Analyzing ESG News Articles and Research Papers through LDA (Latent Dirichlet Allocation)

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Abstract: The evolution of information technology has led to a surge in the publication of research papers across diverse fields. This surge has presented a challenge for academics in finding relevant literature and unexplored research areas. To address this, the current study designs a research gap finding framework using Topic Modeling methodology. For this study, 4,596 news articles were collected from reputable Korean sources such as Chosun, JoongAng, Hankyoreh, and Kyunghyang, alongside 456 ESG-related academic research papers. The Topic Modeling method of Latent Dirichlet Allocation (LDA) was utilized to distill subtopics from these resources. The use of LDA in this context proved crucial as it allowed for the extraction of nuanced subtopics from a large dataset, aiding the identification of underexplored themes. The comparative analysis of subtopics extracted from news articles and academic papers demonstrated a thematic consistency, but a distinct difference in specific subtopics. Results of the study indicated that academic research tends to overlook topics such as community cooperation and industry-academic partnerships. Furthermore, social issues like child labor, forced labor, and workplace health and safety received relatively minimal attention in academic papers. In-depth examination of these results revealed a significant gap between popular social issues and existing academic research, implying a need for more focused research in these areas. This study significantly aids academics in better comprehending current social issues and identifying research gaps. The proposed framework, leveraging both news articles and academic papers, provides a practical tool for academics to stay current with societal issues and recognize the areas lacking in academic exploration. The framework's practicality represents a vital advancement in the field, offering scholars a robust tool for enriching academic literature and engaging more effectively in societal discourse. This dual utility not only bridges the gap between theoretical research and real-world applications but also fosters a more informed and nuanced understanding of the subject matter, thereby contributing significantly to both scholarly inquiry and public conversation.

Keywords: Environmental, Goverance, Social, News articles, Academic paper, Trend, Research gap

1. Introduction

The importance of Environmental, Social, and Corporate Governance (ESG) in responsible and ethical investment is increasingly recognized[1]. ESG factors, significantly influenced by the United Nations Environment Programme Finance Initiative (UNEP FI)[2], are now more than ever incorporated into the decision-making processes of financial institutions. The Principles of Responsible Investment (PRI), which integrate ESG/CSR into investment analysis and decisions, have been adopted by over

3,000 institutional investors and service providers. The assets managed by these entities have risen from $6.5 trillion in 2006 to over $86 trillion in 2019[3]. This shift towards ESG investment is evident in academic research, especially amidst the ongoing pandemic and escalating climate change concerns[4].

However, a significant research gap is observed: the potential of newspaper articles to guide academic research in ESG-related trends and issues remains largely unexplored. Newspapers often focus on critical societal and practical issues[5], can inform policy directions[6], raise public awareness, and provoke public empathy[7]. They can also expose shifts in policy paradigms and highlight societal issues [8].

Identifying this research gap, this study was conducted to leverage both newspaper articles and academic papers to explore ESG-related trends and issues. The study employs topic modeling methods to extract subtopics from ESG-related news articles and academic papers. Therefore, the primary objective of this study is to identify gaps between ESG-related social issues covered in news articles and those discussed in academic research. This could potentially illuminate novel research topics or directions.

The constant emergence of new research fields coupled with the proliferation of both online and offline research papers poses challenges in locating pertinent literature or engaging research topics[9]. Traditional methods to identify new research directions, often involving exhaustive reading and interpretation of previous literature, can be time-consuming and prone to researcher biases, leading to potential misinterpretation of facts[10].

In line with this, the study was conducted to propose the use of text analysis methods for a more objective, efficient, and effective literature analysis. Text mining, a technique to uncover intriguing and non-trivial knowledge from unstructured text[11], is utilized. The overarching goal of this research is not just to expose trends and gaps in ESG-related issues, but also to suggest a practical framework that can assist scholars in identifying fruitful research topics efficiently.

Given these objectives, the study raises the following research questions:
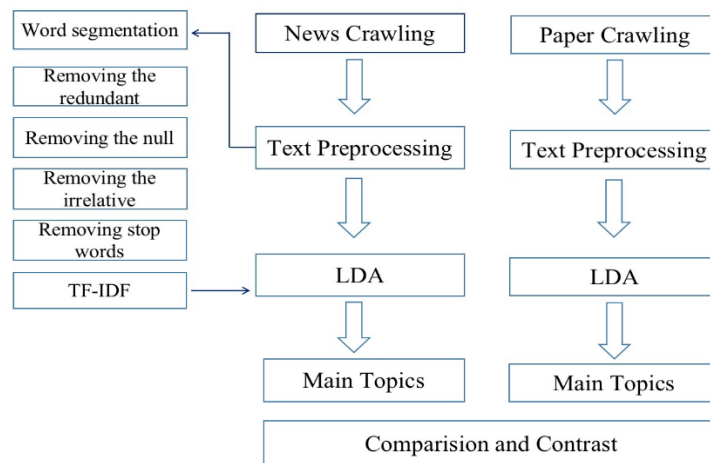
RQ1: What are the main topics in ESG-related academic research?

RQ2: What are the main topics in ESG-related news articles?

RQ3: What are the discrepancies between ESG-related academic research and ESG-related news articles?

2. Research Methodology

2.1 Research Design

[Fig. 1] Research Framework

The proposed research framework, illustrated in Figure 1, is based on Latent Dirichlet Allocation (LDA), a comprehensive probabilistic generative model utilized in fields such as text sentiment analysis, topic mining, knowledge mining, and biomedicine[12]. This approach allows us to analyze societal and temporal trends, explore ESG-related issues, and uncover potential research topics by detecting the likelihood of term co-occurrence in multiple topics. It does so by decomposing the document-term matrix into two low-rank matrices, specifically the document-topic distribution and the topic-word distribution[13].

2.2 Research Instrument

Our primary research instrument is the LDA model. LDA is a comprehensive probabilistic generative model, primarily utilized in fields such as text sentiment analysis, topic mining, knowledge mining, and biomedicine[12]. Topic modeling is based on Latent Dirichlet Allocation (LDA). LDA is a nonlinear generative statistical model that interprets observations through unseen or latent groups which explain the similarities between the observations.

In the context of topic analysis, each document is associated with a small number of topics, and each topic has probabilities of generating various words. Words that don't have specific relevance will have approximately equal probability across topics (or can be placed into a separate category). A topic isn't strictly defined, neither semantically nor epistemologically. It's identified by automatically detecting the likelihood of term co-occurrence. In multiple topics, a single word might appear with different probabilities, but with different typical neighboring words.

The LDA model decomposes the document-term matrix into two low-rank matrices, specifically the document-topic distribution and the topic-word distribution[13]. This decomposition allows the identification of latent topics in the documents and the association of words with these topics.

The use of LDA in this context is commendable as it allows for the objective identification of topics in a large volume of text, which would be almost impossible to accomplish manually. Furthermore, this approach captures the co-occurrence of terms, which can offer deeper insights into the underlying.

2.3 Data Gathering Procedures

The newspaper companies news agencies in South Korea can be divided into two parties: conservative ones and progressive ones. The two parties have different views on the same event, and even the focus of attention[14][15] as well as the language style differs from each other. So, to explore the subtopics of ESG related news articles comprehensively, we selected Chosun, JoongAng, Hankyoreh, and Kyunghyang, which are the two newspapers with the largest number of circulations from the conservative and progressive parties. We collected Korean news articles related to ESG from 2012 to 2022 using Beautiful Soup package in Python.

In this study, papers stored in the RISS DB (Research Information Sharing Service) were collected. We refined the search range only including KCI and KCI candidate. The papers are accredited by KCI and KCI candidate are those published in the listed (candidate) journals evaluated and selected by the National Research Foundation, and the journal level is recognized as above a certain level.

After collecting article upload time, article title, and article content through web crawling and cleaning duplicate articles, a total of 4,596 articles remained. The number of analyzed articles from each news media company and that of papers in KCI DB are presented in Table 1.

[Table 1] Number of ESG related News and Academic Papers from 2012 to 2022

Newspaper	Chosun	JoongAng	Hankyoreh	Kyunghyang	Total
Number	1,252	1,706	533	1,105	4,596
Academic paper	KCI DB				
Number	452				

2.4 Statistical Tools

2.4.1 Data Processing

Before applying topic modeling analysis, we used Python (Python Software Foundation) to perform data cleaning and conduct data processing. We next removed common stop characters. We removed duplicate news reports. We also built a document-term matrix and used term frequency–inverse document frequency (TF–IDF) to process the data. In this study, only nouns were extracted, and TF-IDF (Term Frequency - Inverse Document Frequency) was used for word extraction. TF- IDF value is obtained by multiplying the TF value of a word by the IDF value. The larger the value, the more important the word is to the text, and the more likely it is to become a subject word. The TF-IDF has an effect of filtering out words that appear frequently in all documents[16].

2.4.2 Topic Modeling and Interpretation

A topic model is a type of statistical model used to unearth abstract 'topics' within a collection of documents[17]. Early topic modeling was first described in 1998 by Papadimitriou, Raghavan, Tamaki, and Vempala[18]. In 1999, Thomas Hofmann introduced Probabilistic Latent Semantic Analysis (PLSA)[19]. Latent Dirichlet Allocation (LDA), perhaps the most widely used topic model today, is a generalization of PLSA[20]. This study employs the LDA topic model to analyze the topic strength of ESG-related texts.

In topic modeling, it is crucial to ascertain the number of topics present in the entire set of documents, as the results may vary depending on the pre-set number of topics [8]. To address this issue, one can evaluate the model by applying the Coherence Score. This method evaluates based on the similarity of the top words comprising each topic, as calculated through topic modeling. In other words, the higher the Coherence Score, the more likely it is that each topic calculated by topic modeling is composed of semantically similar words[21]. After calculating the coherence score, we found that the score increases and reaches its peak when the number of topics is set to 10, both for news articles and academic papers.

Once the optimal number of topics has been determined, the next step in the topic modeling process is to extract and interpret the topics. Using LDA, we derived ten topics from our dataset of ESG-related articles and academic papers.

The LDA model outputs a list of words for each topic with associated probabilities indicating how likely each word is to appear in a document about that topic. To interpret these topics, we manually examined these word lists and assigned labels that capture the underlying themes represented by the words. We also considered the context in which these words appeared in the original documents to ensure our labels accurately reflect the subject matter of each topic.

While this manual interpretation process can be somewhat subjective, it is a necessary step in topic modeling. Despite the quantitative nature of the LDA model, understanding the qualitative meaning of the topics it generates requires human judgment and domain expertise. This underscores the importance of integrating both computational and interpretive skills in this type of research.

2.4.3 Validation

In order to verify the accuracy and reliability of our topic modeling results, we conducted a validation step. We randomly selected a subset of documents from our dataset and manually assigned them to the topics we interpreted based on their content. We then compared these manual assignments with the topic assignments generated by the LDA model.

A high degree of agreement between our manual assignments and the model's assignments would indicate that our topic model accurately captures the main themes present in our dataset. On the other hand, if there is a large discrepancy between the manual and model assignments, it may suggest that our topic model or our interpretation of the topics needs refinement.
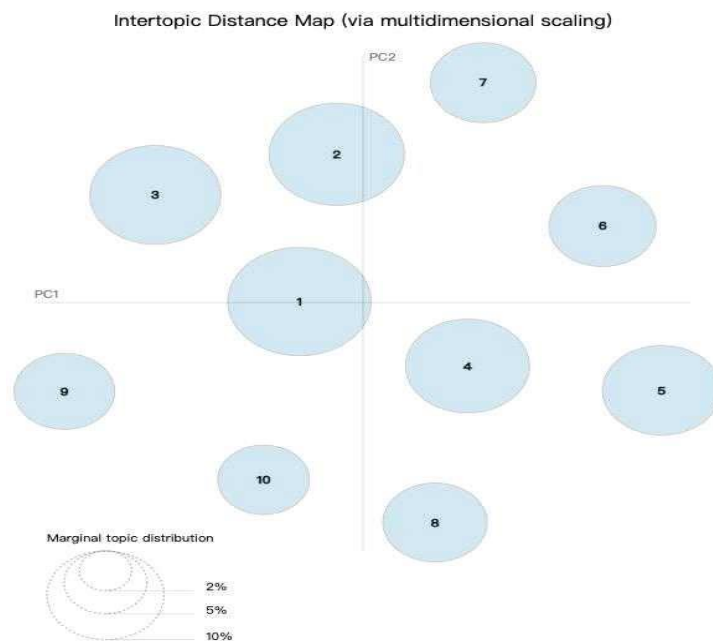
Overall, this methodology provides a robust and comprehensive approach to identifying and interpreting topics in ESG-related news articles and academic papers. By integrating computational methods with manual interpretation and validation, we can ensure our results are both statistically sound and meaningful in the context of ESG research.
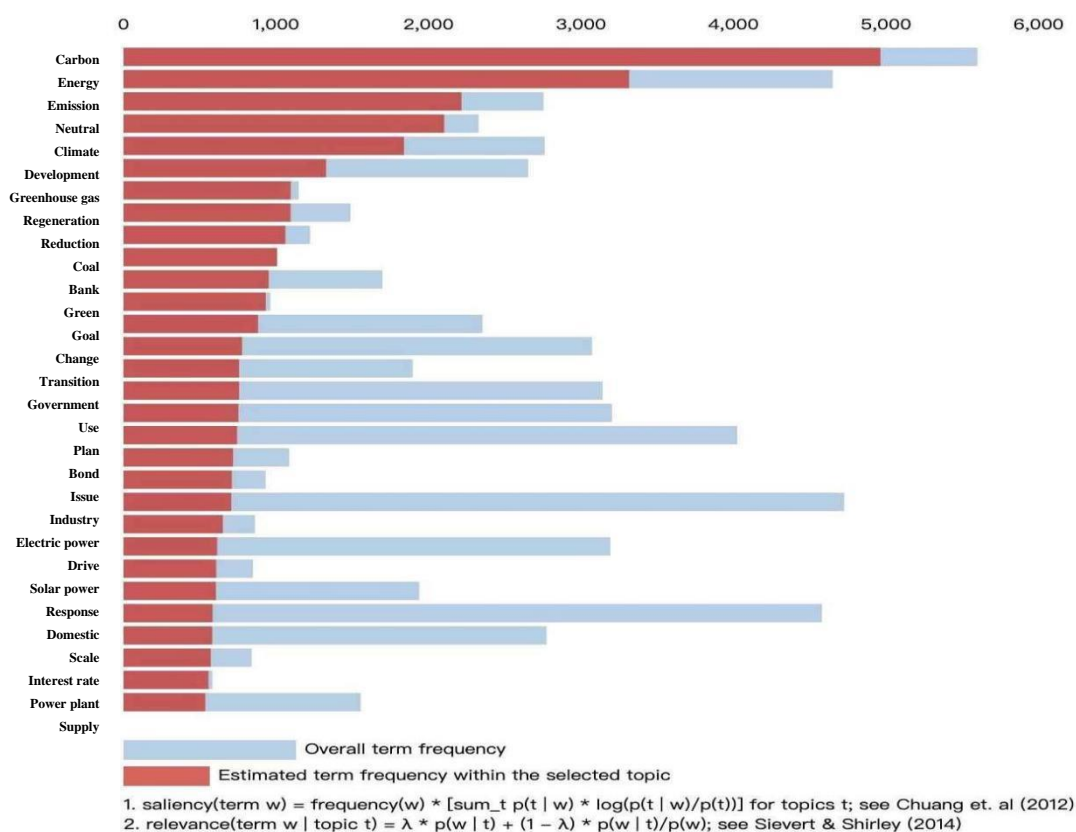
2.4.4 Visualization

Figure 2 depict the design of the topic model, where 10 different topics are represented as circles. The area of each circle indicates the overall prevalence of a topic, and the centers of the circles are determined by computing the distances between topics. These intertopic distances are visualized on a two-dimensional plane[22] using multidimensional scaling. The principal component (PC)1 is represented along the transverse (horizontal) axis, and the PC2 is represented along the longitudinal (vertical) axis.

3. Results and Discussion

[Fig. 3] illustrates the top 30 most relevant terms for Topic 1, which had the highest proportion of all topics. As an example, we selected Topic 1, and the system visualized the word frequency distribution relative to the entire corpus. Each bar represents the overall frequency of a given term and the estimated frequency within Topic 1. The news reports in Topic 1 predominantly discuss carbon emissions and energy consumption. By examining the content of this topic, we can assign a relevant name to the topic. This method aligns with the approach illustrated in previous literature[23].

[Fig. 2] Intertopic Distance map. PC: Principal Component

1. saliency(term w) = frequency(w) * [sum_t p(t | w) * log(p(t | w)/p(t))] for topics t; see Chuang et. al (2012)
2. relevance(term w | topic t) = λ * p(w | t) + (1 − λ) * p(w | t)/p(w); see Sievert & Shirley (2014)

[Fig. 3] Top 30 Most Relevant Terms

3.1 Results for Research Question 1

As Table 2 shows, in our analysis of ESG-related academic paper, we identified 10 main topics that encompass the multi-dimensional nature of ESG issues. These topics demonstrate the complexity and interconnectedness of ESG concerns and underline the need for a comprehensive and integrated approach to address them effectively. The main topics identified are as follows:

Environmental Protection (16.9%): This topic primarily discusses the various measures and policies in place for environmental protection. It explores the impact of economic activities on the environment and evaluates the effectiveness of these policies, taking into account financial and managerial aspects[24][25].

Sustainability (11.9%): Papers under this topic delve into the concept of sustainability, its implementation in domestic and international contexts, and its relevance to various industries. They also consider issues and interests related to sustainability[26][27].

Financial Performance (15.8%): This topic examines the financial performance of organizations, particularly in relation to their ESG efforts. It evaluates factors affecting financial performance and discusses strategies for tax avoidance and financial management[28][29].

Financial Market (7.9%): Papers in this category focus on the role of ESG factors in influencing financial markets. They explore aspects like investments, profits, risk management, and the impact of these factors on stock prices[30][31].

Information Disclosure System (9.6%): This topic is about the disclosure of ESG-related information. It considers the necessity, obligations, regulations, and public expectations associated with such disclosures[32][33].

Board and Audit Committee Composition (8.8%): This topic discusses the composition and roles of

the board of directors and audit committees in governing ESG practices. It evaluates the influence of shareholders and internal management structures[34][35].

Evaluation Criteria (8.7%): This topic covers the standards and criteria for evaluating ESG practices. It examines the significance of different sectors, environmental factors, and corporate structures in this evaluation process[36][37].

Internal Corporate Governance Structure (8.8%): This topic delves into the internal structures that govern ESG practices within corporations. It considers the relationships, costs, and benefits associated with different governance structures[38][39].

Strategy Development (7.9%): Papers under this topic discuss the development and implementation of ESG strategies. They explore innovative approaches, educational initiatives, and the role of customer and regional factors[40][41].

Consumer Trust (8.6%): This topic examines the role of consumer trust in ESG practices. It discusses consumers' perceptions of and attitudes towards brands, their trust in eco-friendly practices, and the impact of these factors on consumer behavior[42][43].

In conclusion, the analysis of ESG-related academic papers reveals a diverse range of topics, reflecting the multi-dimensional nature of ESG itself. These topics range from tangible environmental concerns such as environmental protection and sustainability, to more intangible social and governance issues like financial performance, information disclosure systems, and internal corporate governance structures, to social themes such as consumer trust and perception. Notably, there is significant emphasis on policy and system topics, indicating the critical role of policy frameworks in promoting ESG initiatives. The importance of leadership and strategic direction from businesses is also evident, highlighting the role of commerce in shaping a sustainable future. Furthermore, these topics underline the necessity of collaboration across different fields and stakeholders, including academia-industry cooperation and community participation. Overall, these topics demonstrate the complexity and interconnectivity of ESG issues, emphasizing the need for a comprehensive and integrated approach to effectively address them. The variety of these topics also signifies the broad scope of ESG, illustrating its impact on multiple aspects of business, policy, and society.

[Table 2] Topic Classification and Keywords Extracted from Academic Paper

Topics	Keywords	Proposed Topic Name	Proportion
Topic 1	Environment, Change, Evaluation, Economy, Policy, Management, Possible, Suggestion, Sustainability, Finance	Environmental Protection	16.9%
Topic 2	Sustainability, Possibility, Domestic, Use, Issue, Interest, Industry Expectation, Interest	Sustainability	11.9%
Topic 3	Performance, Finance, Executive, Implementation, Tax, Avoidance, Factors, Implementation, Empirical, Characteristics	Financial Performance	15.8%
Topic 4	Investment, Profit, Market, Investors, Index, Fund, Assets, Risk Increase, Stock price	Financial Market	7.9%
Topic 5	Disclosure, Information, System, Necessary, Finance, Obligation, Plan, Consideration, Regulation, Public	Information Disclosure System	9.6%
Topic 6	Institution, Company, Shareholder, Director, Investor, Control, Interest, Internal, Evaluation, Introduction	Board and Audit Committee Composition	8.8%
Topic 7	Evaluation, Grade, Environment, Credit, Control, Sector, Significance, Accounting, Structure, Index, Information	Evaluation Criteria	8.7%
Topic 8	Structure, Control, Profit, Relationship, Score, Cost, Capital, Corporate Governance, Environment, Adjustment	Internal Corporate Governance Structure	8.8%
Topic 9	Industry, Korea, Strategy, Development, Innovation, Education, Use, Customer, Base, Region	Strategy Development	7.9%
Topic 10	Consumer, Environment, Trust, Perception, Organization, Brand, Eco-friendly, Attitude, Behavior, Generation	Consumer Trust	8.6%

3.2 Results for Research Question 2

As Table 3 shows, in our analysis of ESG-related news articles, we identified ten main topics that encompass the multi-dimensional nature of ESG issues. These topics demonstrate the complexity and interconnectedness of ESG concerns and underline the need for a comprehensive and integrated approach to address them effectively. The main topics identified are as follows:

Carbon Emissions and Climate Neutrality (14.7%): This topic primarily focuses on the discussion surrounding carbon emissions, climate neutrality, and the development of renewable energy sources. It also addresses the broader issue of climate change and strategies for reducing greenhouse gases[44].

Political Sponsorship and Climate Policies (13.5%): This topic revolves around the role of government and policy in addressing climate change and economic issues related to environmental, social, and governance (ESG) factors[45].

Board and Audit Committee Structures (11.4%): Articles in this category delve into the corporate governance aspect of ESG, discussing issues related to the evaluation of board and committee structures, shareholder responsibilities, and the role of women in these contexts[46].

Leadership and Corporate Strategy (10.4%): This topic emphasizes the role of leadership in driving ESG initiatives, focusing on strategic development and innovation for sustainable growth[47].

Community Engagement and Cooperation (10.1%): This topic is about companies' efforts to engage with local communities and make positive contributions, including campaigns, donations, and cultural involvement[48].

Financial Market Dynamics (8.9%): This topic explores ESG from the financial market perspective, discussing the dynamics of funds, assets, stocks, and investor behavior[49].

Executive Compensation and Corporate Policy (8.2%): This topic deals with issues related to executive compensation, corporate policies, and their alignment with ESG goals[50].

Eco-friendly Materials and Consumer Goods (8.2%): This topic talks about the use of eco-friendly materials in product manufacturing, the utilization of plastics, and consumer attitudes towards such products[51].

Consumer Rights and Digital Services (8.1%): Articles in this category often discuss the intersection of consumer rights, digital services, and ESG, including topics like data privacy and ethical technology use[52].

Academia-Industry Collaboration (8.1%): This topic covers collaborations between academic institutions and industries for research, innovation, and education in the ESG field[53].

In conclusion, the analysis of ESG-related news articles reveals a diverse range of topics reflecting the multi-dimensional nature of ESG itself. The topics range from tangible environmental concerns like carbon emissions and the use of eco-friendly materials, to more intangible social and governance issues such as leadership strategies, board structures, and consumer rights. Notably, there is significant emphasis on the role of government and policy, indicating the crucial part of regulatory frameworks in driving ESG initiatives. The importance of leadership and strategic direction from corporations is also evident, emphasizing the role of business in shaping a sustainable future[54].

Additionally, the topics highlight the necessity for collaboration across different sectors and stakeholders, including academia-industry partnerships and community engagement. Overall, these topics demonstrate the complexity and interconnectedness of ESG issues, underlining the need for a comprehensive and integrated approach to address them effectively. The variety of these topics also signifies the broad scope of ESG, illustrating its impact on multiple aspects of business, policy, and society[55].

[Table 3] Topic Classification and Keywords Extracted from News Articles

Topics	Keywords	Proposed Topic Name	Proportion
Topic 1	Carbon, Energy, Emission, Neutral, Climate, Development, Greenhouse Gas, Renewable, Reduction, Coal	Carbon Emissions and Climate Neutrality	14.70%
Topic 2	Government, Economy, Problem, Climate, Crisis, Policy, Change, Need, People, Thought	Political Sponsorship and Climate Policies	13.50%
Topic 3	Evaluation, Committee, Director, Shareholder, Responsibility, Governance, Structure, Sustainability, Pension, Women	Board and Audit Committee Structures	11.40%
Topic 4	Group, Chairman, Growth, Value, Future, Representative, Global, POSCO, Innovation, Strategy	Leadership and Corporate Strategy	10.40%
Topic 5	Activity, Region, Contribution, Progress, Campaign, Donation, Practice, Culture, Participation, Corona	Community Engagement and Cooperation	10.10%
Topic 6	Fund, Market, Asset, Profit, USA, Stock, Operation, Global, Investor, Domestic, Index	Financial Market Dynamics	8.90%
Topic 7	Product, Plastic, Utilization, Use, Food, Brand, Consumer, Material, Container, Certification	Eco-friendly Materials and Consumer Goods	8.20%
Topic 8	Service, Customer, Bank, Kakao, Digital, Provision, Platform, Product, Technology, Data	Consumer Rights and Digital Services	8.10%
Topic 9	Field, Technology, Education, Professor, University, Innovation, Research, Representative, Startup, Industry	Academia-Industry Collaboration	8.10%
Topic 10	Headquarters, Center, Team Leader, Planning, Director, Division Head, Management, Deputy, Promotion, National Head, Policy	Executive Compensation and Corporate Policy	8.20%

3.3 Results for Research Question 3

In the exploration of ESG-related academic papers and news articles, several convergences and divergences emerge, illustrating both the shared concerns and distinct focuses in these discourses. Shared concerns revolve around the environmental, governance, and cooperative aspects of ESG. Both academic research and media coverage underscore the crucial role of environmental protection and sustainability, suggesting a societal consensus on the urgency of these issues. Furthermore, the significance of governance and policy frameworks, manifested in topics such as board and audit committee composition and climate policies, is highlighted in both realms, indicating a shared understanding of the systemic nature of ESG issues. The necessity for collaboration across different

sectors and stakeholders is also emphasized, reflecting the widely recognized interconnectedness of ESG challenges and the collective efforts required to tackle them.

Despite these commonalities, distinct focuses are identified in academic research and news media. Academic research appears to delve more into the internal dynamics of corporations, with emphasis on topics like internal corporate governance structure, information disclosure system, and financial performance. This focus tends to provide a deeper understanding of the mechanisms and processes underpinning ESG practices within organizations.

In contrast, news articles seem more attuned to the practical and emerging issues of ESG, covering areas such as carbon emissions, consumer rights in the context of digital services, and executive compensation alignment with ESG goals. This divergence suggests a more immediate response to the evolving ESG landscape, providing insights into the current societal concerns and real-world applications of ESG principles.

These convergences and divergences offer invaluable insights into the multi-dimensional nature of ESG issues. The shared concerns highlight areas of societal consensus, providing a foundation for collaborative efforts, while the distinct focuses reveal potential gaps and opportunities for future research. Specifically, the practical and emerging issues identified in news articles could inform the development of novel research questions and innovative solutions in academic research. Thus, fostering a dialogue between these discourses may contribute to a more holistic understanding and effective management of ESG challenges.

4. Conclusions

This study aimed to analyze ESG-related news articles and academic papers to understand the multi-dimensional nature of Environmental, Social, and Governance issues. The investigation uncovered significant impact across business, policy, and society, highlighting a growing interest in ESG issues and a diminishing gap within the political spectrum. The study also identified a deficiency in specific areas of ESG-related academic research, such as community collaboration and social dimensions like labor issues. These findings have far-reaching implications, emphasizing the need for increased interdisciplinary research, collaboration among various stakeholders, and an extension of research into underexplored areas. The significance of the study lies in its potential to guide scholars in understanding current social issues and the gaps existing in academic research, thereby contributing to sustainable development and addressing complex social and environmental challenges.

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