을 선출하는 과정에서 사외이사의 역할을 더욱 강화해 나갈 필요가 있다는 결론을 내릴 수 있다.

본 논문의 기여점은 다음과 같다. 첫 번째 소논문은 ESG 평가에 있어서 맥락의 역할과 그 맥락을 어떻게 고려하는 것이 중요한지를 보여주었으며, 표준화된 ESG 평가방법의 필요성과 성공적으로 적용할 수 있는 사례를 학계에 시사하였다. 또한, ESG 평가 촉진을 위한 정부의 역할이 중요하다는 시사점을 제공하였다. ESG 경영에 관심이 있는 ESG 평가기관, 기업의 경영진 그리고 ESG 담당자 등에게 ESG 경영전략 수립과 세부이행에 있어 실질적 도움이 될 것이며, K-ESG 가이드라인의 추후 개정 시 참고할 제언도 제공하였다. 두 번째 소논문은 서로 다른 산업의 효율성을 비교하지 않았던 기존 연구에 비해 TCFD 가이던스를 활용하여 금융회사와 비금융회사의 ESG 경영활동의 효율성을 비교하였다. 또한 기존에 투입 및 산출변수로 사용하지 않았던 TCFD점수와 ESG 등급을 변수로 사용하여 해당 분야의 학문적 발전에 기여하였다. 세 번째 소논문은 대한민국 상장기업 중 CEO Non-Duality를 시행한 기업과 그렇지 않은 기업들을 PSM-DID 분석을 통하여 시행효과를 검증하였고, 기존 연구에서 사용하지 않았던 맘퀴스트(MPI)를 PSM-DID의 결과를 보완 검증하는 방법으로 사용한 것이 학문적 기여점이라 할 수 있다.

[주요어] *ESG 평가, K-ESG 가이드라인, TCFD, 메타프론티어, CEO 와 이사회의장 분리, 성향점수매칭, 이중차분법, 맘퀴스트생산성지수*