

Green Tides in Silicon Waves: Evaluating the Impact
of Policy Shifts vs. Corporate Operation on ESG
Disclosure in the Chinese Semiconductor Industry

by

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Abstract

This thesis examines the impact of policy changes and corporate operations on Environmental, Social, and Governance (ESG) disclosure practices in the Chinese semiconductor industry. Using event study and Difference in Differences (DiD) methodologies, the research assesses how recent regulatory policies and differing corporate behaviors influence the quantity and quality of ESG disclosures. The study spans from 2015 to 2022, a period marked by significant policy introductions aimed at enhancing corporate transparency and accountability in China.

The findings reveal that the 2021 environmental policy significantly influenced ESG disclosures, with firms showing marked improvements in both the depth and transparency of their reporting. Additionally, the results indicate that prior to the policy implementation, ESG disclosure practices did not vary significantly between firms with different financial performances. However, post-policy changes have stimulated more pronounced differences in disclosure practices, particularly in firms with better financial standings. This suggests that while policies are effective in elevating overall disclosure standards, corporate operations, especially financial performance, play a crucial role in determining the extent and efficacy of these disclosures.

The implications of this research are significant for policymakers, corporate managers, and investors, as they highlight the importance of tailored regulatory frameworks and the need for firms to integrate ESG considerations into their core operational strategies. This study not only contributes to the academic discussion on ESG practices but also provides practical insights for enhancing corporate governance and sustainability initiatives in emerging markets.

Keywords: ESG Disclosure, Semiconductor Industry, Policy Impact, Corporate Operations, Event Study, Difference in Differences, China

1 Introduction

1.1 Literature Review

1.1.1 ESG & Finance

The interplay between Environmental, Social, and Governance (ESG) performance and financial metrics in the Chinese market has garnered significant attention, particularly in the wake of the COVID-19 pandemic. This section synthesizes insights from recent studies to explore the evolving dynamics of ESG finance in China, highlighting both the impact on firm values and investment strategies.

Increasingly, the strategic significance of ESG investing has been recognized for its reflection on firm values, especially in a post-pandemic era. Cheng, Kim, and Ryu (2023) argue that ESG disclosures significantly enhance firm value in the Chinese market, a trend that has become more pronounced since the pandemic. They note that while the Environmental aspect of ESG distinctly influences firm values, the Social and Governance aspects do not exhibit a similar effect [3].

Parallel to this, Zhang, Zhao, and Qu (2021) examine the influence of green policies on ESG investing, emphasizing the crucial role of the 2016 “Guidelines for Establishing a Green Financial System” in shaping investment strategies in China. Their research suggests that, following the implementation of these guidelines, portfolios with high ESG ratings have earned markedly higher abnormal returns, indicating a direct correlation between green policies and enhanced ESG performance [17]. This relationship suggests a broader implication for policy-driven ESG evolution within the financial landscape, affirming the pandemic’s role as a catalyst in sharpening the financial sector’s focus on sustainability.

Further examining the relationship between ESG performance and financial risk, Feng, Goodell, and Shen (2022) examine how ESG ratings correlate with stock price crash risk among Chinese

firms. They find a statistically significant negative relationship, suggesting that higher ESG ratings—which reflect a company’s commitment to environmental stewardship, social responsibility, and robust governance—can mitigate the risk of sudden stock price declines [6]. This finding supports agency theory, which posits that firms with higher ESG standards are likely to reduce adverse risk exposures.

Moreover, the study by Feng et al. adds a novel dimension by using comprehensive ESG ratings to analyze the potential for future stock price crashes, offering empirical support for stakeholder theory. This theory suggests that high ESG ratings contribute to a transparent information environment that reduces the likelihood of accumulating and concealing adverse news, subsequently decreasing stock price crash risk. The implications of their findings are particularly relevant for investors and policymakers who are navigating the complexities of ESG evaluation in the volatile Chinese stock market.

This discussion also underscores the unique institutional environment in China, where ESG evaluation is still emerging but rapidly gaining importance among regulators and market participants. The insights into the implications of ESG ratings on stock price crash risk not only illuminate the context of China but also offer perspectives for other emerging markets worldwide, where regulations and market transparency continue to evolve.

Building upon the previously discussed dynamics of ESG in the financial context of China, this section extends the narrative to explore ESG disclosures and their nuanced effects on financial performance. As the significance of ESG metrics in shaping investment decisions and firm value becomes increasingly apparent, understanding the specific impacts of ESG disclosures becomes crucial.

1.1.2 ESG Disclosure: Impact and Investor Interaction

The burgeoning interest in Environmental, Social, and Governance (ESG) disclosures and their impact on financial performance is supported by a growing consensus on the importance of sustainable practices for long-term firm value. A notable study by Sun, Xu, Ding, and Cao (2023) investigates the complex dynamics of ESG disclosures within the Chinese capital market. Utilizing a comprehensive dataset from 1169 firms listed in China between 2006 and 2019, their analysis reveals a nuanced relationship between the level of integrated ESG disclosures and firm value. Contrary to conventional expectations, they find that higher integration levels of ESG disclosures are negatively associated with firm value, attributing this inverse relationship to institutional characteristics unique to the Chinese market, such as resistance to transparency and lower investor sophistication. This study underscores the complexity of ESG reporting in environments where cultural and institutional factors may dilute the positive impacts typically associated with high levels of disclosure [16].

Further complementing this perspective, another seminal work explores the moderating role of ESG investors in the relationship between ESG disclosure and financial performance. This research underscores that while ESG disclosures are fundamentally aimed at enhancing firm transparency and improving investor information, their effectiveness in boosting financial performance is significantly influenced by the presence of ESG-focused investors. The findings suggest that ESG disclosures, in isolation, do not directly lead to better financial outcomes but do so more effectively in the presence of active engagement from investors who prioritize ESG performance in their investment decisions [16].

Together, these studies contribute to the evolving narrative on ESG disclosure practices, suggesting that the impact of these disclosures on firm value is not straightforward. They highlight the importance of considering the broader institutional and investor context in which these disclosures occur, particularly in markets like China where ESG reporting practices and investor behaviors

may differ markedly from those in more developed markets. Insights from Sun et al. (2023) and related research call for a more nuanced understanding of how ESG disclosures are interpreted by investors and their subsequent impact on firm financial performance, connecting back to the broader discussions on ESG, finance, and risk covered in the previous sections.

1.1.3 ESG Development in China: Corporate and Social Dimensions

Following the exploration of ESG disclosures and financial performance, this section targets the broader trajectory of Environmental, Social, and Governance (ESG) practices in China. This review extends the previous discussions by examining the multifaceted panorama marked by evolving practices, a burgeoning body of research, and dynamic public perceptions as elucidated by recent academic contributions.

Yin et al. (2023) and Liu et al. (2023) highlight ESG's pronounced impact on China's corporate and social landscape, reflecting a complex interplay of regulatory, market, and societal forces. These studies collectively illuminate the nuanced contours of ESG's ascendance in the Chinese context, offering insights into its current state and projecting its future pathways. Yin et al. (2023) provide a comprehensive review of how ESG is being integrated into China's business ethos, emphasizing the implications for sustainability and corporate governance. The paper underscores China's unique position in the global ESG narrative, driven by its rapid economic ascent and the consequential environmental and social challenges. Amidst international scrutiny and domestic policy shifts, Chinese firms and regulators are increasingly aligning with global ESG benchmarks, albeit while navigating the nuances of China's economic and political milieu. This transition is further complicated by the diverse nature of ESG standards and their application across different sectors and regions within China.

Concurrently, Liu et al. (2023) explore public perceptions regarding ESG through social media analytics, particularly on platforms like Sina Weibo. Their findings reveal a spectrum of perceptions ranging from enthusiastic endorsement to skepticism and critique, underscoring the pivotal

role of public discourse in shaping ESG's trajectory in China. The study highlights the growing consciousness and engagement with ESG issues among the Chinese populace, influenced by social media dynamics and the broader informational ecosystem. This engagement, however, faces challenges, as evidenced by concerns over greenwashing, inconsistencies in ESG ratings, and the demand for more transparent and localized ESG reporting standards.

These scholarly endeavors underscore a critical juncture in China's ESG evolution, marked by increased corporate adoption, regulatory emphasis, and public engagement with ESG principles. However, they also spotlight the imperative for more coherent policies, standards, and educational initiatives to foster a more informed and constructive ESG discourse within the Chinese context.

Building on the insights from Yin et al. (2023) and Liu et al. (2023), it becomes evident that the academic understanding of ESG's development in China offers practical implications for policymakers, corporate leaders, and stakeholders aiming to navigate the complexities of ESG integration and sustainability in the Chinese market. As China continues to chart its course towards sustainable development, these studies highlight the importance of inclusive, informed, and adaptive approaches to ESG, capable of addressing the unique challenges and opportunities presented by China's socio-economic landscape.

1.1.4 Textual Analysis & Topic Modeling of ESG Data

Following the exploration of ESG's impact on public perceptions and corporate practices in China, this section focuses on the innovative methodologies used to further understand the nuances and evolution of sustainability practices among corporations through textual analysis and topic modeling. These techniques offer a fresh perspective that complements the broader discussions of ESG integration and stakeholder engagement.

Goloshchapova et al. (2019) employ Latent Dirichlet Allocation (LDA) for topic modeling, analyzing CSR reports from major stock market indices across 15 industrialized countries. Their

study reveals predominant themes such as ‘employee safety’, ‘carbon emission’, and ‘efficient power’, underscoring the dynamic and multifaceted nature of CSR reporting. These findings highlight sector-specific emphases within ESG reporting, driven by industry specifics and geographical contexts, and suggest how such methodologies can illuminate the complex landscape of corporate sustainability practices [7].

Building on this, advancements in textual analysis methodologies are showcased in research that utilizes machine learning and deep learning algorithms to dissect vast amounts of ESG reports. These sophisticated techniques not only deepen the analytical depth but also expand the analytical scope, allowing for a more granular understanding of ESG topics and their implications on corporate behavior and investor decision-making. Such integrated approaches underscore the potential of these technologies to uncover insights that traditional analysis methods might overlook.

Additionally, the adoption of BERTopic, a novel technique based on the Bidirectional Encoder Representations from Transformers (BERT) model, offers a groundbreaking perspective on comparing ESG discourse across different mediums, such as news articles and academic papers. This method facilitates a deeper comprehension of the public and academic sentiment towards ESG issues, bridging the gap between theoretical research and practical real-world applications.

The integration of big data approaches in textual analysis marks a pivotal shift in CSR and ESG research. These methodologies enable stakeholders to navigate the complex landscape of sustainability reporting with greater precision and insight. As these techniques continue to evolve, they promise to unveil richer, more nuanced understandings of how corporations articulate and implement their sustainability agendas. This progression not only informs policy, investment, and strategic decisions but also enhances our understanding of sustainable development within the global and Chinese contexts.

1.1.5 Event Study & DiD Analysis in ESG Literature

Building on the innovative methodologies discussed previously, such as textual analysis and topic modeling, this section shifts focus to the empirical strategies employed to analyze the causal relationships within the Environmental, Social, and Governance (ESG) framework. The intricate interplay between ESG policies and market dynamics has been increasingly explored through event study and Difference in Differences (DiD) methodologies, providing profound insights into the effects of these policies.

Sun, Zhou, and Gan (2023) utilize a DiD approach to examine the impact of green finance policies on ESG performance among Chinese manufacturing firms. Their findings reveal a positive influence, particularly pronounced in the environmental domain of ESG. This study leverages the establishment of green finance pilot zones in China as a quasi-natural experiment, demonstrating how targeted financial policies can enhance firms' ESG engagement. The effects are notably distinct across different types of firms and regions, such as state-owned enterprises, economically developed areas, and under varying financial constraints [15].

Complementing this, another pivotal work employs an event study methodology to scrutinize the secondary market reactions to ESG policy announcements. This analysis elucidates the nuanced market perceptions regarding ESG initiatives, highlighting the critical role of timely and effective policy implementation in shaping corporate ESG trajectories. The immediate financial market's response to these announcements offers insights into how quickly and effectively market actors assimilate and react to new ESG regulations.

Together, these studies underscore the utility of event study and DiD analyses in disentangling the nuanced impacts of ESG policies on corporate performance and market dynamics. By leveraging exogenous policy interventions and market events, researchers can isolate the direct effects of ESG policies, offering invaluable insights into the mechanisms driving ESG integration into corporate practices and investment strategies. This body of work not only contributes to the academic

discourse on ESG but also offers practical implications for policymakers and corporate strategists aiming to navigate the complexities of ESG integration and sustainability in the global market landscape.

1.2 Research Question and Hypotheses

Building upon the comprehensive review of the ESG literature, this research seeks to investigate deeper into the dynamics specific to the Chinese Semiconductor Industry, a pivotal sector under China's current economic strategies. Previous sections have discussed the multifaceted impacts of Environmental, Social, and Governance (ESG) factors on financial performance, disclosure practices, and corporate and societal behaviors in broader contexts. Studies like those by Cheng, Kim, and Ryu (2023) and Zhang, Zhao, and Qu (2021) have provided insights into how ESG practices influence firm value and investment strategies in China, primarily driven by overarching policies and market conditions [5, 17]. Similarly, Sun, Xu, Ding, and Cao (2023) highlighted the complex interplay between ESG disclosures and firm value, noting specific institutional characteristics unique to the Chinese market, such as varying degrees of transparency and investor sophistication [16].

However, a critical gap remains in the existing literature: the nuanced understanding of how these dynamics play out within the high-tech and strategically significant semiconductor industry. This industry is not only central to China's technological ambitions but also presents unique challenges and opportunities for ESG integration due to its rapid innovation cycles, extensive supply chains, and significant environmental impacts. Current research largely aggregates findings across industries without distinguishing the peculiarities that might affect ESG strategies and their outcomes in high-tech sectors. This oversight suggests a need for a targeted industry-specific analysis that could provide deeper insights into the relative impacts of government policies versus corporate operations on ESG Disclosure performance.

1.3 Research Question

Given the identified gaps, this study poses the question: To what extent do government policies, versus corporate operations, influence the observed changes in the trajectory of ESG Disclosure performance in the Chinese Semiconductor Industry? This research question is designed to dissect the influence of external regulatory frameworks compared to internal corporate governance on ESG practices within a sector that is both globally competitive and domestically crucial.

1.3.1 Hypothesis 1

Based on the discussions in the literature review, particularly the findings from Feng, Goodell, and Shen (2022) about the impact of ESG ratings on financial risk mitigation [6], it is hypothesized that in the Chinese Semiconductor Industry, ESG Disclosure behavior is predominantly shaped by policy implementations rather than by individual firm behaviors. This hypothesis will be tested using Event Study methodologies to analyze the immediate impact of policy announcements and changes on corporate ESG disclosures, reflecting the broader discussions about policy-driven ESG evolution in the financial landscape noted by Zhang, Zhao, and Qu (2021).

1.3.2 Hypothesis 2

In contrast to the first hypothesis, this study also proposes that ESG Disclosure behavior in the Chinese Semiconductor Industry exhibits significant heterogeneity based on corporate operations. This hypothesis stems from observations made by Sun et al. (2023) about the negative associations between integrated ESG disclosures and firm value in contexts with specific institutional characteristics [16]. It is expected that firms with better financial performance and more robust internal governance structures will show more effective and substantive ESG disclosures. This hypothesis will be explored through DiD analysis methodologies to isolate the effects of intrinsic corporate operations from those of external policy interventions.

2 Data

2.1 Overview

The primary dataset for this study comprises annual reports published by firms in the Chinese semiconductor industry from 2015 to 2022. A total of 482 reports were analyzed, with the number of reports increasing annually from 29 in 2015 to 135 in 2022. These documents are pivotal as they contain comprehensive disclosures on financial and operational performance, as well as ESG-related activities. The reliance on annual reports, rather than specific ESG reports, is due to the standardized format of annual disclosures, which facilitates a consistent comparison across firms and years. Specialized ESG reports, while detailed, often contain non-standardized images and qualitative descriptions that pose challenges for systematic textual analysis and quantitative assessment. This standardization is crucial for employing textual analysis and topic modeling techniques effectively, as noted in the methodologies outlined by Goloshchapova et al. (2019) for analyzing structured corporate disclosures [7].

In addition to the annual reports, operational metrics regarding financial performance and two selected policy changes are also collected to conduct the event study and DiD analysis mentioned in the previous sections. This data will help in quantifying the impact of policy implementations and operational strategies on ESG disclosure behaviors, drawing on the event study and DiD methodologies that have been effectively used in prior research to isolate the effects of such external and internal influences on corporate ESG practices [15].

2.2 Data Collection

2.2.1 Annual Reports

The data for the annual reports and operational metrics are sourced from the Wind Information terminal, covering the eight-year period from 2015 to 2022. This period was chosen to include several significant regulatory changes and technological advancements that have potentially in-

fluenced ESG practices within the sector. The scope of the research targets firms categorized within the semiconductor sector of the Chinese A-share market by Wind. This categorization includes companies involved in Integrated Circuit Design, Manufacturing, and other high-tech semiconductor-related activities. In terms of the operational metrics, the information of the ranking by the annual EBITDA divided by the annual operating income.

2.2.2 Policies of Interest

This research focuses on two pivotal policies influencing ESG disclosure practices within the Chinese semiconductor industry. The first policy, the “Measures for Disclosure of Environmental Information of Enterprises and Institutions” was instituted by the Ministry of Environmental Protection in 2015. This policy laid the groundwork for the standardized disclosure of environmental information across various industries, emphasizing transparency and public supervision. It required enterprises, including public and private firms, to openly share information about their environmental impact and management practices, which was a significant step towards modern environmental governance and supported China’s goals for peak carbon emissions and carbon neutrality [19].

The second policy, implemented towards the end of 2021 by the Ministry of Ecology and Environment, is titled “Measures for the Management of Legal Disclosure of Enterprise Environmental Information.” This newer regulation builds upon its predecessor by enhancing the requirements for environmental disclosures. It was part of a broader “Environmental Information Legal Disclosure System Reform Plan” established in May 2021, which aims to solidify the framework for mandatory environmental information disclosures by 2025. This policy not only unifies and clarifies previous disparate provisions but also addresses key obstacles that hindered the effective advancement of corporate disclosures. These include improving the specificity and guidance of disclosures for enterprises, thus significantly impacting how environmental information is managed and communicated in high-scrutiny sectors such as semiconductors [19].

The 2015 policy initiated a crucial shift towards environmental transparency, aligning with international practices and supporting the Chinese government’s push towards a modern environmental governance system. As detailed in the article by Dialogue Earth, this shift was fundamental in setting the stage for more rigorous environmental governance and informed public engagement [19].

On the other hand, the 2021 policy further elaborates on the 2015 foundations by explicitly incorporating carbon emission reporting and other ecological compliance details into corporate disclosures. It reflects a growing trend towards integrating ESG metrics into broader financial and operational reporting frameworks, especially significant in light of China’s increasing emphasis on climate change and sustainable development. This policy also facilitates a deeper alignment with global ESG investment criteria, influencing how Chinese firms, particularly those in pollution-intensive industries like semiconductors, are perceived and engaged by global investors [19].

While both policies are integral to understanding the regulatory context of ESG disclosures, only the 2021 policy titled “Measures for the Management of Legal Disclosure of Enterprise Environmental Information” will be utilized for the event study methodology in this research. This decision is based on the policy’s comprehensive reformative impact and its recent implementation, providing a fresh and measurable influence on corporate ESG practices within the semiconductor industry. By focusing on this policy, the study aims to critically assess the immediate effects of enhanced disclosure requirements introduced in 2021 on corporate governance and investor relations. This approach will offer detailed insights into how newer regulatory frameworks shape ESG strategies and outcomes in a rapidly evolving economic and environmental landscape in China.

2.3 Data Processing

The data processing workflow for the annual reports begins with the conversion of each document from PDF to Microsoft Word format using Adobe Acrobat. This initial step is essential

to facilitate more accessible text manipulation and extraction processes required for subsequent analysis. An inverse selection approach is applied, meaning that all content not related to ESG disclosures is systematically removed, ensuring that the subsequent analysis is focused solely on relevant ESG data.

Once the relevant sections are isolated, the data is further segmented based on operational metrics obtained from the Wind Information terminal. Each firm is classified annually into one of two groups according to their financial performance metrics: the top 50% and the bottom 50%. This classification allows for comparative analysis across different performance tiers within the industry, facilitating a nuanced investigation of the correlation between financial performance and ESG disclosure practices.

For each group, ESG disclosure information is compiled into text files designated for each year and performance tier. For instance, “2015_L.txt” aggregates all ESG disclosure information from the lower 50% of firms by financial performance for the year 2015, while “2021_T.txt” contains disclosures from the top 50% for the year 2021. This organization aids in the structured analysis of temporal and performance-related trends in ESG practices.

The final stage of data processing involves the consolidation of these yearly and group-specific text files into comprehensive annual datasets (e.g., “2015.txt” through “2022.txt”). These files represent the entire spectrum of ESG disclosures within the industry for each respective year, providing a robust dataset for in-depth analysis in the subsequent stages of this research. This methodological approach ensures that each dataset is prepared with a high level of precision and consistency, as recommended by Goloshchapova et al. (2019) for conducting reliable and replicable textual analyses in corporate studies [7].

3 Methodologies

3.1 Topic Modeling using LDA

3.1.1 Theoretical Framework

Latent Dirichlet Allocation (LDA) is a generative statistical model that allows sets of observations to be explained by unobserved groups that explain why some parts of the data are similar. For topic modeling, LDA assumes that documents are produced from a mixture of topics, where each topic is characterized by a distribution over words. The model's mathematical foundations are rooted in Bayesian inference. Specifically, LDA posits that each document within a corpus can be represented as a random mixture of latent topics, where each topic is characterized by a distribution over words.

In the context of this study, LDA is employed to analyze the text data extracted from the annual reports of Chinese semiconductor companies. This method is particularly suited to handling the complexities and nuances of textual data in Chinese, a language with significant semantic and contextual layers. To process the text effectively, the “jieba” package in Python is utilized for segmenting Chinese text, which is essential for breaking down content into analyzable components. The “jieba” toolkit is adept at handling Chinese characters and provides functionalities to customize segmentation by adjusting stopwords, which are frequently occurring words that are typically ignored in text analysis tasks.

The preprocessing of text data involves cleaning and parsing the words using the “jieba” package, where manual tuning is performed iteratively to refine the list of stopwords contained in “stopwords.txt”. This iterative refinement is crucial for enhancing the quality of topic models by ensuring that the stopwords list accurately reflects the linguistic nuances and technical jargon prevalent in corporate environmental disclosures.

Once the text data is preprocessed, LDA is applied to the eight consolidated “{Year}.txt” files, each representing the aggregate ESG disclosures of the semiconductor industry for a particular year, from 2015 to 2022. This application will allow us to examine the evolution of topics over time, providing insights into how certain themes or focus areas have emerged, evolved, or diminished across the years in response to regulatory changes and industry shifts.

The effectiveness of LDA in uncovering latent topics within large datasets makes it an invaluable tool in this research, enabling a systematic exploration of underlying themes in ESG disclosures over time. Such analysis not only contributes to academic knowledge but also offers practical insights for industry stakeholders aiming to understand the trajectory of ESG practices in the context of evolving regulatory environments.

3.1.2 Data Overview

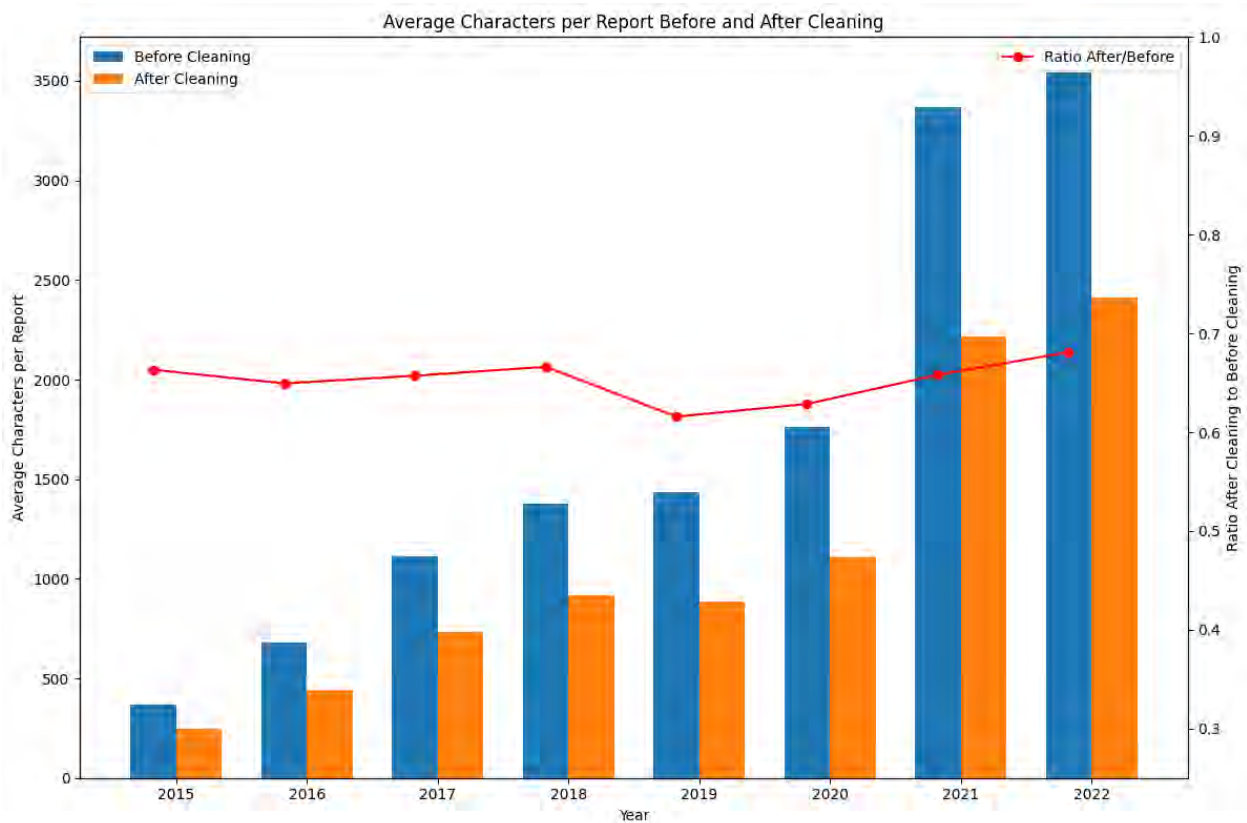


Figure 1: Average Characters per Report Before and After Cleaning

The cleaning process reduces the character count of reports each year, as expected, by eliminating non-substantive text elements such as common stopwords. This reduction allows for a clearer focus on relevant content, enhancing the quality of subsequent analyses. From 2015 to 2022, there is a clear upward trend in both the pre- and post-cleaning character counts, suggesting an increase in the volume of reported ESG information over time.

In 2015, the average number of characters per report before cleaning was 369.48, which was reduced to 245.03 after cleaning, corresponding to a reduction of approximately 33.7%. By 2022, the reports initially contained 3542.75 characters on average, which were reduced to 2412.61 characters post-cleaning, showing a reduction rate of about 31.9%. This consistent reduction percentage indicates that while the reports have become substantially longer over time, the proportion of content considered non-essential (as defined by the stopwords list) has remained relatively stable.

A closer examination of the ratios of post-cleaning to pre-cleaning text length across the years reveals insights into the evolving complexity and detail of ESG disclosures. The decrease in the ratio from approximately 66.3% in 2015 to about 68.1% in 2022 suggests a slight increase in the density of relevant content, which may reflect both a maturation in reporting practices and an adaptation to more stringent disclosure standards.

3.1.3 Evolutions of Topics Covered

The longitudinal analysis of topics from the annual ESG disclosures of the Chinese semiconductor industry provides insights into the shifting focus areas over the observed period. This section presents a comparative view of the top three topics from each year, illustrating the evolution of discourse and priority shifts in ESG practices. The analysis helps to discern how certain themes emerge, evolve, or recede in response to regulatory changes, industry challenges, and market demands.

The topics have been translated into English using Google Translation Package for clarity, and only the top three topics for each year from 2015 to 2022 are discussed below to highlight major trends and shifts:

Year	Topic 1	Topic 2	Topic 3
2015	Pollution, Ministry of Environmental Protection	Society, Investors, Legal Compliance	Customers, Suppliers, Operations
2016	Poverty Alleviation, Employee Welfare	Environmental Protection, Energy Conservation, Green Policies	Customer Relations, Supplier Compliance
2017	Employment, Customer Relations, Supplier Management	Wastewater Management, Pollution Control	Emission Standards, Environmental Protection Ministry
2018	Social Responsibility, Environmental Impact	Poverty Alleviation, Environmental Protection	Emission Controls, Regulatory Compliance
2019	Waste Gas Management, Emission Control	Environmental, Safety Training	Employee Rights, Workforce Development
2020	Safety, Poverty Alleviation	Environmental Monitoring, EU Standards Compliance	Employee Welfare, Social Responsibility
2021	Employee Focus, Administrative Penalties	Environmental Safety, Regulatory Systems	Pollution Control, Environmental Monitoring
2022	Social Welfare, Environmental Governance	Investor Relations, Corporate Governance	Energy Conservation, Resource Management

Table 1: Evolution of Top Three Topics in ESG Disclosures from 2015 to 2022

Analysis of the table shows a clear transition from initial general environmental and social concerns towards a sharper focus on compliance and detailed management practices over the years. Early topics predominantly revolve around broader themes such as “Pollution” and “Society”, reflecting a foundational stage of ESG reporting. As years progress, the focus shifts to more actionable and specific aspects such as “Waste Gas Management”, “Emission Control”, and sophisticated “Regulatory Compliance”. By 2020 and onwards, the emphasis on “Employee Welfare”, “Environmental Monitoring”, and “Investor Relations” indicates a matured approach to ESG, where companies not only address external regulations but also enhance internal governance and stakeholder engagement. This evolution mirrors the regulatory pressures and market conditions influencing corporate behavior in China’s semiconductor industry, suggesting an increasing alignment with global ESG standards.

3.1.4 Evolutions of Selected Keywords Frequencies

This study examines the frequency of selected keywords within ESG disclosures across an eight-year span to understand the emphasis on various ESG components over time. Due to the size limit, the results of the keywords frequency analysis are included in the appendix. The keywords selected for analysis represent diverse dimensions of ESG disclosures: “environment”, “society”, “green”, “laws and regulations”, “employees”, “safety”, “shareholders”, “emissions”, “public welfare”, “poverty alleviation”, “rural”, “ISO”, “dB”, “mg”, and “ten thousand yuan”. The first eleven keywords address various ESG dimensions, while “ISO” signifies compliance with standards, and the last three indicate the presence of quantitative data in disclosures.

Analysis of keyword frequencies from 2015 to 2022 reveals a significant increase in mentions across all terms, suggesting a growing complexity and breadth in ESG reporting within the industry. Notably, the keywords “environment” and “society” show a pronounced increase, reflecting heightened regulatory focus and societal expectations around corporate environmental and social responsibilities. The keyword “ISO” also shows substantial growth, indicating an increased adherence to recognized standards, which aligns with global trends towards standardization in sustainability reporting.

Quantitative terms like “dB,” “mg,” and “ten thousand yuan” provide insights into the extent of detailed numerical reporting, which enhances the transparency and specificity of disclosures. The noticeable increase in these terms from 2015 to 2022 suggests that firms are not only reporting more about their impacts and practices but are also providing more detailed and measurable data, enhancing the utility of these reports for stakeholders.

3.1.5 Evolutions of Topics Coherence Score

In the application of topic modeling through Latent Dirichlet Allocation (LDA), it is essential to pre-specify the number of topics the model is expected to identify within the documents. This pre-

requisite limits our ability to directly measure the evolution of topic dimensionality as an indicator of the depth or breadth of ESG discussions over time. Consequently, we utilize the coherence score to gauge the quality and clarity of the topics formed each year. The coherence score, a measure of how well topics are understood based on the consistency of the semantic similarity among high scoring words within the topic, serves as an indicator of the quality of the ESG discourse.

The coherence score for a set of topics is calculated using the Gensim package's coherence model in Python. This model employs the `get_coherence()` method, which aggregates the pairwise word similarity scores across the top words in each topic, enhancing the interpretability of the topics. The coherence score is defined mathematically as follows:

$$C_v = \sum_{m < n} \text{score}(w_m, w_n)$$

where w_m and w_n are words in the topics being scored, and `score` is a measure of the degree of semantic similarity between pairs of words, calculated using specific coherence measures available in Gensim, such as `'c_v'`, `'u_mass'`, `'c_uci'`, and `'c_npmi'`. Higher coherence scores indicate topics with better semantic structure and relevance, which are more interpretable and meaningful.

Using the coherence score, we assess the quality of topics extracted each year to understand the evolution of ESG discourse within the Chinese semiconductor industry. The coherence scores serve as a quantitative metric to evaluate the clarity and structure of the thematic content derived from ESG reports, indicating the effectiveness of topic modeling in capturing relevant ESG trends over time.

Analysis of these scores reveals an overall increasing trend in coherence, with a notable improvement in the years 2021 and 2022. This improvement suggests that the topics derived from the ESG disclosures are becoming more structured and thematically consistent, which may reflect an enhancement in the strategic focus and clarity of ESG reporting practices over the years. The

Year	Coherence Score
2015	0.3704
2016	0.4437
2017	0.4562
2018	0.4296
2019	0.4299
2020	0.4031
2021	0.5048
2022	0.4904

Table 2: Coherence Scores from 2015 to 2022

peak in 2021 can particularly be attributed to possibly more rigorous ESG reporting standards or enhanced corporate awareness towards more coherent disclosure practices. However, the slight decline in 2022, while still high compared to earlier years, might suggest a variation in the topics covered or changes in the reporting environment that could have affected the semantic consistency of the topics.

3.2 Event Study

3.2.1 Theoretical Framework

The Event Study methodology is a statistical tool used to assess the impact of a specific event on the value of a firm. This technique is particularly useful in finance and economics to study the effect of unexpected or significant occurrences on firm performance, as measured by stock prices, financial performance, or other relevant metrics. In the context of this research, the event study will analyze the impact of the 2021 environmental policy on the ESG disclosure performance of firms in the Chinese semiconductor industry.

The theoretical foundation of an event study involves estimating the normal performance of firms (e.g., ESG disclosure levels) and comparing it to the actual performance observed after the introduction of a significant event (i.e., the implementation of a new policy). The difference, typically termed as the abnormal return or effect, is then analyzed for statistical significance to infer the impact of the event.

3.2.2 Dataframe Construction

To assess the direct effect of the 2021 policy on disclosure performance, we construct a dataframe that categorizes the available data into two distinct groups: pre-event (2015 to 2020) and post-event (2021 to 2022). The event window approach allows us to isolate the influence of the policy by comparing the predicted and observed ESG disclosure performances before and after the policy implementation.

The dataframe will be structured with the following columns, incorporating both raw data and computed metrics:

- Year
- Avg_Chars_Before
- Avg_Chars_After
- Coherence_Score
- Keyword frequencies for each of the 15 selected keywords

Given the limited number of observations (eight years) and the high dimensionality from multiple metrics, dimensionality reduction is critical. To achieve this, we compute an overall ESG Disclosure Score, which serves as the dependent variable in our regression model. The independent variables are the years, treated as categorical to capture temporal effects.

The ESG Disclosure Score is calculated using the following formula:

$$\begin{aligned} \text{ESG Disclosure Score} &= 0.3 \times (\text{Avg_Chars_After}) \\ &+ 0.1 \times (\text{Avg_Chars_Before}) \\ &+ 0.3 \times (\text{Coherence Score}) \\ &+ 0.3 \times (\text{Sum of Keyword Frequencies}) \end{aligned}$$

The weights assigned in this formula are based on the presumed importance of each component in representing the quality and comprehensiveness of ESG disclosures, with equal weighting distributed among the keyword frequencies to emphasize their collective relevance.

To mitigate potential issues of overfitting, given the high dimensionality and limited data points, ridge regression is selected. Ridge regression is favored for its ability to handle multicollinearity and overfitting by introducing a penalty term that shrinks the coefficients of less important predictors. This approach ensures a more robust and generalizable model, crucial for reliable inference in policy impact analysis.

3.2.3 Statistical Testing

The event study's effectiveness in measuring the impact of the 2021 policy on ESG disclosure scores is quantitatively assessed through statistical tests, including Mean Squared Error (MSE) analysis and the calculation of Cumulative Abnormal Returns (CAR).

The Mean Squared Error for the training data spanning 2015 to 2020 was calculated at 1065.89, reflecting the model's accuracy in capturing the underlying pattern within the pre-policy implementation period. The MSE for the predictions, encompassing the entire period from 2015 to 2022, significantly increased to 128935.31. This dramatic increase is attributed to the model's extrapolation beyond the training period, particularly for the years 2021 and 2022, indicating substantial deviations between predicted and actual scores post-policy implementation.

Predicted ESG Disclosure Scores for the years 2021 and 2022 were 565.61 and 644.39, respectively, whereas the actual scores observed were considerably higher at 898.26 and 1028.07. This discrepancy highlights the pronounced effect of the policy on enhancing ESG disclosures beyond the expected trends.

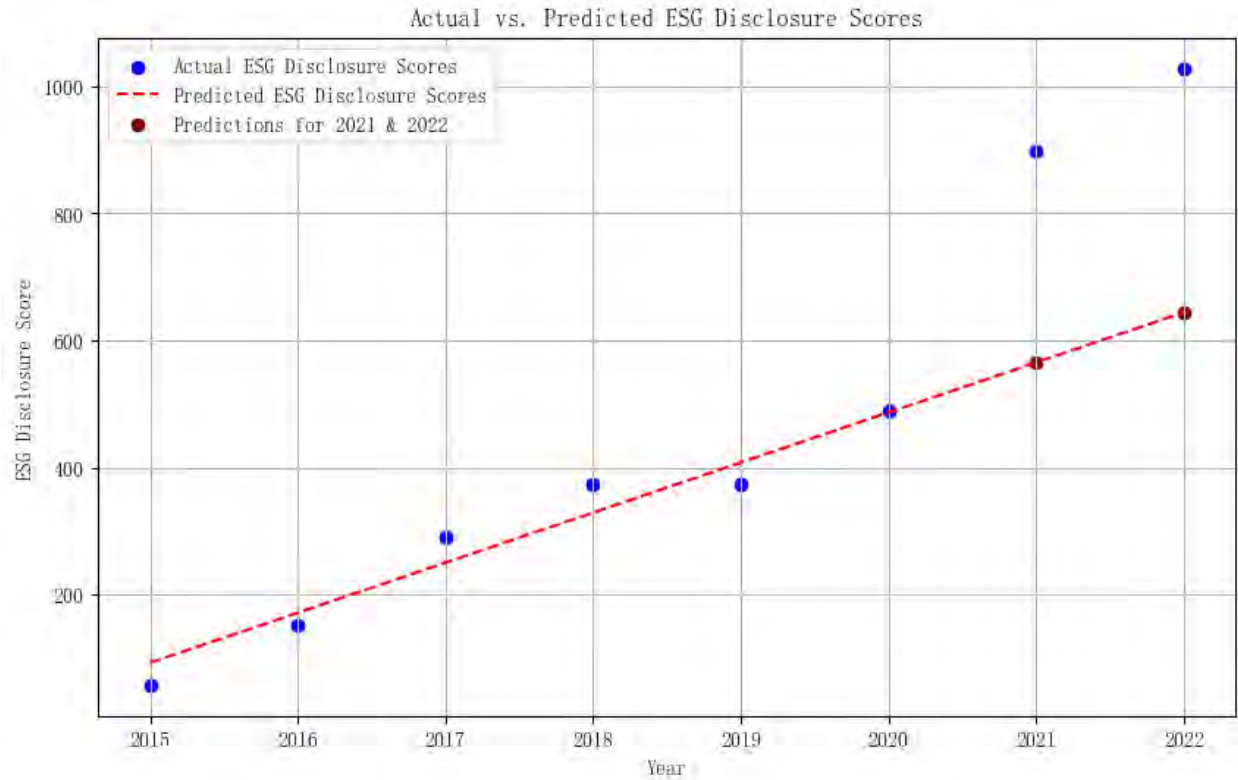


Figure 2: Actual vs. Predicted ESG Disclosure Scores

The Cumulative Abnormal Returns (CAR) calculated for this period amounted to 716.34, with a T-statistic of 14.04, suggesting a strong statistical significance. The corresponding P-value of 0.045 indicates that the null hypothesis, stating no effect of the policy, can be rejected at conventional significance levels.

These results underscore the policy’s significant impact on ESG disclosure scores. Notably, the high test MSE underscores the unpredicted substantial rise in ESG disclosures, reflecting the policy’s effectiveness in elevating corporate transparency and accountability in environmental and social issues. The statistical analysis confirms that the policy implementation led to a meaningful improvement in ESG practices among firms in the Chinese semiconductor industry.

In conclusion, the statistical testing confirms that the 2021 policy has had a significant and positive impact on ESG disclosure scores within the sector, corroborating the theoretical expectations

and reinforcing the importance of regulatory frameworks in shaping corporate behavior in sustainability practices.

3.3 Difference in Differences Analysis

3.3.1 Theoretical Framework

The Difference in Differences (DiD) approach is a quantitative method used to measure the effect of a treatment or intervention by comparing the changes in outcomes over time between a population that is exposed to the intervention and a population that is not. This method helps in isolating the “treatment effect” from other external factors that could influence the outcome. In the context of ESG disclosure, DiD analysis will be employed to compare changes in disclosure practices before and after a specific policy intervention, controlling for natural trends in disclosure behavior over time.

The formula for the Difference in Differences (DiD) estimation can be expressed as follows, ensuring clarity and conciseness in its presentation:

$$\Delta Y = (\bar{Y}_{\text{post, treat}} - \bar{Y}_{\text{pre, treat}}) - (\bar{Y}_{\text{post, ctrl}} - \bar{Y}_{\text{pre, ctrl}})$$

Here, $\bar{Y}_{\text{post, treat}}$ and $\bar{Y}_{\text{pre, treat}}$ represent the average outcomes in the treatment group after and before the policy intervention, respectively. Similarly, $\bar{Y}_{\text{post, ctrl}}$ and $\bar{Y}_{\text{pre, ctrl}}$ denote the averages in the control group for the same periods. This formulation succinctly captures the essence of the DiD methodology, highlighting the net effect of the intervention by comparing changes in outcomes between the treatment and control groups over time.

3.3.2 Data Overview

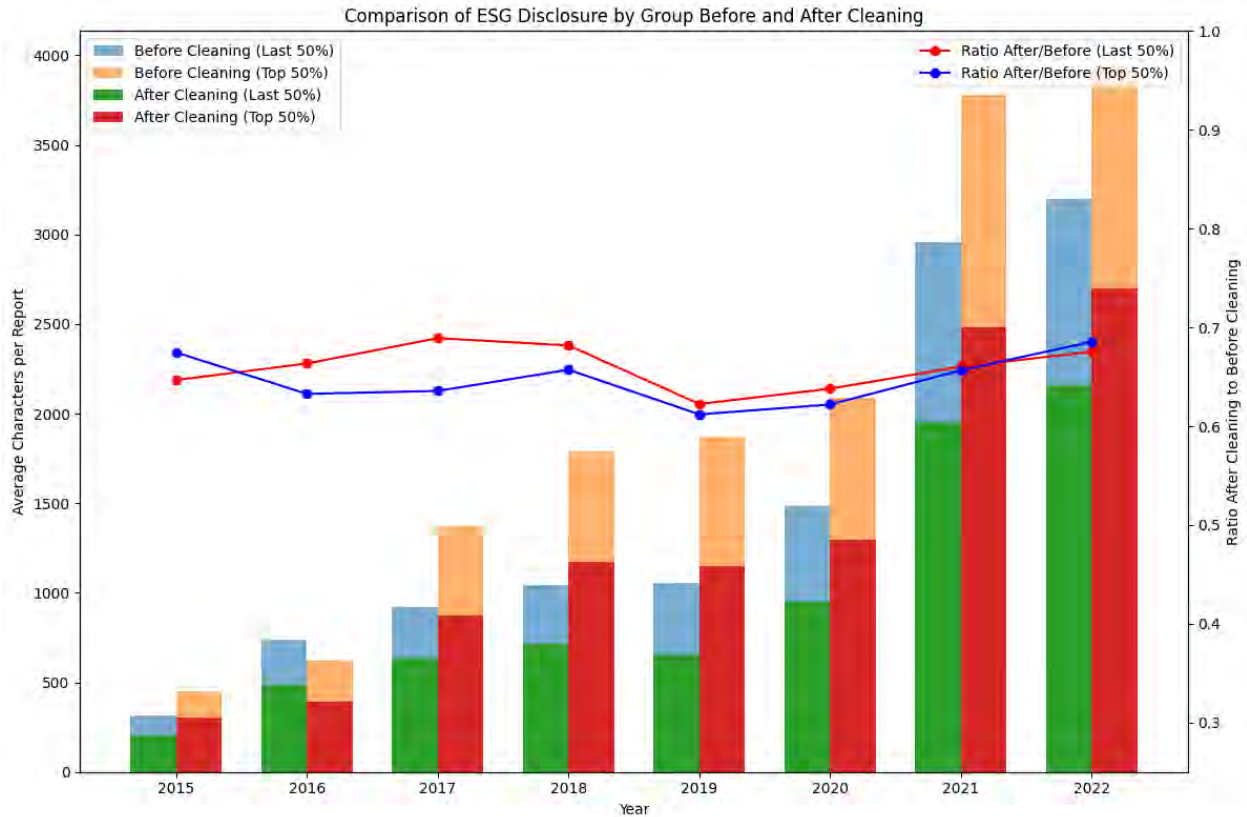


Figure 3: Comparison of ESG Disclosure by Group Before and After Cleaning

The analysis of average character counts before and after cleaning provides a quantifiable measure of how extensively firms disclose ESG-related information, and how much of this content remains substantive after removing less meaningful text (like stopwords). By comparing these metrics across firms categorized into “Top 50%” and “Last 50%” based on financial performance, we gain insights into the relationship between financial performance and the depth and focus of ESG disclosures.

In the “Top 50%” group, the average character count before cleaning in 2015 was 448.64, which was reduced to 302.64 after cleaning, yielding a cleaning reduction ratio of approximately 32.5%. This trend of reduction is consistent but shows an increase in both pre-cleaning and post-cleaning character counts over the years. By 2022, the average characters before cleaning rose to 3938.21, with 2700.06 characters remaining post-cleaning, corresponding to a cleaning reduction ratio of

about 31.5%. This slight decrease in the ratio suggests that as firms improve financially, the proportion of substantive content in their disclosures may increase slightly, indicating a potential enhancement in disclosure quality or a greater focus on providing relevant ESG information.

Conversely, the “Last 50%” group started with an average of 316.86 characters in 2015 before cleaning, reduced to 204.93 after cleaning, which gives a higher reduction ratio of about 35.3%. Over the years, this group also saw an increase in the volume of text both before and after cleaning. By 2022, the figures were 3200.16 characters before and 2161.18 after cleaning, with the ratio slightly improving to about 32.5%. This consistent ratio across the years suggests that lower financial performing firms maintain a relatively stable proportion of relevant content in their disclosures, despite the overall increase in the amount of text.

3.3.3 Evolutions of Selected Keywords Frequencies

The analysis of keyword frequencies over time offers insights into the specific areas of ESG that firms prioritize in their disclosures. By examining the evolution of keyword frequencies in the “Top 50%” and “Last 50%” groups, we observe how financial performance might influence the emphasis on different ESG dimensions. The figures for the evolutions of these keywords are included in the appendices as well.

In the “Top 50%” group, keywords such as “environment” and “safety” show a pronounced increase in frequency from 2015 to 2022, which suggests a growing focus on these areas. The frequency of “environment” increased from 10 mentions in 2015 to 766 in 2022, and “safety” from 20 to 218 over the same period. This substantial rise indicates that higher-performing firms are progressively emphasizing their environmental responsibilities and safety measures in their ESG disclosures.

Conversely, in the “Last 50%” group, while there is also an overall increase in keyword mentions, the magnitude is less pronounced. For instance, the keyword “environment” increased from

5 mentions in 2015 to 653 in 2022, and “safety” from 14 to 239. Although these increases are significant, they are not as steep as in the top-performing group, suggesting that while ESG concerns are increasing across the board, top financial performers might be more proactive or have more resources to report on these issues comprehensively.

3.3.4 Evolutions of Topics Coherence Score

Year	Last 50% Coherence Score	Top 50% Coherence Score
2015	0.4152	0.4863
2016	0.6247	0.5346
2017	0.6114	0.6284
2018	0.5937	0.6341
2019	0.6520	0.7337
2020	0.7340	0.7666
2021	0.7543	0.7768
2022	0.7660	0.7557

Table 3: Average Coherence Scores for the Last 50% and Top 50% Groups

From 2015 to 2022, the coherence scores in the “Top 50%” group have shown a consistent improvement, moving from 0.487 in 2015 to 0.759 in 2022. This trend indicates that top-performing firms are not only increasing the quantity of their ESG disclosures but are also enhancing the quality and comprehensibility of the information provided. This improvement could be attributed to better internal controls, more sophisticated reporting practices, or increased investment in ESG governance.

In the “Last 50%” group, the coherence scores also improve but with a slightly less steep trajectory, starting at 0.404 in 2015 and reaching 0.770 in 2022. The scores in 2022 are comparable between the two groups, suggesting a convergence in the quality of disclosures as all firms possibly respond to similar regulatory pressures or market expectations.

3.3.5 Dataframe Construction

In constructing the dataframe for the DiD analysis, the dataset is organized to reflect differences in ESG disclosure behaviors across two financial performance groups: “Top 50%” and “Last 50%”. This classification helps to investigate how financial performance influences the depth and scope of ESG disclosures. The data points span from 2015 to 2022, providing a temporal dimension that captures trends over time, crucial for the DiD analysis.

The dataframe includes various metrics that reflect both the quantity and quality of ESG disclosures:

- **Year:** The year the data was recorded, crucial for temporal analysis.
- **Avg_Chars_Before:** The average number of characters in the reports before cleaning, indicating the initial volume of disclosure.
- **Avg_Chars_After:** The average number of characters remaining after cleaning processes like stopwords removal, providing insights into the substantive content of the disclosures.
- **Coherence_Score:** A metric indicating the logical consistency and clarity of the report’s text, serving as a quality indicator of the disclosures.
- **Keyword Frequencies:** This includes counts for each of the 15 selected keywords which are pivotal in understanding the specific ESG aspects emphasized by the firms. These keywords are integral to assessing the focus areas within the ESG disclosures across different financial performance groups.

Additionally, each record in the dataframe is tagged with a categorical variable, “Group”, which identifies whether the data belongs to the “Top 50%” or “Last 50%” based on the firm’s financial performance. This variable is critical for segmenting the data in the DiD analysis, allowing us to isolate the effects of financial performance on ESG disclosure practices.

3.3.6 Statistical Testing

Statistical testing was conducted to identify significant features in the ESG disclosure data across different years, specifically looking at the annual changes in keyword frequencies. The aim was to determine which aspects of ESG disclosures were most affected by changes in the corporate or regulatory environment within each specific time period.

The analysis spanned from 2015 to 2022, focusing on the evolution of keyword frequencies that demonstrate significant changes with a p-value of less than 0.05. These results are pivotal in understanding which ESG dimensions are gaining importance or receiving more focus in corporate disclosures over time.

- From 2015 to 2020, no significant features were found in the ESG disclosures across the sectors analyzed.
- For the period from 2020 to 2021, significant changes were noted in the following keywords:
 - **Green Frequency** - indicating an increased emphasis on environmental initiatives or green policies.
 - **Emissions Frequency** - reflecting heightened attention to emission-related disclosures, likely driven by increased environmental regulation.
 - **Poverty Alleviation Frequency** - showing an enhanced focus on social responsibility initiatives, particularly in poverty reduction.
 - **Rural Frequency** - suggesting increased disclosures related to rural development or engagement, which could be tied to corporate social responsibility strategies targeting rural communities.
- From 2021 to 2022, the significant feature found was:
 - **Poverty Alleviation Frequency** - continued to be a significant aspect of disclosures, implying ongoing or intensified efforts in social responsibility practice.

4 Results

4.1 Event Study

The Event Study analysis was conducted to evaluate the impact of the 2021 policy on ESG disclosure practices within the Chinese semiconductor industry. The results are summarized in the table below, which presents the R-squared, the Adjusted R-squared of the training model, both the predictive and actual ESG disclosure scores, the Mean Squared Error (MSE) of the predictions, and the results of the Cumulative Abnormal Returns (CAR).

Metric	Value
R-squared	0.9498202630063841
Adjusted R-squared	0.9372753287579801
Coefficients	[78.77777763]
Intercept	-158644.2735602056
Mean Squared Error (Training, 2015-2020)	1065.89
Mean Squared Error (Prediction, 2015-2022)	128935.31
Predicted ESG Disclosure Scores (2021-2022)	[565.61, 644.39]
Actual ESG Disclosure Scores (2021-2022)	[898.26, 1028.07]
Cumulative Abnormal Returns (CAR)	716.34
T-statistic	14.04
P-value	0.04527

Table 4: Summary of Event Study Results

The CAR is statistically significant, with a T-statistic of 14.04 and a P-value of 0.04527, suggesting that the policy implementation had a significant impact on ESG disclosure scores. This significant result confirms Hypothesis 1, which proposed that the 2021 policy would act as a strong incentive for firms to enhance their ESG disclosure practices.

Analysis of the Mean Squared Error (MSE) for predictions demonstrates a substantial increase compared to the training phase, indicating that the actual ESG disclosure scores in 2021 and 2022 were significantly higher than expected based on historical trends. This divergence highlights the effectiveness of the policy in motivating companies to go beyond previous disclosure practices.

The predicted vs. actual disclosure scores further illustrate the impact of the policy. The scores for 2021 and 2022 exceeded predictions by a considerable margin, underscoring the robust response of firms to the regulatory changes. This outcome not only validates the effectiveness of the policy but also reflects an overall shift towards more comprehensive and transparent ESG reporting in the sector.

In conclusion, the results from the Event Study provide strong empirical support for the assertion that the 2021 policy significantly influenced ESG disclosure practices in the Chinese semiconductor industry, leading to a marked improvement in both the quality and quantity of disclosures.

4.2 Difference in Difference Analysis

The Difference in Difference (DiD) analysis was utilized to assess the impact of internal corporate operations and external policy changes on ESG disclosure practices over several periods. This method helps in isolating effects that are directly attributable to changes in operational strategies and regulatory frameworks.

Period	Significant Features ($p < 0.05$)]
2015 to 2016	No significant features found
2016 to 2017	No significant features found
2017 to 2018	No significant features found
2018 to 2019	No significant features found
2019 to 2020	No significant features found
2020 to 2021	Green Frequency, Emissions Frequency, Poverty Alleviation Frequency, Rural Frequency
2021 to 2022	Poverty Alleviation Frequency

Table 5: Summary of Significant Features in DiD Analysis

The results from the DiD analysis, as shown in Table 5, indicate no statistically significant features in ESG disclosure behaviors from 2015 to 2020 across different financial performance groups. This finding suggests that during this period, there was a uniform approach to ESG disclosures, possibly influenced by a stable regulatory environment that did not differentiate significantly between different operational performances.

However, the period from 2020 to 2021 shows significant features, including increases in the frequency of mentions related to green initiatives, emissions, poverty alleviation, and rural engagement. This shift coincides with the implementation of the 2021 policy, potentially indicating that the new regulatory environment not only pushed firms towards better ESG disclosure but also highlighted differences in how firms with varying operational metrics responded to these changes. Notably, the continued significance of poverty alleviation in the 2021 to 2022 period suggests that firms increasingly focused on this aspect, potentially due to its growing importance in corporate social responsibility strategies and change in the disclosure structure.

These findings partially reject Hypothesis 2 for the earlier periods, suggesting that up to 2020, the heterogeneity in ESG disclosure behavior based on corporate operations was not statistically significant. However, the post-2021 data suggests a clear differentiation, indicating that the 2021 policy effectively influenced how firms disclose ESG information, with operational metrics playing a more significant role in shaping these disclosures.

In conclusion, the DiD analysis provides insights into the evolving dynamics of ESG disclosure influenced by both internal corporate operations and external policy shifts. The results underline the importance of considering both elements in understanding the drivers behind effective ESG disclosures.

5 Conclusions & Implications

The comprehensive analysis conducted through event studies and Difference in Difference (DiD) methodologies has provided insightful findings into the impacts of policy changes and internal corporate operations on Environmental, Social, and Governance (ESG) disclosures within the Chinese semiconductor industry. This research has identified key trends, behaviors, and significant changes over the periods studied, leading to several important conclusions and implications for policymakers, corporate leaders, and stakeholders.

5.1 Major Findings

1. **Impact of Policy Implementation:** The implementation of the 2021 environmental policy has had a profound impact on ESG disclosure practices. Event study results showed a statistically significant increase in ESG disclosure scores post-policy implementation, confirming the effectiveness of regulatory changes in enhancing corporate transparency and accountability in environmental and social issues.

2. **Corporate Operations and ESG Disclosure:** The DiD analysis highlighted that until 2020, there was no significant heterogeneity in ESG disclosure practices based on the financial performance of firms. However, post-2021, significant features such as Green Frequency, Emissions Frequency, and Poverty Alleviation Frequency were identified, indicating that corporate operations began to play a more distinct role in shaping ESG disclosures, influenced heavily by the new policy framework.

3. **Temporal Stability and Shifts:** Prior to 2021, the analysis shows a period of stability in ESG disclosures with no significant changes across years. This changed dramatically with the introduction of the 2021 policy, suggesting that external policy forces are potent drivers of change in corporate ESG practices.

5.2 Implications

For Policymakers: The findings suggest that well-designed policies can effectively influence corporate behavior towards more sustainable practices. Policymakers should consider crafting targeted regulations that address specific areas of ESG to stimulate desired outcomes.

For Corporations: Companies should be proactive in integrating ESG considerations into their core strategies, anticipating regulatory changes and aligning their operations with global sustainability trends. The results indicate that firms with higher financial performance are better able to enhance and articulate their ESG practices, suggesting the importance of integrating ESG goals with overall business health.

For Stakeholders: Investors and other stakeholders should closely monitor the impacts of policy changes on corporate ESG practices, using these insights to make informed decisions. The significance of internal operations on ESG disclosures post-2021 highlights the need for stakeholders to assess not just the content but also the context of disclosures.

5.3 Limitations

This study, while providing significant insights, is subject to certain limitations that must be acknowledged:

1. **Limited Data Points:** The construction of the dataframe involved only 8 observations, which restricts the statistical robustness of the findings. Such a limited dataset may not capture the full variability and complexities of ESG disclosure practices across different time periods or regulatory environments. This small sample size limits the generalizability of the results and may increase the susceptibility to outliers influencing the overall analysis.
2. **Textual Analysis Techniques:** The study primarily relied on basic textual analysis metrics such as word counts, coherence scores, and keyword frequencies. While these methods

provide valuable initial insights, they fall short of capturing deeper semantic and contextual meanings that more advanced techniques, such as those offered by Large Language Models (LLMs), could achieve. LLMs could analyze the textual data more comprehensively, potentially uncovering more nuanced insights into the tone, sentiment, and deeper thematic elements of ESG disclosures.

5.4 Future Studies

The limitations identified in this study pave the way for several future research directions:

- **Expanding the Dataset:** Future studies should aim to include a larger dataset, potentially over more extended periods and across various industries, to enhance the robustness and generalizability of the findings. This would allow for a more detailed analysis of trends and provide a more nuanced understanding of the impacts of regulatory changes and corporate behavior on ESG disclosures.
- **Utilizing Advanced Analytical Techniques:** Implementing more sophisticated analytical tools, such as Large Language Models, could provide deeper insights into the qualitative aspects of ESG disclosures. Such models can process and analyze large volumes of text to detect underlying patterns and sentiments that simpler analytical methods may overlook.
- **Investigating Cyclic Effects:** Referring back to the observed trends in the data, the significant increases in certain ESG dimensions in 2017 and 2018, followed by declines in 2019 and 2020, and a subsequent surge post-2021 policy, suggest a potentially cyclic nature of ESG disclosure practices. Future research could explore these cyclic effects in depth, examining how economic incentives, market conditions, and regulatory pressures influence these cycles. This approach would help in understanding the temporal dynamics of ESG disclosures and in predicting future trends based on past patterns.

These future directions not only aim to address the current study's limitations but also seek to broaden the scope of research into ESG disclosures, providing valuable insights for academics, corporate leaders, and policymakers.

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Appendix

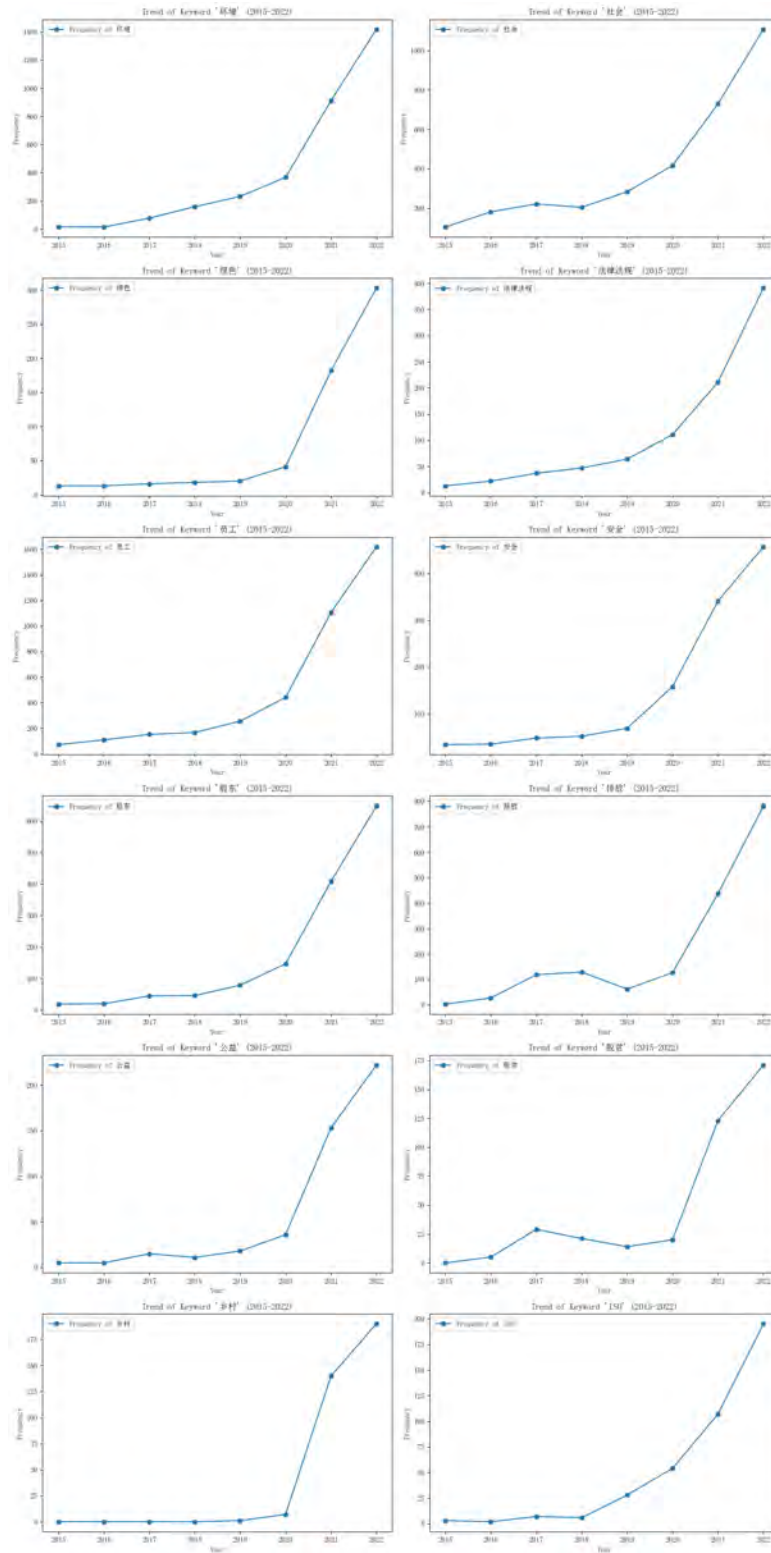


Figure 4: Overall Keywords Frequencies 1

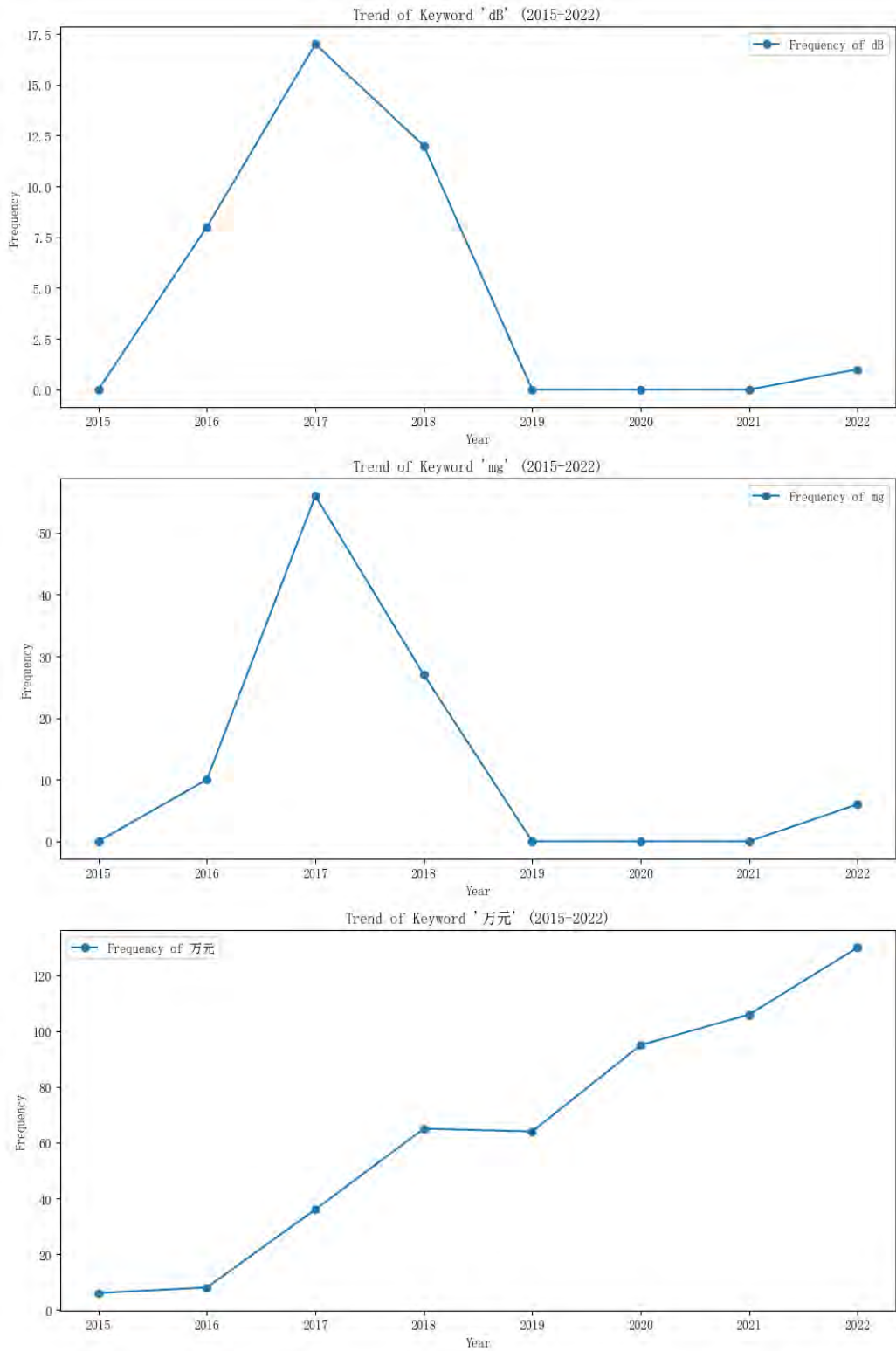


Figure 5: Overall Keywords Frequencies 22

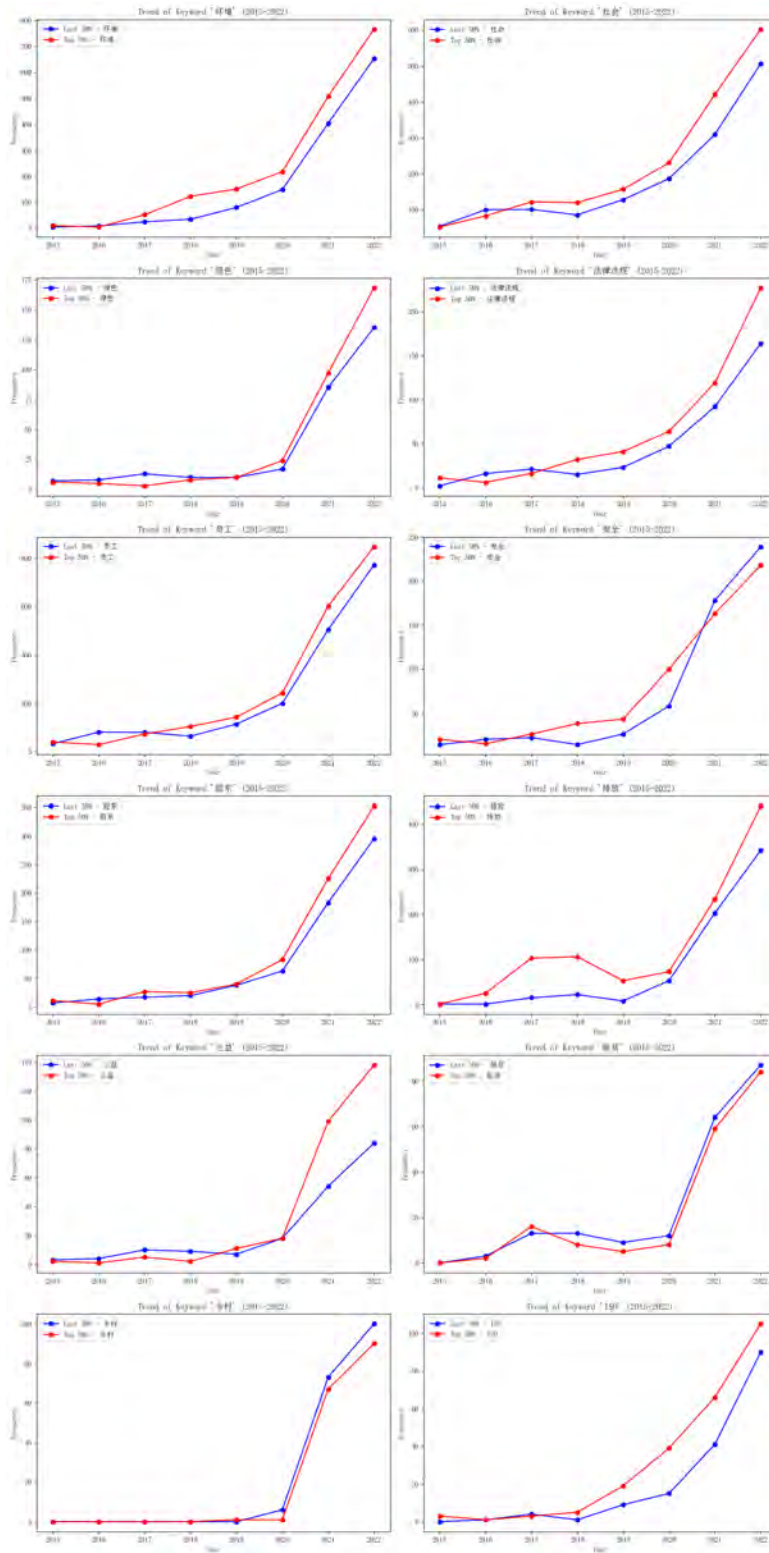


Figure 6: Keywords Frequencies by Groups 1

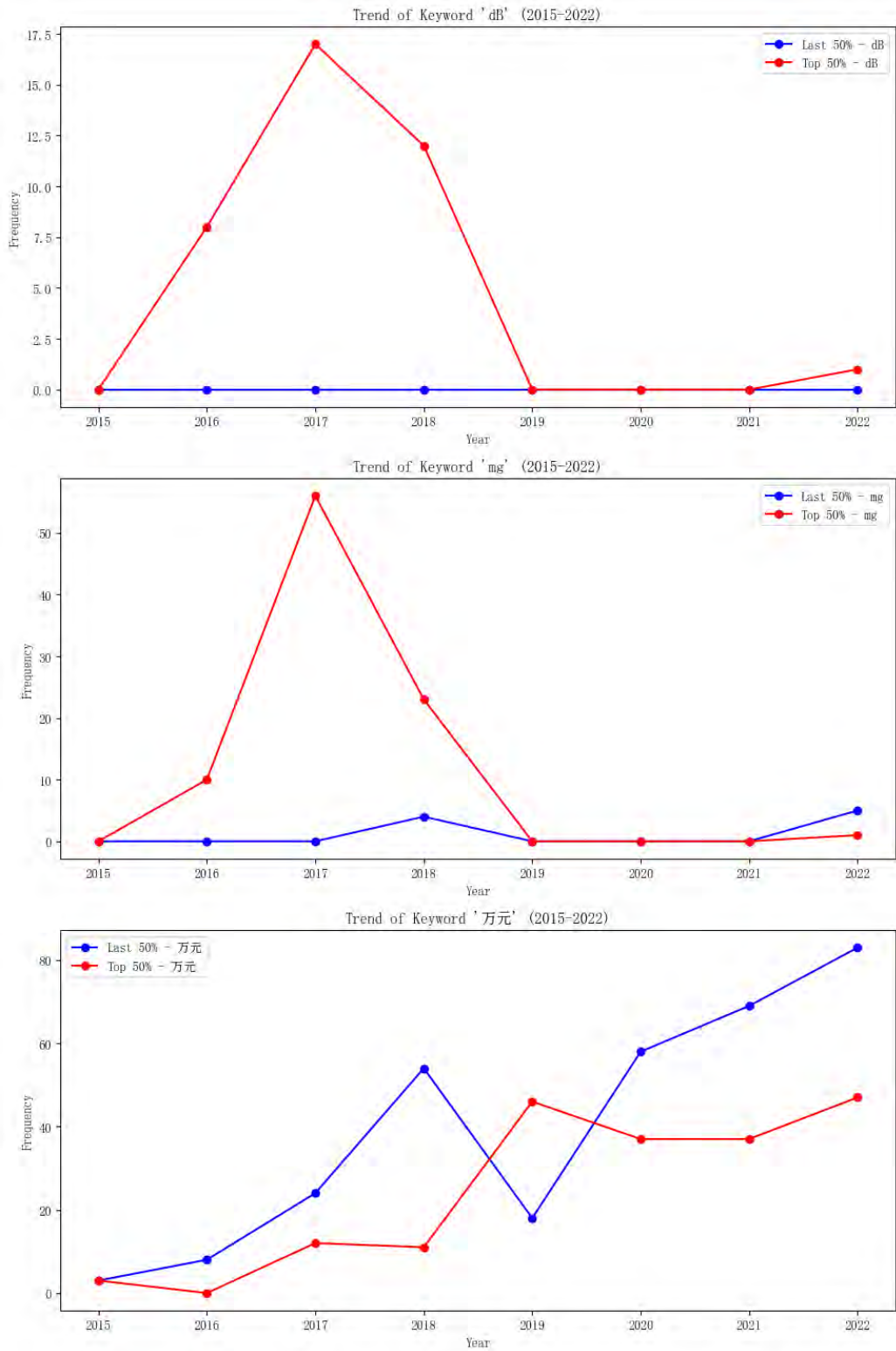


Figure 7: Keywords Frequencies by Groups 2