Universiteit Leiden
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Bachelor Data Science & Artificial Intelligence

Reading Between the Lines:

The communication of corporate sustainability in

CEO statements across regions from 2013 to 2022

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Abstract

Existing research on corporate sustainability communication has primarily examined sustainability and CSR reports. However, these reports focus specifically on sustainability and therefore provide limited insight into how sustainability is positioned as part of corporate priorities. In addition, we know less about how sustainability communication changes over time and across regions. This thesis therefore, examines sustainability communication in CEO annual statements to shareholders using computational text analysis methods, including word frequency, word co-occurrence, and topic modelling. The study analyses 1,000 CEO statements from 100 large companies across Asia, Europe, and North America between 2013 and 2022. The findings show that sustainability is not a central focus in CEO statements, with business priorities such as growth, markets, strategy, and financial performance dominating CEO communication. Although sustainability-related language appears less frequently, terms such as *energy* are consistently present and become more prominent over time. Importantly, sustainability communication shifts from broader terms such as *environment* and *sustainability* towards more specific and technical language, including *decarbonisation, emissions,* and *circularity*. Regional differences are also evident. European and Asian companies communicate sustainability more frequently and across a broader range of themes, including energy transition, sustainable finance, and environmental responsibility, whereas North American firms discuss sustainability less often and mainly in relation to operations and energy-related activities. Overall, the study demonstrates that CEO statements provide a complementary perspective to CSR reports by showing how sustainability is framed alongside broader business priorities and how this communication has evolved across regions and over time. Methodologically, the study shows how combining word frequency, word co-occurrence, and topic modelling can provide a more holistic understanding of corporate sustainability communication than relying on a single text analysis approach.

Keywords Corporate sustainability, sustainability communication, CEO statements, annual reports, text analysis, topic modelling, cross-regional analysis, longitudinal analysis.

Contents

1 Introduction

Achieving sustainable development is one of the greatest challenges facing society today. Companies play an important role in addressing sustainability challenges because of their significant environmental and social impacts. For example, it was estimated that in 2010 the greenhouse gas emissions of the world's 500 largest publicly listed companies accounted for approximately 11% of total human-related emissions ([DGG+16]). At the same time, firms often possess the financial, technological, and organisational resources needed to address sustainability challenges. Driven by growing societal, regulatory, and stakeholder expectations, companies have increasingly engaged in sustainability efforts, often through corporate social responsibility (CSR) activities ([Eur21]). Since sustainability activities can strengthen corporate reputation and competitive advantage, firms also increasingly communicate these efforts to stakeholders ([DBS10]). As a result, research on corporate sustainability communication has expanded considerably ([CHZ16]).

Research on corporate sustainability communication has identified recurring themes such as health and safety, human rights, greenhouse gas reduction, and energy conservation ([LAS14]). Studies have also shown that sustainability communication changes in response to major external events and shifting environmental and governance priorities ([BCT+23]; [KK22]; [Pol18]). However, this research relies largely on sustainability and CSR reports ([WYWL20]). While such reports provide valuable insight into corporate sustainability activities, they are designed specifically to communicate sustainability performance and therefore reveal little about how sustainability is positioned alongside other organisational priorities. Moreover, sustainability reports often emphasise positive achievements and may selectively communicate progress, raising concerns around greenwashing ([CCGM17]; [KK22]). For example, a KPMG ([KPM20]) study found that sustainability reports are often less transparent about the negative impacts of corporate activities on the UN Sustainable Development Goals (SDGs). Focusing only on sustainability reports may therefore provide a partial picture of how companies communicate sustainability.

One alternative source is the CEO statement in annual reports. CEOs play a key role in shaping and advancing an organisation's environmental sustainability efforts ([VNYR23]). The CEO's statement is also one of the most widely read sections of the annual report and, unlike sustainability reports that follow GRI guidelines ([FMF14]), it is not bound by a format and is not audited. This flexibility allows for a freer expression of executive-level perspectives and strategic priorities ([AC07]). Importantly, since CSR reports are only focused on sustainability, they offer limited insight into how sustainability is positioned within a firm's overall business priorities ([SRD17]). Accordingly, recent studies have begun to study CEO statements as a distinct form of sustainability communication ([Arv23]).

In addition, we know less about how sustainability communication differs across regions and over time. Existing longitudinal studies have focused mainly on sustainability reports and changes in reporting requirements (e.g., [LS21]), while comparative research has largely examined CSR reporting rather than CEO communication ([KK22]). Prior studies suggest that sustainability communication varies across countries and institutional contexts ([RL18]). For example, Chapple and Moon ([CM05]) found substantial variation in CSR communication across Asian firms, reflecting differences in national business systems and priorities, while Naudé ([NQRN12]) identified differences between ISO 14001 certified and non-certified firms. However, it remains unclear whether similar patterns are reflected in CEO sustainability communication.

To address these gaps, this thesis uses computational text analysis to examine 1,000 CEO statements from 100 large companies across Asia, Europe, and North America between 2013 and 2022. Using word frequency, word co-occurrence, and topic modelling, the study addresses the following research question: *How do CEOs communicate sustainability in their annual statements as part of overall business communication?* Two sub-questions guide the analysis: (1) *How does sustainability communication in CEO annual statements differ across Asia, Europe, and North America?* (2) *How has sustainability communication in CEO annual statements changed between 2013 and 2022?*

The findings suggest that sustainability is present in CEO communication but is generally embedded within broader business priorities rather than treated as a central focus. Variation across regions and over time also suggests differences in how CEOs communicate sustainability. By examining CEO statements, this study extends current understanding of how sustainability is positioned within broader business communication. In addition, the study demonstrates the value of combining multiple computational text analysis methods to examine sustainability communication.

The rest of the thesis is structured as follows: the next section reviews the relevant literature, followed by the methodology, findings, discussion, and conclusion.

2 Literature Review

The literature review begins with a background on corporate sustainability research and its communication, with an emphasis on how CEOs discuss sustainability in their annual statements, and changes in corporate sustainability communication over time and across regions.

2.1 Corporate sustainability

Under growing pressure from society and regulators, companies are motivated to act responsibly and protect the environment. The integration of economic, environmental, and social considerations into a firm's strategic and operational decision-making is referred to as corporate sustainability ([VG20]). According to this view, sustainability is therefore, an integral part of the organisation and involves balancing financial outcomes with environmental and social outcomes. On the other hand, a somewhat narrower view is reflected in the term Corporate Social Responsibility (CSR), which refers only to "the corporate activities and policies that assess, manage, and govern a firm's responsibilities towards society and the environment" ([CSS22]). However, in practice and in theory, corporate sustainability and CSR are often used interchangeably. Showing the importance of sustainability for organizations, studies have found for example, that CSR can improve a firm's financial performance and valuation ([KS12]); strengthen its reputation ([CCCN15]); and give it a competitive advantage, allowing it to differentiate its products. However, to leverage the benefits of their sustainability efforts, companies must effectively communicate these efforts to stakeholders. Moreover, increasing pressure from stakeholders and regulators is also ensuring that companies report more actively on their sustainability efforts. For instance, policies such as the EU's Non-Financial Reporting Directive (NFRD) and the Corporate Sustainability Reporting Directive (CSRD) are making it mandatory for large companies to publish sustainability reports ([Eur22]).

2.2 Corporate Sustainability Communication

Organisations use various methods and tools to communicate their sustainability performance including printed reports, websites and social media. In fact, a 2001 study by Hutton and colleagues found that CSR communication expenses was one of the largest budget expenses for corporate communication in large companies. While there are many benefits of CSR such as enhanced reputation, higher stock returns, and product differentiation ([KK22]), corporate sustainability communication can also have negative impacts when companies exaggerate or misrepresent their environmental efforts, a practice known as greenwashing ([Bra07]). To overcome these downsides, transparency is recognized as an important factor in effective and ethical sustainability communication ([FFRR14]). Therefore, principles outlined by organizations such as the GRI are aimed at enhancing the quality of sustainability reporting including transparency in CSR reports ([FFRR14]).

CSR reports are one of the most common sources of corporate sustainability communication. CSR reporting is defined as measuring and disclosing sustainability performance to stakeholders, to show a company's social, environmental, and economic impacts, both positive and negative ([Elk98]). Evidencing the growth in CSR reporting, KPMG's Survey of Sustainability Reporting

(2024) has shown that 96% of the largest companies in the world publish these reports. Since they are widely available and standardized, most academic research on sustainability communication has focused on analysing these documents. These studies have explored, for example, how sustainability reports vary across industries ([MIJ10]), how organizations understand and frame sustainability, and what are the main sustainability themes ([ABN18]). Although sustainability reports are an important source of information, focusing on them may limit insights into how sustainability is positioned within the company's overall strategic priorities ([SRD17]). While sustainability reports are the most common sources of understanding an organization's sustainability practices, calls have been made for other approaches that can provide additional perspectives ([DM21]). For instance, Demir and Min (2021) show that looking at other forms of sustainability communication such as integrated reports can give a more complete view of a company's sustainability practices.

An important but underexplored source of sustainability communication is the annual CEO statement to shareholders ([Arv23]). Statements from CEOs are part of the annual reports of organizations and provide an overview of the firm's performance and future plans which include sustainability related content ([BCFN14]). Understanding CEOs communication of sustainability is important for a few reasons. First, the CEO's statement is the most read and influential part of the annual report ([Cou04];[ML11]). Second, the statements communicate the views of top management who influence the strategy and decision making of companies ([ACTnd]). Finally, unlike CSR reports, the CEO statements are unstructured and unrestricted forms of communication and can show how sustainability appears in the overall goals of the company. This makes CEO statements particularly useful for understanding how sustainability is prioritised relative to other business objectives. Therefore, the presence/absence of sustainability themes in these statements can indicate an organisation's sustainability priorities. The few studies on sustainability based on CEO statements have found, for example, that leaders use sustainability language in their statements to increase legitimacy with shareholders ([BCFN14]) and to signal company's social responsibility and future orientation ([Arv23]). Similarly, [Alb21], found that CEOs of major European companies often talked about the importance of environmental issues for creating long-term value. While analysing CEO statements can give a more holistic view of sustainability communication, it is also important to understand how such develops over time and across regions.

2.3 Changes in Corporate Sustainability Communication

Sustainability communication has developed from early voluntary environmental reports to more organised forms of reporting shaped by standards such as GRIs which have helped make disclosures more consistent and comparable ([BdJL09]). The growth of digital media and social platforms has also changed how companies share sustainability information, giving organisations more ways to

reach and engage stakeholders ([And21]). International frameworks such as the Paris Agreement and the UN SDGs have further increased expectations for clearer and more transparent communication.

Understanding how sustainability communication changes is important because it shows us how company priorities evolve in response to internal and external pressures. Although most studies have analysed CSR reports and CEO statements for specific industries or countries in a single year (e.g., [Dil10]), a few have also looked at how sustainability communication changes over time. Over the years, corporate sustainability reporting has expanded rapidly, with fewer than twenty firms producing a corporate sustainability report in the early 1990s whereas by 2019 this number had grown to more than 10,000 companies ([GRS19]). In addition, the nature of these reports has also changed with [NP95] finding that Finnish companies substantially increased the level of detail in their environmental reports between 1987 and 1992. However, recent studies suggest a stabilizing of sustainability communication. For example, [KK22] found that although different companies focus on different sustainability themes, these themes change very little over time. [Pol18] similarly observed that while companies may shift attention to certain issues in response to major environmental events, they generally follow consistent environmental strategies. At the same time, looking specifically at CEO statements, [Arv23] found that CEOs now talk about sustainability in a more future-focused way. This change may indicate a gradual shift from a narrow focus on shareholder value towards a stronger emphasis on sustainability as part of the core business. In addition to changes over time, it is also important to examine how sustainability communication varies across regions.

Research on CSR reports across regions shows that national institutions, cultural norms, and regulatory environments strongly shape how companies report on sustainability. These studies have found that despite increasing global standardisation of CSR reporting, national differences remain in reporting styles ([CB09]; [YOJC21]). For instance, [Dil10] found that companies located in Europe were positively associated with greater CSR reporting. In addition, there are differences between developing and developed countries, with CSR reports from developing countries typically emphasizing social issues, employees, and consumers, while those from developed countries focus more on environmental performance ([BM20]).

While studies based on CSR reports offer important insights into how sustainability communication varies over time and across place, very little is known about whether CEO statements show similar patterns. How do CEOs across regions differ in their sustainability-related messages? Has this language changed over time? Addressing these gaps, my thesis analyses CEO statements from different regions over a ten-year period to examine corporate sustainability communication.

3 Methodology

3.1 Research Design

My study uses a computational text analysis design to examine how CEOs communicate corporate sustainability in their statements and how these patterns evolve across regions and over time. This design enables the exploration of large volumes of unstructured text, allowing researchers to detect patterns and recurring themes that would be difficult to identify manually ([FS06]; [GR18]). CEO statements represent unstructured textual data, which require text mining techniques for systematic analysis. Text mining refers to computational methods used to extract insights from textual data ([FS06]). Specifically, methods of word frequency analysis, word co-occurrence matrices, and topic modelling were used to understand sustainability communication. While frequency analysis identifies the main terms used and their evolution across place and time, co-occurrence analysis uncovers the relationships between words ([ZYZW23]), and topic modelling reveals themes in CEO statements ([BNJ03]). Although these approaches have been usually applied separately, recent work shows the benefits of combining them to achieve a better understanding of communication patterns ([RRT23]). All computational text analyses were done using Python scripts. Python was selected since it is widely used in natural language processing and text mining due to its flexible libraries for tokenisation, lemmatisation, data processing, and topic modelling ([JM08]). Therefore, this research design is suitable for analysing long-term and cross-regional variation in corporate sustainability communication (an overview of the method is in Figure 1 below).

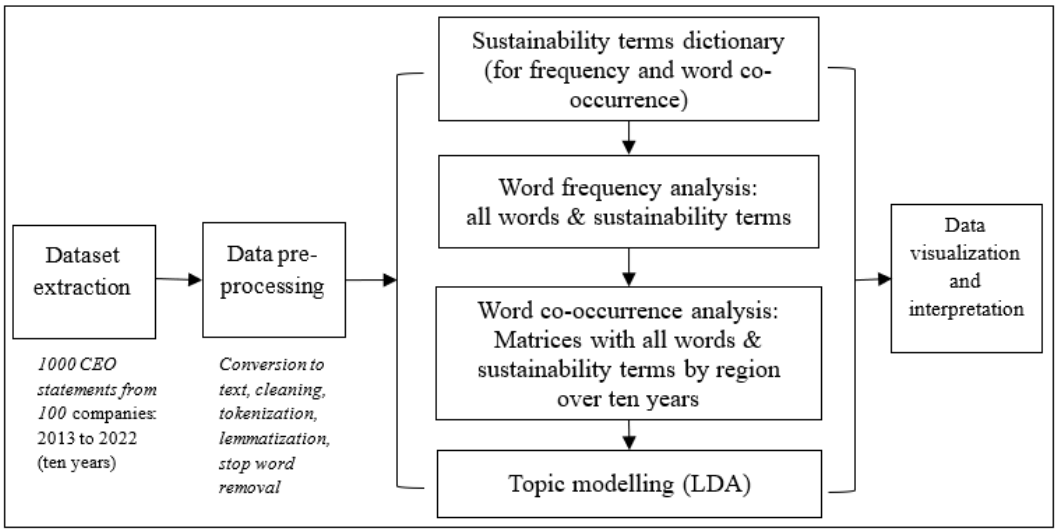

Figure 1: Overview of Research Design

A total of 1,000 CEO statements were collected from the annual reports of 100 companies (40 from North America, 30 from Europe, and 30 from Asia) spanning the years 2013 to 2022 (A list of companies by region is in Table 3 under the results section). The companies were selected from the Fortune Global 500 list based on revenue rankings, ensuring a diverse and global sample ([MM08]). Moreover, large firms also tend to publish more detailed reports and are more likely to include CEO statements, making them suitable for this kind of analysis ([EIS14]). Annual reports were sourced from publicly available locations, including company investor-relations websites, annual report repositories such as corporateannualreports.com, and financial databases used for public filings (e.g. EDGAR, SEC database).

3.2 Data Pre-processing

Preprocessing steps followed established text mining practices ([JM08]) and included: (i) cleaning: removal of tables, numbers, punctuation, page headers and footers, and non-informational content such as legal disclaimers; (ii) tokenisation: splitting text into individual words; (iii) lowercasing all tokens to standardise word forms; (iv) lemmatisation: reducing words to their base form (e.g., accelerate, accelerated, accelerating -¿ accelerate); and (v) stopword removal: elimination of common function words such as and, the, to, and of. In addition to standard stop words, words that did not add analytical meaning to this study were removed. These included pronouns (e.g. our), generic verbs (e.g. make, become), and routine words (e.g. also, well, year). Prior research shows that such words are part of conventions and do not have meaningful content, and that their removal improves the interpretability of word frequency results ([CJ03]). Next, to support the frequency and co-occurrence analyses, a dictionary of common sustainability-related terms was developed based on a combination of two recent and relevant peer-reviewed articles: [MRBM18] and [VBFKB23]. (Table 1 below).

3.3 Word Frequency Analysis

Word frequency analysis was used to identify the most commonly used terms in the CEO statements across regions and over time. Frequency analysis examines how often each word appears in a dataset and is widely used to identify language patterns, dominant themes, and the overall structure of a text ([Neu17]). After preprocessing, term frequencies were calculated separately for the combined dataset and for each region (Asia, Europe, and North America). Although only the top 30 terms are shown in the tables for ease of presentation, a larger frequency list (1000 terms) was examined to determine where sustainability-related terms appear in the data set. In addition to frequency tables, changes in key terms across regions and over time was visualised using rank-based bump

Table 1: Sustainability Terms Dictionary

air, air quality, alternative fuel, animal welfare, biodiversity, biofertilizer*, biogas*, biological diversity, carbon, carbon abatement, carbon capture, carbon disclosure, carbon footprint, carbon-free, carbon-neutral, circular economy, clean air, clean coal, clean energy, clean water, clean-energy, cleaner coal, cleaner energy, cleaner operations, climate, climate action, climate activities, climate change, climate impact, climate policy, climate protection, climate strategy, climate-change, climate-friendly, co2-footprint, co2-reduction, conservancy, conservation, conserve natural resources, conserve, conserved, conserves, conserving, consumption, contaminat*, cop21, deforestation, eco-activis*, eco-friendly, ecolog*, emission*, emit*, energy, energy-efficien*, environment*, environmental*, epa, erod*, erosion, externalit*, fertilis*, fertiliz*, fuel-efficien*, future generations, global warming, green building, green buildings, green energy, green investment, green investments, green tech, green technologies, green technology, greener, greenhouse, greenlife, habitat*, hazardous waste, kyoto, landscaping, low-carbon, natural, natural environment, ocean acidification, our planet, ozone, paris agreement, pollut*, preserv*, preservation, protect our environment, purifi*, rainforest*, recharg*, re-charge*, recycl*, reduce carbon dioxide, reduce co2, reduce methane, reduce waste, reducing waste, reforestation, renewable*, resource consumption, salvag*, solar*, species, sustainability, sustainable, sustainable business, sustainable energy, sustainable future, sustainable operations, sustainable processes, sustainable production, sustainable products, sustainable supply chain, sustainable technologies, sustainable technology, the environment, toxic*, unpollut*, unspoil*, upcycl*, waste reduction, wast*, waste-reduc*, waste-to-energy, water scarcity, water*, water-saving, wildlife, zero-carbon

Note 1: The environmental sustainability terms were directly extracted, without modification, from two recent peer-reviewed academic sources that had already categorised sustainability terms specifically related to the environmental dimension.

Note 2: Terms containing an asterisk (*) represent wildcard entries, allowing for the inclusion of all word variations sharing the same root (e.g., sustainab* captures sustainable, sustainability, etc.).

Sources: [MRBM18]; [VBFKB23].

charts. Bump charts show changes in rank over time and can therefore make it easy to identify emerging keywords, persistent terms, and changes in CEO language from 2013 to 2022 for each region, Europe, Asia and North America.

To better identify differences across regions, an additional filter was applied to get unique terms. Words that appeared across multiple regions and years were removed, as these can be considered common language used by CEOs. The remaining words were then grouped by region to identify terms that are more specific to each region's communication. This gives a more meaningful analysis by focusing on the regional differences rather than common vocabulary.

Although word frequency counts can help extract meaning from textual data, they recognise words as having only one meaning ([LL10]), but based on how words are used in connection with other words, their meanings can differ. Consequently, word clustering techniques that analyse how words are grouped together can provide a better interpretation ([BC08]). Therefore, in addition to word frequency analysis, I used word-co-occurrence and topic modelling in this study.

3.4 Word Co-occurrence Analysis

Word co-occurrence analysis was done to examine how sustainability concepts are used with other terms in the CEO statements. Co-occurrence analysis identifies which terms frequently appear near each other within a window of text ([WYS21]). After lemmatisation, co-occurrence counts were calculated using a window of ± 5 words around each sustainability term in the dictionary. For each region (Asia, Europe, North America) and for the combined dataset, this produced co-occurrence matrices in which rows represented sustainability terms and columns represented all other terms in the dataset. From these matrices, two types of outputs were generated. First, for each non-sustainability term, co-occurrence counts were totalled for all sustainability terms to obtain the "sustainability co-occurrence" frequency. Second, the matrices were used to find the strongest co-occurrence pairs, which are the combinations of a sustainability term and a non-sustainability term with the highest co-occurrence counts (e.g., growth–sustainable). These outputs were used to analyse which general terms are most strongly connected to sustainability language and which sustainability-related pairings are most frequent in CEO statements.

3.5 Topic Modelling (LDA)

To understand how CEOs communicate sustainability in their annual messages across different regions, Latent Dirichlet Allocation (LDA), an unsupervised probabilistic topic modelling technique was also used ([BNJ03]). LDA assumes that each document consists of a mixture of topics, with each topic characterised by a word probability distribution. With the pre-processed dataset, topic

modelling was carried out in Python using the Gensim library and involved identifying the optimal number of topics for each dataset by region, extracting the topics, and then labelling them, following established procedures in prior research ([ALBM23]).

Optimal Topic Identification. Selecting the appropriate number of topics (k) is a key parameter in LDA modelling ([BNJ03]) and typically involves evaluating model performance across a range of topic numbers ([ALBM23]). To identify the optimal number of topics (k), the coherence score (C_v) that measures the similarity in meaning among the top words within a topic was evaluated for a range of topics. The C_v measure was selected because higher coherence scores indicate more interpretable topics ([MWM+21]). Before selecting the optimal number of topics, the LDA model was first tested across a large range of values, from k = 2 to k = 40, using a step size of 6. The coherence scores indicated that the highest values for all regions occurred within the lower range of topic numbers (between k = 1 and k = 15), after which coherence scores dropped. Based on this, a more detailed evaluation was done by running the LDA model for each value of k from 1 to 15. As can be seen in Table 2 below, there was clear regional variation in the C_v scores, with k=11 showing the highest score for Europe and North America (Europe: 0.5077; North America: 0.5558) while for Asia, the highest C_v was for k=10 (0.4848). Therefore, the number of topics selected as optimal varied by region, with 11 topics for Europe and North America and 10 selected for Asia.

Table 2: LDA Coherence Scores by Region

k	**Europe**	**Asia**	**North America**
1	0.2091	0.1647	0.2058
2	0.3251	0.2589	0.3941
3	0.4118	0.3568	0.3612
4	0.4621	0.4274	0.3983
5	0.4604	0.4182	0.4857
6	0.4467	0.4465	0.4992
7	0.4594	0.457	0.5086
8	0.4617	0.3655	0.5414
9	0.4740	0.4376	0.5404
10	0.4614	**0.4646**	0.5385
11	**0.5077**	0.4292	**0.5558**
12	0.4994	0.4018	0.5370
13	0.4997	0.3909	0.4998
14	0.4703	0.39	0.5163
15	0.4401	0.4053	0.4676

Figure 2 below shows the coherence scores graph for k = 1 to 15 across Asia, North America, and Europe.

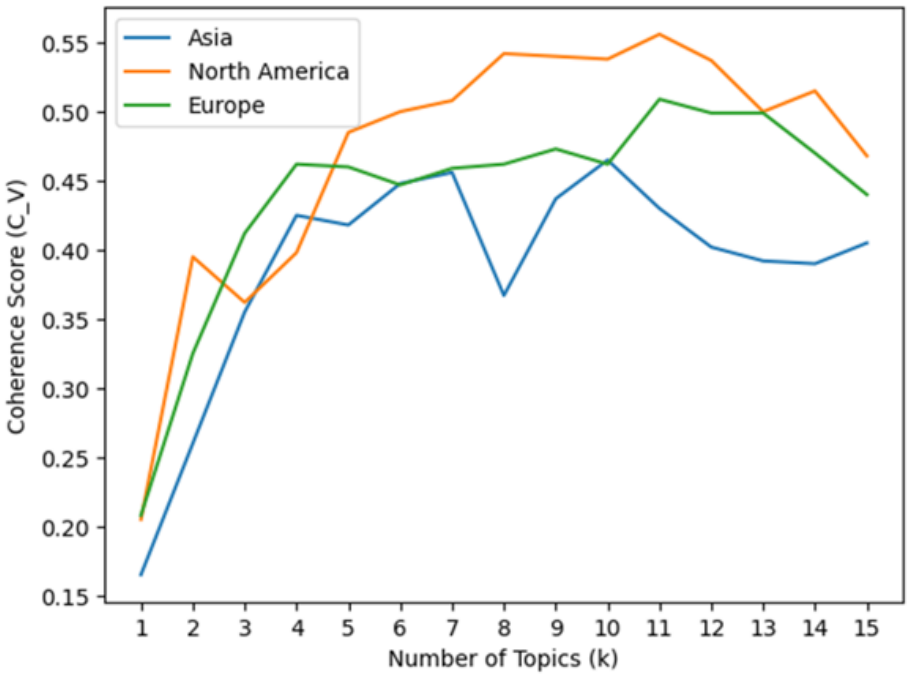

Figure 2: Graph Showing Coherence Scores by Number of Topics by Region

Topic Extraction. After determining the optimal number of topics for each region based on coherence scores, the final LDA model extracted the topics. Each topic is defined by a group of words with weights indicating the importance of terms within a topic. In addition, visualisations for these topics were generated using pyLDAvis library, which showed the most relevant term for each topic in the dataset and showed extent of topic distinctiveness.

Mapping Topics onto Sustainability Themes. After extracting the optimal number of topics for each region, a mapping procedure was conducted to identify sustainability-related themes. For topics identified as sustainability-related, existing literature on sustainability communication in CEO letters and CSR reporting (e.g., [NLCK20]) was used to guide and validate the labelling. On the other hand, the presence of terms such as *oil*, *gas*, or *production* alone was not sufficient for classification especially if these words are part of CEO messages of companies in the oil and gas sector, where such terms were part of their core business operations. Furthermore, topics that were not about sustainability were categorised based on their focus (e.g., financial performance, governance, crisis management, or operational strategy).

Topic Labelling. The next step involved assigning labels to each topic. Although LDA is data-driven, the labelling process requires researcher interpretation and therefore involves some subjectivity ([RSN20]). Topic labels were determined using three main outputs from the LDA model. First, the highest-probability keywords for each topic were examined to identify the central

meaning contained in that topic. Studies suggest that these keywords are useful for assigning topic labels ([RSN20]). Second, the document–topic weight distributions, which indicate the proportion of each topic within each CEO statement, were analysed to identify which statements were most strongly associated with each topic. The CEO statements with the highest topic weights were manually reviewed to check how keywords were used in context and to support the interpretation of the topic. Third, the pyLDAvis visualisation was used to assess topic distinctiveness, helping ensure that labels reflected clearly separated themes rather than overlapping content. For example, in Asia, Topic 1 was labelled as "Sustainable Finance" based on first, a review of the keywords comprising of *bank, income, client, loan, community, transformation, platform, wealth, finance, sustainability.* Next a review of the dominant documents showed that they consisted of CEO statements from financial service companies such as OCBC, UOB, and DBS. Some of these were manually reviewed to ensure the context and meaning of the terms in the document. For example, the OCBC CEO statement from 2016 (p. 8) where the terms appeared stated,

> *"Responsible financing is an important part of our sustainability practice, and we are committed to advancing environmental and social development in the markets we operate in....we will not engage in or knowingly finance any activity where there is clear evidence of immitigable adverse impact to the environment, people, or communities. Our Responsible Financing Framework sets out our overall approach,... we seek to positively influence our clients' behaviours by engaging them in adopting appropriate sustainable practices"*

Finally, a review of the literature that used similar terms showed the use of the term "Sustainable Finance" (e.g., [RH24] even had the term in the title of their paper). Thus, the term was chosen as the label for Topic 1.

3.6 Ethical Considerations

All data used were publicly available documents. No confidential or proprietary content was accessed.

4 Results

4.1 Sample Description

This section begins by presenting an overview of the data used in the thesis to provide the context within which the findings are interpreted. The list of all 100 companies included in the study can

be found in Table 3 below, and the industry-wise breakup of the companies is in Figure 3. As can be seen, most companies are in the oil & gas and financial sectors since these sectors are typically the ones with higher revenues.

Table 3: Companies Included in the Study by Region

Region	**Companies (in alphabetical order)**
Asia	Aramco, Bharat Petroleum, DBS, Foxconn, Hitachi, Indian Oil Corporation, Itochu, Kia, Marubeni, Mitsubishi, Mitsui, NTT, OCBC, Olam, Panasonic, Petronas, PTT, Reliance Industries, Sabic, Samsung, Singapore Airlines, Sony, Sumitomo, TCS, Tencent, Toyota, Trafigura, TSMC, UOB, Wilmar International
Europe	Ahold Delhaize, Airbus, Allianz, AXA, BASF, Bayer, BMW, BP, Carrefour, Deutsche Bank, Enel, ENI, E.ON, Equinor, Inditex, Loreal, Mercedes Benz, Nestle, Novartis, Renault, Roche, Santander, Shell, Siemens, Stellantis, Tesco, Unilever, Vodafone, Volkswagen, Volvo
North America	Accenture, ADM, Amazon, American Express, ATT, Bank of America, Berkshire Hathaway, Cencora, Centene, Chevron, Cigna, Citigroup, Coca Cola, Costco, CVS Health, Elevance Health, Exxon Mobil, FedEx, Ford, General Electric, General Motors, Goldman Sachs, Home Depot, IBM, Johnson & Johnson, JP Morgan Chase, Kroger, Marathon Petroleum, McKesson, Microsoft, Nike, Nvidia, Pepsico, Pfizer, Procter & Gamble, Target, Verizon, Walmart, Walt Disney, Wells Fargo

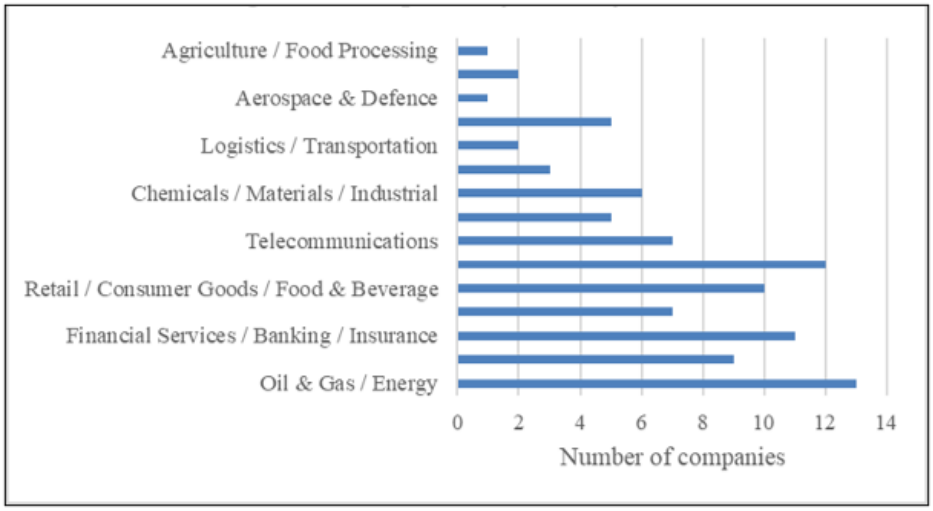

Figure 3: Sample Distribution by Sector

4.2 Word Frequency Analysis

The word frequency analysis shows the main vocabulary used in the CEO statements over time and across regions, and the extent to which sustainability terms are part of these messages. The results are presented in the following order: 1) All regions (the full dataset); 2) Europe; 3) Asia; 4) North America; 4) Cross-region comparison.

4.2.1 All Regions

The language used by CEOs in their annual messages (see Table 4 below for the top 30 words) shows that common business terms such as *customer*, *growth*, *market*, and *value* occur in high frequencies across all years for the full dataset. In addition, reflecting the global nature of the companies that are part of my dataset, the words *world* and *global* appear frequently, while the use of words such as *investment, growth, future,* and *increase* suggest an emphasis on strategy and planning. Perhaps reflecting concerns related to the COVID-19 pandemic, in 2020, the most frequent words were *people, build, work* and *change*.

Although sustainability-related words do not appear among the top 30 terms, they do appear later in the overall frequency list, showing that sustainability concepts are present in CEO statements but are not a top priority. For instance, *energy*, which is the most frequent of the sustainability terms, comes at rank 45, appearing a total of 2647 times with usage increasing steadily each year with 182 mentions in 2013 and going up to 459 in 2022. The next sustainability term mentioned is *environment* at rank 48, but it remains at a similar frequency in all years, with 237 mentions in 2013 and 250 mentions in 2022. The word *sustainable* (rank 81) shows an increasing trend. Although *carbon*, *emission*, and *climate* appear only between ranks 300 to 400, they show sharp increases in later years, with the largest jump coming in 2020 and 2021. Similarly, *ESG* appears only at rank 758 but increases from 1 appearance in the first three years to a frequency of 103 in 2021. Moreover, some sustainability terms make an appearance only in later years, suggesting a newer vocabulary emerging with words like *earth* (from 0 mentions in 2014 to 27 in 2021), *circularity* (no mentions before 2021 and 2022), and *decarbonise* (0 to 1 mention until 2020, with a sharp and steady increase after that to 23 in 2022).

Table 4: Top 30 Most Frequent Words (All Regions, 2013-2022)*

Rank	**Word**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**Total**
1	customer	730	781	**953**	763	792	894	792	916	820	744	8185
2	new	874	850	875	720	833	**921**	773	850	816	672	8184

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Table 4 – Continued from previous page

Rank	Word	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
3	growth	**836**	775	800	796	739	822	729	682	672	669	7520
4	market	**795**	776	760	662	605	638	532	535	573	527	6403
5	value	436	449	489	520	515	546	565	508	**567**	555	5150
6	work	364	385	426	432	454	459	521	**704**	623	524	4892
7	world	453	420	422	437	445	530	414	**559**	532	410	4622
8	increase	476	461	**515**	458	479	502	360	405	489	441	4586
9	bank	369	511	**581**	489	382	462	334	473	447	444	4492
10	service	480	469	**547**	515	377	446	377	463	378	364	4416
11	global	409	438	415	436	412	437	439	472	**492**	410	4360
12	group	379	362	424	401	382	453	414	**484**	420	474	4193
13	product	484	**492**	458	418	352	425	390	374	408	313	4115
14	share	453	415	439	423	**457**	415	376	359	386	380	4103
15	report	304	349	365	367	360	385	453	471	**520**	425	3999
16	financial	342	381	415	344	324	443	418	**505**	376	345	3893
17	management	317	380	386	373	352	393	358	**441**	359	339	3699
18	investment	405	352	**428**	424	385	343	326	316	342	332	3655
19	grow	350	414	**428**	365	380	401	320	274	379	341	3652
20	strong	319	346	**400**	351	334	367	315	393	395	365	3585
21	focus	349	315	345	312	306	379	354	**383**	361	357	3461
22	technology	282	254	302	345	352	**429**	343	359	382	353	3405
23	change	305	264	283	330	353	398	360	**426**	345	307	3372
24	people	247	250	309	297	319	341	333	**507**	412	332	3347
25	create	254	232	316	**360**	283	360	310	358	357	314	3144
26	deliver	306	244	304	290	292	378	325	283	337	**376**	3135
27	future	281	272	268	305	306	334	281	356	**367**	312	3084
28	build	241	260	298	314	310	323	288	**380**	336	332	3083
29	capital	341	332	**370**	356	286	358	253	296	239	228	3059
30	result	319	327	**390**	331	283	263	273	298	263	272	3019

*Note: Bold numbers represent the year in which the word appears most frequently.

4.2.2 Europe

The average length of a CEO statement in Europe was 1460 words. As can be seen from Table 5 below, the top 30 most frequent words in European CEO statements are business terms such as *customer, market, product,* and *management*, which occur with a relatively similar frequency across all years. In addition, words such as *development, strategy* and *future* are present, which suggest that CEO messages to shareholders are often about the future of the company, while the words *global* and *world* in the top 30 reflect the international nature of the business. Words such as

financial, management, work, and *global* are the most frequently occurring words in the year 2020, perhaps reflecting concerns related to the COVID-19 pandemic.

Although only one sustainability-related word, *energy*, makes an appearance in the top 30 at rank 19, it shows a steady increase in usage over the years. And while not in the top 30, the terms *environment* and *sustainable* appear at relatively high ranks of 34 and 37, respectively, though *environment* has a decreasing trend in usage over the years. While *electric* comes in only at a rank of 104, it shows an increase of over six times from 9 mentions in 2013 to 61 mentions in 2022, with an especially sharp increase between 2021 and 2022. The term *carbon* also shows a rapid increase in usage from only 6 times in 2013 to 41 times in 2021, and the term *greenhouse* appears to be an emerging word going from 0 to 4 in 2021 and to 7 in 2022. While the term *climate* also shows a steady increase from 10 in 2013 to 51 in 2021, it then shows a drop to 29 mentions in 2022. Similarly, the word *sustainability* shows a downward trend. Other sustainability terms in the list include *carbon, renewable,* CO_2*, green, and footprint.*

Table 5: Top 30 Most Frequent Words (Europe, 2013 - 2022)

Rank	**Word**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**Total**
1	new	214	217	152	175	177	**196**	163	153	136	138	1721
2	customer	124	**193**	161	135	146	150	149	182	175	148	1563
3	market	189	**212**	160	136	147	138	130	121	141	108	1482
4	growth	**191**	177	143	127	128	140	119	96	154	131	1406
5	increase	114	108	91	96	121	110	107	97	**148**	128	1120
6	report	95	86	95	79	80	62	135	**162**	107	98	999
7	financial	91	70	88	60	65	69	123	**125**	84	82	857
8	work	89	68	59	80	68	62	87	**123**	95	76	807
9	board	96	78	67	58	63	49	**146**	140	40	37	774
10	product	80	**108**	73	68	58	76	103	84	67	48	766
11	strong	**96**	80	66	54	59	74	79	75	95	85	763
12	world	**94**	88	65	69	73	72	64	90	78	68	761
13	share	**87**	76	72	63	79	73	74	61	**87**	69	741
14	value	83	76	49	61	79	65	**84**	69	72	82	720
15	future	**92**	90	68	77	65	61	64	74	72	53	718
16	result	79	85	**92**	62	62	66	53	69	70	79	717
17	performance	**94**	80	52	55	67	65	67	62	65	90	697

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Table 5 – Continued from previous page

Rank	Word	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
18	sale	**84**	70	69	70	82	59	62	61	73	55	685
19	energy	42	50	58	61	49	60	54	78	**114**	111	683
20	management	72	71	69	55	49	38	86	**117**	69	52	679
21	global	50	62	63	60	73	58	75	**81**	78	74	674
22	change	**99**	71	70	74	69	57	68	74	54	34	671
23	focus	79	**96**	69	52	67	57	64	65	57	60	666
24	operate	**87**	68	64	51	65	60	50	61	84	70	660
25	strategy	71	**81**	65	61	61	55	61	65	71	62	654
26	development	64	72	73	67	63	47	68	**82**	63	40	639
27	bank	**86**	76	51	63	50	61	77	43	70	45	622
28	brand	44	37	58	65	64	60	63	47	75	**85**	598
29	improve	74	**75**	70	71	50	68	57	36	54	40	595
30	grow	54	59	48	50	58	68	66	40	**71**	64	578

*Note: Bold numbers represent the year in which the word appears most frequently.

Sustainability terms are underlined.

To visualise how frequently word usage changes over time, rank-based bump charts are used. The bump chart for Europe (Figure 4 below) shows that the ranking of frequently used words remains relatively stable across the ten-year period, with terms such as *customer*, *deliver*, and *market* consistently appearing among the most top words (*customer* is the number one ranked word every year except 2013 and 2014). However, some shifts can also be seen over time. For instance, the term *energy* does not appear among the top-ranked words in Europe until 2021, after which it enters at rank 4 and rises to rank 3 in 2022. Words such as *pandemic* and *Covid* appear in 2020-2021 and then disappear indicating one-off events.

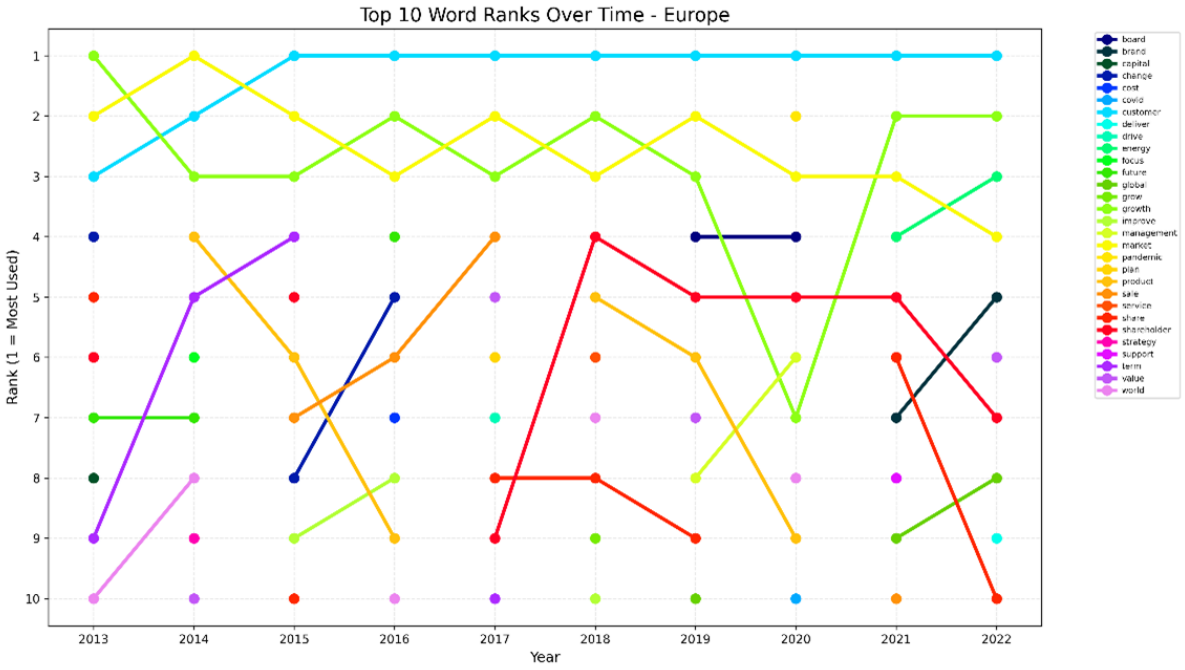

Figure 4: Europe: Bump Chart for Top 10 Word Ranks Over Time

4.2.3 Asia

The average number of words in CEO statements in Asia was 2156 words. As can be seen in the top 30 most frequent terms (Table 6 below), the most used words included *market, service, customer,* and *product*. The word *technology* is at rank 12 among the most frequent terms in Asia and shows a growing trend with 94 mentions in 2013 going up to 178 mentions in 2022. Words such as *strategy, investment, development,* and *plan* in the top 30 show a future-orientation in CEO messages. In 2020, the year of the pandemic, the words *work, financial, management,* and *customer* peak.

Although only two sustainability-related terms, *energy* (rank 16) and *environment* (rank 24) can be seen in the top 30 words, they show a steady increase over the years. For instance, *energy* goes up by 197% over the ten years while *environment* also increases steadily until 2021, followed by a drop in 2022. Between the 300 to 500 ranked words, sustainability terms that appear include *emission* (from 0 mentions in 2013 to 87 mentions in 2022), and *renewable* (from 3 mentions in 2013 to 25 in 2022) and although the word *electric* comes in only at rank 519, there is a large jump from 3 mentions in 2013 to 52 mentions in 2022. Terms that make an appearance only in the last two to three years include *hydrogen, circular* and *decarbonise/decarbonize*.

Table 6: Top 30 Most Frequent Words (Asia, 2013 - 2022)*

Rank	**Word**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**Total**
1	growth	275	**297**	279	269	256	281	280	249	224	216	2626
2	new	223	234	247	192	245	248	284	321	**297**	218	2509
3	group	160	144	191	194	200	**299**	246	314	280	294	2322
4	customer	146	150	178	201	205	240	296	**304**	289	200	2209
5	value	119	110	151	189	193	194	**248**	236	249	244	1933
6	management	136	181	169	192	178	212	183	**215**	187	168	1822
7	market	**207**	175	179	181	163	150	159	136	161	151	1662
8	global	115	123	106	147	175	182	201	182	**211**	170	1612
9	service	137	110	169	164	107	123	152	**186**	141	134	1423
10	report	80	109	101	116	126	164	170	147	**199**	146	1358
11	increase	135	147	150	151	**167**	160	104	107	129	97	1347
12	technology	94	78	91	121	132	161	127	168	**189**	178	1343
13	financial	96	121	133	111	104	142	152	**162**	114	117	1252
14	product	139	96	107	118	104	121	150	112	**151**	115	1214
15	bank	74	124	170	**186**	93	132	116	104	118	96	1213
16	energy	78	60	71	66	50	73	130	162	**234**	232	1162
17	change	60	59	74	111	116	132	**160**	151	**160**	132	1156
18	world	79	72	81	74	120	115	126	147	**164**	125	1103
19	work	69	92	80	93	111	95	144	**148**	145	122	1099
20	investment	129	82	136	**147**	106	102	103	82	86	110	1085
21	strategy	89	98	91	102	112	**137**	104	139	92	112	1077
22	support	87	67	88	104	87	101	108	159	**142**	131	1074
23	achieve	105	85	98	99	96	108	124	109	**137**	110	1071
24	environment	72	71	92	113	73	100	137	151	**164**	94	1071
25	industry	75	68	76	113	84	**148**	102	138	135	91	1030
26	development	91	79	102	90	95	**128**	104	118	115	96	1018
27	profit	85	123	**141**	116	121	109	114	71	70	64	1014
28	plan	159	81	91	84	97	89	105	**108**	82	87	983
29	future	84	56	64	99	80	110	93	133	**145**	116	982
30	share	79	82	98	89	105	104	90	113	105	**116**	981

Note: Bold numbers represent the year in which the word appears most frequently, sustainability terms are underlined.

The bump chart for Asia (Figure 5 below) shows greater variation in word rankings over time compared to Europe, perhaps reflecting the diversity of countries in this region with large variations of reporting systems and national policies. As expected, words related to corporate strategy and performance such as growth, market, and management remain important throughout the period. At the same time, terms such as technology show increasing usage in later years. The only sustainability term is energy which makes an appearance in 2021 and 2022.

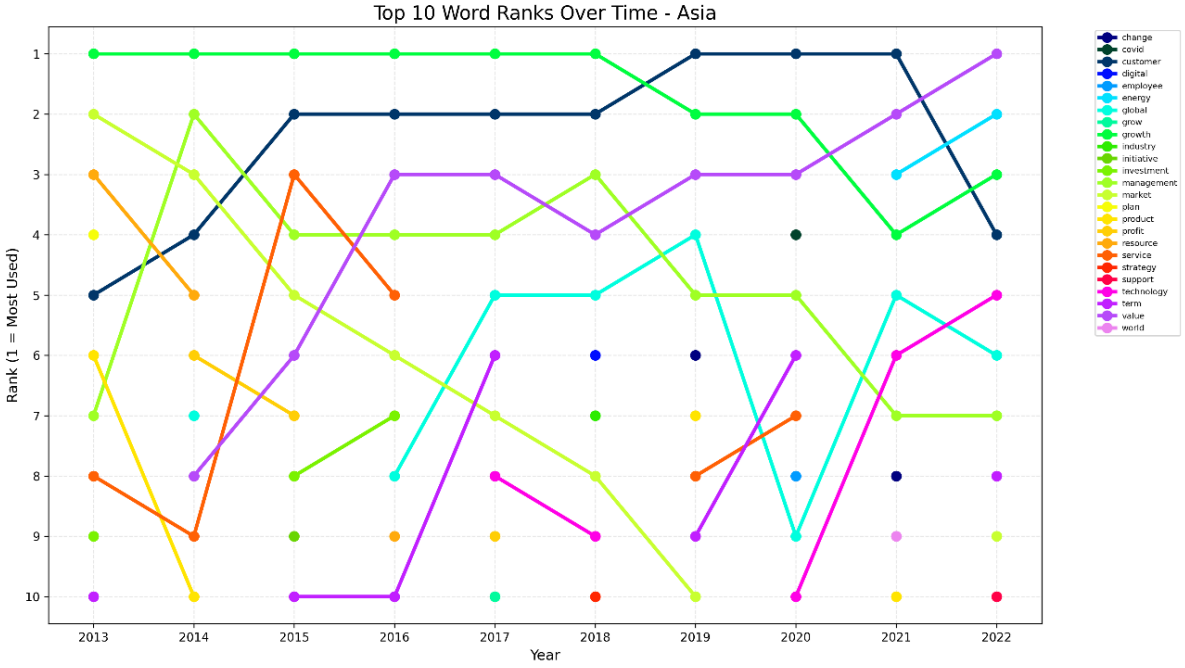

Figure 5: Asia: Bump Chart for Top 10 Word Ranks Over Time

4.2.4 North America

The words that CEOs in this region most often use in their annual statements include *customer, service, growth* and *market* (see Table 7 below). Words such as *people, build, health,* and *community* show peak mentions in 2020, the time of the COVID-19 pandemic. Other common words that appear include *capital, investment,* and *create*, while a focus on performance can be seen in the use of words *deliver, drive, increase*, and *grow*.

Although terms such as *community* and *people* appear in the top 30, sustainability terms only appear much lower in the rankings. For instance, the first term seen is *environment* (coming in at 77), followed by *energy* at 103 (with a steady increase from 62 mentions in 2013 to 116 in 2022), and lastly *sustainable* at 197. In addition, between ranks of 500 to 1000, the words *emissions, ecosystem,* and *footprint* appear for the first time.

Table 7: Top 30 Most Frequent Terms (North America 2013 - 2022)*

Rank	Word	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
1	customer	460	438	**614**	427	441	504	347	430	356	396	4413
2	new	437	399	476	353	411	**477**	326	376	383	316	3954
3	growth	370	301	378	400	355	**401**	330	337	294	322	3488
4	market	399	389	**421**	345	295	350	243	278	271	268	3259
5	work	206	225	287	259	275	302	290	**433**	383	326	2986
6	world	280	260	276	294	252	**343**	224	322	290	217	2758
7	bank	209	311	360	240	239	269	141	**326**	259	303	2657
8	value	234	263	**289**	270	243	287	233	203	246	229	2497
9	service	288	313	**332**	303	219	249	181	217	190	189	2481
10	share	**287**	257	269	271	273	238	212	185	194	195	2381
11	client	223	217	**309**	169	180	253	215	222	235	262	2285
12	grow	236	**293**	287	240	207	240	171	156	191	197	2218
13	product	265	**288**	278	232	190	228	137	178	190	150	2137
14	increase	227	206	**274**	211	191	232	149	201	212	216	2119
15	deliver	202	166	219	203	187	**258**	224	187	225	233	2104
16	people	169	166	214	199	199	236	176	**300**	255	188	2102
17	global	244	**253**	246	229	164	197	163	209	203	166	2074
18	investment	203	218	**248**	226	235	207	173	183	210	164	2069
19	health	195	146	221	231	157	234	159	**260**	206	201	2010
20	capital	218	240	**270**	252	167	196	136	201	135	123	1938
21	strong	160	192	**243**	197	170	206	164	203	205	180	1920
22	build	139	170	192	186	188	184	171	**228**	204	200	1863
23	focus	205	150	195	164	147	**218**	182	197	192	196	1846
24	create	156	132	197	211	159	**227**	164	214	194	179	1833
25	financial	155	190	194	173	155	**232**	143	218	178	146	1784
26	consumer	150	179	151	127	170	**243**	176	202	196	188	1782
27	drive	134	144	172	181	180	**237**	182	169	198	182	1779
28	community	120	101	146	107	157	155	168	**304**	221	204	1683
29	report	129	154	169	172	154	159	148	162	**214**	181	1642
30	technology	150	147	178	187	182	**215**	162	138	146	126	1635

Note: Bold numbers represent the year in which the word appears most frequently.

The bump chart for North America (Fig. 6) shows the words *customer* and *capital* occupying top positions across the period. The word *consumer* is also high in most years but drops in 2020 perhaps due to the pandemic. Compared with Europe and Asia, the vocabulary shows more use of stakeholder related terms such as *people* and *client*. 2020, the pandemic year, shows the appearance of *health* and *community*. Unlike the other regions, no sustainability terms appear among the top words in the chart.

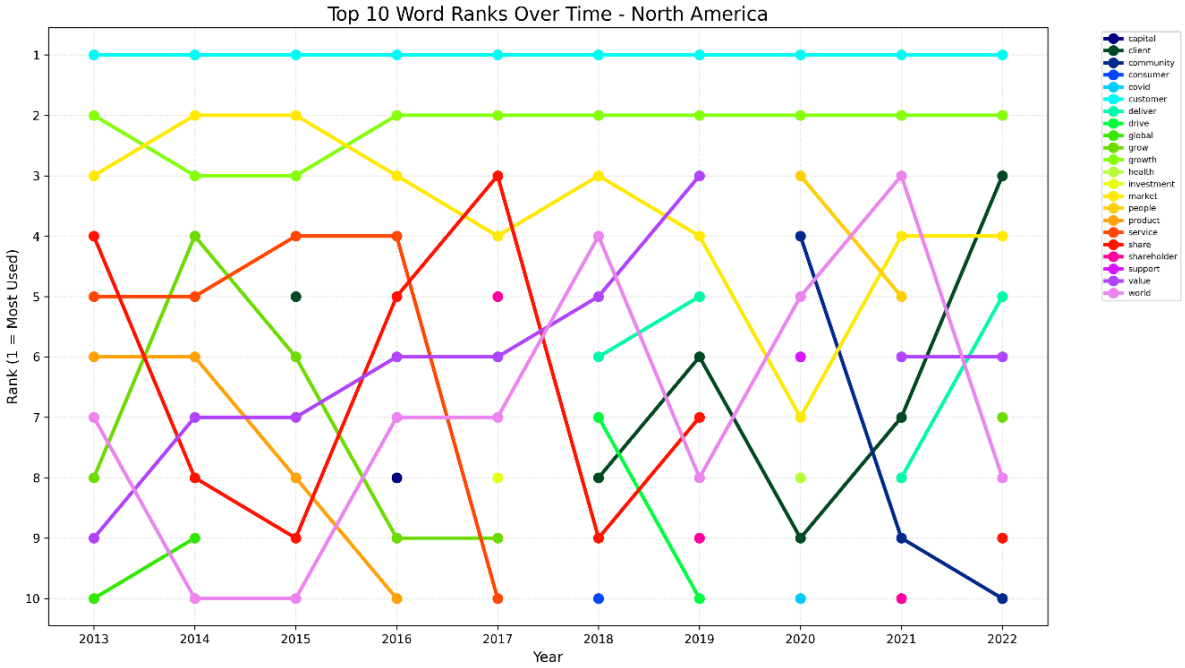

Figure 6: North America: Bump Chart for Top 10 Word Ranks Over Time

4.2.5 Cross-region and Temporal Comparison

Across all three regions, CEO statements commonly use business words such as *market, growth, product, consumer* etc. This pattern is stable over time and across regions, indicating a shared language globally. At the same time, some differences can be seen. For example, in the top 30 ranked terms, the words *board* and *performance* are only found in Europe while the word *health* only appears in North America. Perhaps reflecting the effect of external events, during the pandemic, words such as *people, financial,* and *work* appear with the highest frequency in 2020 for all regions showing its global nature.

Although sustainability terms are not high in the frequency lists, they appear among the lower ranked words with some new sustainability terms emerging in later years. A comparison of the top 5 sustainability terms in CEO statements by region can be seen in Table 8 below. Overall, Europe and Asia show the presence of more sustainable terms than North America and they appear with

greater frequency. In both these regions, *energy* appears among the top 30 most frequently used sustainability-related terms while in Asia the word *environment* also appears in the top 30. More specific climate-related terms such as *carbon, CO_2, greenhouse, hydrogen,* and *decarbonization* rank much lower in all regions, with some variation over time. Some sustainability terms that seem to be emerging in CEO language in the last 3 to 4 years across all regions include *decarbonization* and *greenhouse*. Additionally, the term *circularity* also makes an appearance in Asia and Europe. The steepest increase in usage over time in both Asia and Europe is that of the term *electric* but the term does not feature in North America.

Table 8: Top 5 Sustainability Terms by Region

Region	**Top 5 environmental sustainability terms (rank)**
Asia	energy (18), environment (26), sustainable (48), emission (258), green (272)
Europe	energy (21), environment (34), sustainable (37), electric (104), carbon (178)
North America	environment (77), energy (103), sustainable (196), climate (469), ecosystem (659)

4.2.6 Unique Word Frequency Analysis

To highlight region-specific patterns in CEO communication, terms that appeared across multiple regions and years were removed from the frequency lists. Table 9 below shows the top 30 unique words for each region. European CEO statements include more formal and technical terms such as *solvency, renegotiation, and reconversion*, suggesting a stronger focus on structure. Also, a reference to sustainability can be seen in the use of the word *hydroelectric* which appears six times. In contrast, Asian CEO statements contain more industrial and production-related terms such as *wafer, plantation, phosphate*, and *gasification*, reflecting an emphasis on resources and manufacturing. North American CEO statements, on the other hand, include words such as *teammate, homeowner*, and *nonprofit* indicating a stronger focus on people and service. Similarly, words such as *injustice, racism*, and *poor* could also indicate more engagement with social or ethical issues and may reflect regional concerns. Interestingly, only a few sustainability-related terms appear among these region-specific words and are not in the top 30 list. This suggests that, unlike business or industry-specific language, sustainability language tends to be more consistent across regions and follows a more common global language, rather than reflecting strong regional differences.

Region	Unique words in order of rank with frequencies
Europe	solvency (20), booker (15), renegotiation (12), plateau (11), plenitude (11), appropriation (9), excavator (8), glossary (7), loader (7), sickness (6), premiere (6), hydroelectric (6), cervical (6), fireman (5), sewing (5), reconversion (5), dressing (5), intended (4), demonstrator (4), raft (4), multipolar (4), cohesion (4), unsold (3), superplus (3), maiden (3), fascinate (3), coupe (3), forecourt (3), austerity (3), parallelization (3)
Asia	wafer (113), plantation (57), ending (29), affluence (22), contextual (21), axis (19), scoot (16), gestate (14), literature (14), gasification (13), sunny (13), cabin (13), sow (12), stably (12), enrichment (12), repose (11), foray (11), overconfidence (11), commendable (10), classification (10), substrate (10), humbly (10), precedent (10), fielder (10), patronage (9), creed (9), stickiness (9), phosphate (8), quadrant (8), blossom (8)
North America	pharmacy (335), teammate (213), nonprofit (112), fortress (60), notification (59), underserve (37), payor (35), marketable (33), speedway (32), pair (30), courier (29), restock (29), indemnity (25), enforcement (24), enclose (24), purple (24), skip (23), dose (23), typeset (23), racism (21), thoughtfully (21), flaw (20), postpaid (20), homeowner (20), poorly (20), suffice (20), false (19), boot (19), injustice (19), wildfire (19)

Table 9: Top 30 Unique Word Frequencies

4.3 Word Co-Occurrence Analysis

The co-occurrence analysis consists of two matrices for each of the individual regions and the combined dataset. The first matrix shows how many times a word appears against all sustainability terms from the sustainability dictionary. For example, if the word *growth* appears within the defined co-occurrence window of any sustainability term a total of 900 times, then its co-occurrence frequency is 900. This helps identify which terms are most strongly connected to sustainability language overall. The second matrix looks at individual term pairs. Instead of adding all sustainability terms together, it shows how individual sustainability terms occur with other terms most often, showing, for example pairs such as *sustainable–growth, energy–transition,* or *emission–reduce*. This shows how CEOs link certain sustainability words with general terms in their statements. The results are first presented for the combined dataset, followed by results for Europe, Asia, and North America.

4.3.1 All Regions

The most frequent words that co-occur with all sustainability dictionary terms across the full dataset include terms such as *growth, gas, new, reduce,* and *global* (Table 10 below shows the 30 most frequent words that occur with all sustainability terms). The high co-occurrence of sustainability terms with words such as *global* (rank 5) and *world* (rank 6) may indicate a reference to a broad framing of sustainability as a global concern. While sustainability terms co-occurring frequently with words such as *growth* (rank 1), *new* (rank 3), *development* (rank 11), *future* (rank 16), *project* (rank 21), *target* (rank 29), *transition* (rank 28), and *create* (rank 27) may suggest that CEOs speak of sustainability as related to the future performance of the company. At the same time, sustainability terms co-occurring often with words such as *solution* (rank 14), *challenge* (rank 18), *change* (rank 22), *help* (rank 25), and *impact* (rank 30) may suggest that sustainability is seen as an issue that need to be managed and solved.

Table 10: Top 30 Words Co-occurring with All Sustainability Terms (All Regions)

Rank	**Co-occurring word**	**Frequency**
1	growth	1027
2	gas	926
3	new	828
4	reduce	808
5	global	732
6	world	702
7	value	691
8	achieve	565
9	customer	561
10	social	549
11	development	545
12	goal	539
13	include	534
14	solution	517
15	market	498
16	future	484
17	resource	481
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Table 10 – Continued from previous page

Rank	Co-occurring word	Frequency
18	challenge	480
19	product	474
20	need	463
21	project	463
22	change	458
23	focus	458
24	term	456
25	help	454
26	commitment	447
27	create	444
28	transition	443
29	target	438
30	impact	428

The highest frequency of pairs of words that co-occur with specific sustainability terms are *sustainable-growth, environment-social, natural-gas, environment-challenge,* and *environment-change* (Table 11 below presents the 30 highest sustainability–term co-occurrence pairs in the combined dataset for all regions) which appears to align with the previous assessment that for CEOs, sustainability is seen as both, an obstacle and an opportunity for transformation. Besides *sustainable* and *environment*, one of the most commonly co-occurring sustainable words is that of *energy* (*energy-world, energy-transition, energy-global*) which reflects perhaps the concerns around energy security and sources of energy. Another sustainability term that frequently co-occurs with other terms is *emission* (e.g., *emission-reduce, emission-zero, emission-gas*) suggesting concerns about managing corporate impacts on the environment. Moreover, the appearance of *sustainability* with *report* suggests that CEOs also discuss the governance side of sustainability and its reporting.

Table 11: Top 30 Pairs of Co-occurring Terms (All regions)

Rank	Sustainability term	Other term	Frequency
1	sustainable	growth	525
2	environment	social	327
3	natural	gas	276

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Table 11 – Continued from previous page

Rank	Sustainability term	Other term	Frequency
4	environment	challenge	252
5	environment	change	238
6	sustainable	value	226
7	energy	world	221
8	sustainable	development	217
9	emission	reduce	216
10	energy	new	214
11	energy	transition	214
12	environment	operate	198
13	environment	economic	177
14	natural	resource	176
15	emission	gas	173
16	emission	zero	171
17	greenhouse	gas	163
18	environment	market	159
19	energy	need	158
20	environment	global	157
21	sustainable	term	157
22	energy	global	154
23	environment	impact	154
24	sustainable	long	149
25	sustainable	goal	147
26	environment	value	143
27	environment	growth	143
28	energy	future	141
29	sustainability	report	134
30	energy	solution	133

4.3.2 Europe

The words that co-occur most frequently with sustainability-related words in European CEO statements include *new, growth, world, reduce, development,* and *customer* (See Table 12 below). In addition, words such as *product, market,* and *value* co-occurring frequently with sustainable

terms indicates that CEOs speak of sustainability in the context of marketing related impacts. Also, frequent occurrences of words such as *future, goal, strategy, project, commitment,* and *long* appear to convey the long-term nature of sustainability issues and environmental solutions. The appearance of *report* may suggest that CEOs talk of sustainability alongside its reporting and governance.

Table 12: Top 30 Words Co-occurring with All Sustainability Terms (Europe)

Rank	**Co-occurring word**	**Frequency**
1	new	295
2	growth	239
3	world	228
4	reduce	227
5	development	216
6	customer	202
7	gas	198
8	target	180
9	product	172
10	market	163
11	value	162
12	transition	160
13	term	148
14	achieve	146
15	challenge	146
16	solution	146
17	future	145
18	increase	145
19	global	142
20	goal	141
21	strategy	141
22	project	133
23	commitment	131
24	low	123

Continued on next page

Table 12 – Continued from previous page

Rank	Co-occurring word	Frequency
25	need	123
26	social	123
27	production	116
28	report	112
29	long	111
30	zero	111

The most common co-occurring pairs of sustainability and all terms include *energy-transition, energy-world, sustainable-growth,* and *sustainable-development* (See Table 13 for the top 30 pairs). As indicated by the table, *energy* appears frequently with a range of words (e.g., *energy-transition, energy-supply, energy-world, energy-customer, energy-market*). Pairs such as *emission-reduce, emission-target, emission-zero, sustainability-report* indicate that sustainability related messages in European CEO statements are often linked to measuring, reporting and achieving sustainability targets.

Table 13: Top 30 Co-occurring Sustainability–Term Pairs (Europe)

Rank	Sustainability term	Other term	Frequency
1	energy	transition	95
2	energy	world	94
3	sustainable	growth	88
4	sustainable	development	85
5	energy	new	80
6	emission	reduce	78
7	environment	challenge	72
8	environment	social	71
9	emission	zero	61
10	renewable	capacity	59
11	energy	customer	56
12	emission	target	54
13	environment	economic	53

Continued on next page

Table 13 – Continued from previous page

Rank	Sustainability term	Other term	Frequency
14	sustainable	goal	51
15	environment	market	49
16	sustainable	value	48
17	emission	gas	47
18	energy	market	46
19	natural	gas	46
20	emission	net	44
21	energy	supply	42
22	sustainability	report	41
23	environment	new	40
24	environment	growth	39
25	sustainable	strategy	37
26	sustainable	term	37
27	emission	reduction	37
28	energy	system	37
29	waste	food	37
30	renewable	generation	37

4.3.3 Asia

The most frequently-used words used with sustainability words by CEOs in Asia include *growth, gas, value, global, resource,* and *new* (see Table 14 for the top 30 most frequently occurring words). As expected, since CEO statements are focused on business, sustainability terms appear often with operational and management concerns as seen in co-occurring words of *customer, management,* and *market*. The frequent use of words such as *challenge, change,* and *solution* with sustainability terms perhaps refers to how sustainability is seen as something that needs resolving. Words such as *strategy, achieve, development, project, future, initiative, solution,* and *change* suggest that CEOs speak of sustainability as long-term concerns. In Asian CEO statements, sustainability terms also appear together with the word *technology*.

Table 14: Top 30 Words Co-occurring with All Sustainability Terms (Asia)

Rank	**Co-occurring word**	**Frequency**
1	growth	515
2	gas	398
3	value	384
4	global	361
5	resource	321
6	new	283
7	achieve	274
8	social	274
9	development	256
10	society	243
11	change	240
12	customer	213
13	solution	213
14	management	211
15	world	210
16	project	206
17	initiative	204
18	future	203
19	reduce	193
20	issue	178
21	market	176
22	term	176
23	create	175
24	power	174
25	transition	174
26	impact	169
27	focus	167
28	challenge	164
29	technology	164
30	supply	163

Pairings of words with specific sustainability terms that occur together include *sustainable-growth, environment-social, environment-change, natural-gas,* and *natural-resource* (Table 15 below shows the top 30 pairs). While some of the associations seem to show sustainability as related to business operations and finance (e.g., *environment-operate, environment-economic*), others also show sustainability issues as something to be managed (e.g., *environment-challenge, environment-issue, energy-achieve*). Concerns around the future are especially visible in pairs such as *energy-future, energy-security,* and *energy-transition.*

Table 15: Top 30 Co-occurring Sustainability–Term Pairs (Asia)

Rank	**Sustainability term**	**Other term**	**Co-occurrence frequency**
1	sustainable	growth	290
2	environment	social	149
3	environment	change	147
4	natural	gas	142
5	natural	resource	134
6	sustainable	value	131
7	sustainable	development	109
8	environment	global	97
9	energy	new	96
10	environment	operate	94
11	environment	value	94
12	energy	transition	92
13	sustainable	achieve	92
14	environment	challenge	91
15	sustainable	society	89
16	energy	future	80
17	environment	issue	70
18	environment	continue	69
19	energy	resource	68
20	energy	solution	66
21	energy	security	66
22	environment	economic	65

Continued on next page

Table 15 – Continued from previous page

Rank	Sustainability term	Other term	Co-occurrence frequency
23	energy	global	64
24	greenhouse	gas	62
25	energy	growth	61
26	sustainable	realize	60
27	sustainable	goal	59
28	sustainable	create	59
29	environment	growth	58
30	energy	power	57

4.3.4 North America

The words used by CEOs that frequently occur with sustainability terms include *reduce, gas, growth, world, goal,* and *new* (see Table 16 below for the top 30 words). Among these co-occurring terms, words such as *global* and *world* indicate the framing of sustainability as a global concern, while language such as *create, impact, deliver,* and *build* suggest talk of strategic plans related to sustainability. Language suggesting societal concerns is also visible in co-occurring words such as *health, social,* and *community.*

Table 16: Top 30 Words Co-occurring with All Sustainability Terms (North America)

Rank	Co-occurring word	Frequency
1	reduce	388
2	gas	330
3	growth	273
4	world	264
5	goal	253
6	new	250
8	help	248
9	global	229
10	zero	192

Continued on next page

Table 16 – Continued from previous page

Rank	Co-occurring word	Frequency
11	create	191
12	impact	189
13	focus	188
14	include	187
15	technology	185
16	commitment	174
17	challenge	170
18	deliver	167
19	support	163
20	build	160
21	low	159
22	market	159
23	solution	158
24	community	157
25	power	156
26	product	156
27	health	155
28	social	152
29	operation	151
30	drive	150

Table 17 shows the top 30 pairs of words that show how specific sustainability terms co-occur with other words in CEO statements in North America. Some of the most commonly occurring pairs are *sustainable-growth* (147 times), *environment-social* (107 times), *environment-challenge* (89 times), *natural-gas* (88 times) and *emission-reduce* (86 times). While the pairs of *natural* and *greenhouse* with *gas* is to be expected, pairs of *environment-performance, waste-zero, emission-reduce,* and *environment-governance* show that measurement and governance aspects of sustainability are also part of CEO language. There are several pairs that suggest that sustainability is often viewed as a long-term issue (e.g., *sustainable-long, sustainable-build, environment-create,* and *environment-growth*). This view is reinforced seeing pairs of *environment-challenge, environment-impact,* and *environment-change*, indicating that CEOs talk of sustainability as a concern that needs to be managed or resolved as well.

Table 17: Top 30 Co-occurring sustainability–term pairs (North America)

Rank	Sustainability term	Other term	Frequency
1	sustainable	growth	147
2	environment	social	107
3	environment	challenge	89
4	natural	gas	88
5	emission	reduce	86
6	environment	impact	85
7	environment	operate	79
8	greenhouse	gas	75
9	sustainable	long	74
10	energy	world	73
11	waste	zero	71
12	emission	gas	71
13	sustainable	term	68
14	environment	change	65
15	emission	zero	62
16	environment	economic	59
17	environment	governance	58
18	energy	global	55
19	environment	market	54
20	environment	focus	51
21	environment	performance	50
22	energy	power	49
23	sustainable	build	47
24	environment	create	47
25	sustainable	value	47
26	carbon	low	47
27	energy	reduce	46
28	environment	growth	46
29	energy	technology	46
30	sustainable	drive	46

4.3.5 Cross-regional comparison

Across all three regions, the words most frequently co-occurring with the full set of sustainability terms are similar, suggesting a global convergence on how CEOs talk of sustainability in their annual messages (see a sample of top 10 terms in Table 18 below). For instance, the terms *growth, global, market, solution* and *challenge* are seen frequently in the context of sustainability terms suggesting that it may be framed as a global and growth-related concern. But there are some differences. European firms tend to use more measurement and governance related words with terms such as *transition, target,* and *commitment,* while in Asia, CEOs tend to emphasize development and operational terms such as *resource, management,* and *technology*. Finally, North American firms show a more action-oriented view with CEOs using terms such as *deliver, support,* and *impact*. These differences suggest that while sustainability talk is similar, there are some variations which could be based on regional priorities and contexts.

Table 18: Cross Regional Comparison Top 10 Co-occurring Terms

Europe	**Asia**	**North America**
new	growth	reduce
growth	gas	gas
world	value	growth
reduce	global	world
development	resource	goal
customer	new	new
gas	achieve	help
target	social	global
product	development	zero
market	society	create

An analysis of term pairs shows some similarities as well as some regional variations (see sample of pairs in Table 19 below). Across all regions, common pairings such as *sustainable-growth, environment-social,* and *environment-challenge* can be seen. In Europe, CEOs appear to use sustainability terms with combinations that suggest attempts to reduce environmental impact, such as *energy–transition, emission–reduce, emission–zero, emission–target,* and *renewable–capacity,* together with *sustainability–report* which shows governance and reporting concerns. On the other hand, in Asia, co-occurring pairs include *sustainable–growth, natural–resource, energy–resource,* and *sustainability–development* which suggest that sustainability is influenced by economic concerns

and resource management. In North America, the pairs suggest an emphasis on action and implementation with pairs such as *environment–impact, sustainability–build, sustainability–drive, sustainability–deliver,* and *environment–operate*. Overall, while all regions show similar concerns, the difference in frequencies suggest some variations in priorities.

Table 19: Top 10 Co-occurring Pairs Across Regions

Europe	**Asia**	**North America**
energy–transition	sustainable–growth	sustainable–growth
energy–world	environment–social	environment–social
sustainable–growth	environment–change	environment–challenge
sustainable–development	natural–gas	natural–gas
energy–new	natural–resource	emission–reduce
emission–reduce	sustainable–value	environment–impact
environment–challenge	sustainable–development	environment–operate
environment–social	environment–global	greenhouse–gas
emission–zero	energy–new	sustainable–long
renewable–capacity	environment–operate	energy–world

4.4 Topic Modelling (LDA)

4.4.1 Europe LDA Results

As shown in Table 20 below, European CEOs discuss business themes such as financial performance, strategy, and sales, usually in relation to the firm's industry (e.g., banking, automotive, and pharmaceutical firms). The pandemic also appears as a distinct theme, particularly in healthcare-related companies and documents from COVID-19 years. Also, as can be seen, for some topics (e.g., 6 and 7) the keywords were similar, and a review showed they were part of the same documents. Sustainability-related language is clearly visible as seen in topics 2 (*Energy Production & Renewable Energy Transition*) and 11 (*Sustainable Production & Reporting*). In addition, sustainability references can be seen in other topics such as Topic 5 (*Electric Vehicles & Product Strategy*). Although sustainability language is often used in the context of competitiveness and operations, it is clearly present in European CEO communication across industries. In addition, some documents also show sustainability as part of environmental responsibility.

Table 20: Europe LDA: Topics and Main Themes

Topic No.	**Assigned Label**	**Keywords**	**Dominant Document (companies)**	**Label Source**
Topic 1	Healthcare & Patient Focus	medicine, patient, innovation, treatment, healthcare, disease, cancer, health, diagnostic	Healthcare: Roche, Novartis, Bayer	Based on keywords and document overview
Topic 2	**Energy Production & Renewable Energy Transition**	energy, project, gas, production, oil, price, operation, expect, compare, **renewable**, operation, price	Energy: Equinor, ENI, Shell	Based on keywords, document overview and literature (e.g., Kalair et al., 2021)
Topic 3	Brand Management & Governance Focus	consumer, brand, digital, board, officer, review, innovation, statement, underlie, social	Consumer Goods: L'Oréal, Unilever, Nestle	Based on keywords, document overview
Topic 4	Financial Structure Focus	bank, client, capital, revenue, ratio, core, asset, transformation, tax, loan	Financial Services: Deutsche Bank, Santander, Axa	Based on keywords & document overview
Topic 5	Product Strategy & Electric Vehicles	vehicle, **electric**, truck, mobility, transport, letter, brand, solution, adjust, success	Automotive: BMW, Mercedes, Volkswagen	Based on keywords, document overview
Topic 6	Sales, Finance & Management Focus	food, store, brand, local, board, bank, capital, together, team	Mixed: BASF, Bayer, Vodafone	Based on keywords and document overview
Topic 7	Product & Sales Focus	brand, energy, food, local, project, store, team, example, price	Mixed: BASF, Bayer, Vodafone	Based on keywords and document overview
Topic 8	Corporate Governance & Results Focus	profit, country, revenue, income, risk, credit, supervisory_board, main, profitability, commercial	Mixed: Santander, EON, Siemens	Based on keywords and document overview
Topic 9	Crisis Management & Pandemic Focus	officer, crisis, pandemic, covid, programme, operational, aircraft, priority, team, delivery	Mixed: Airbus, Vodafone, Renault	Based on keywords and document overview

Topic No.	**Assigned Label**	**Keywords**	**Dominant Document (companies)**	**Label Source**
Topic 10	Retail and Supply Chain Focus	store, food, brand, colleague, community, local, online, supplier, retail, shop	Retail: Tesco, Ahold Delhaize, Carrefour	Based on keywords, document overview
Topic 11	**Sustainable Production & Environmental Responsibility**	geographical, **environmental**, registration, document, vehicle, **electric**, brand, record, production, transformation	Mixed: BASF, Bayer, Vodafone, Renault	Based on keywords, document overview and literature (e.g., Arvidsson, 2023)

4.4.2 Asia LDA Results

Table 21 below presents the LDA results for Asia. Three topics had distinct sustainability theme including topics 1 (*Sustainable Finance*), 3 (*Competitiveness & Green Mobility*) and 10 (*Agricultural Commodities & Sustainability*). Interestingly, sustainability terms appear across a wide range of industries such as finance and agriculture. Many of the topics were dominated by oil and gas firms (e.g., Aramco, Petronas, Bharat Petroleum), conglomerates (e.g., Mitsui, Mitsubishi, Marubeni), and technology and semiconductor companies (e.g., TSMC, Tencent, Foxconn) which usually had key terms related to business aspects such as strategy, production, competitiveness, and financial results. There were some overlapping topics which had similar keywords and documents related to the same companies. This may reflect the relatively lower coherence score observed for the Asia model compared with other regions (Röder et al., 2015). Although Topics 5 and 9 share some overlapping terms related to production and energy activities (e.g., oil and production), an examination of the documents shows that they capture distinct themes. Topic 5 is primarily focused on agricultural production and supply chain processes, while Topic 9 reflects energy-related activities alongside financial and corporate performance considerations. This distinction is further supported by the LDA visualization where the two topics appear as separate clusters, indicating limited semantic overlap. Therefore, they were retained as distinct topics.

Table 21: Asia LDA: Topics and Main Themes

Topic No.	**Assigned Label**	**Keywords**	**Dominant Documents (companies)**	**Label Source**
Topic 1	**Sustainable Finance**	bank, income, client, loan, community, transformation, platform, wealth, finance, **sustainability**	Financial services: OCBC, UOB, DBS	Based on keywords, document overview and literature (Rahman & Hossain, 2024)
Topic 2	Pandemic, Governance & Energy Focus	oil, gas, supply, pandemic, near, covid, price, tax, nation, compliant	Mixed: Mitsubishi, Mitsui, Aramco, Bharat Petroleum	Based on keywords, document overview
Topic 3	**Competitiveness, Growth & Green Mobility**	creation, issue, competitiveness, mobility, **environmental**, covid, goal, structure, accelerate, promote	Automotive: Kia, Toyota and Electronics: Hitachi, Panasonic	Based on keywords, document overview and literature (Choi & Cho, 2021)
Topic 4	Corporate Strategy & Operations Focus	caliber, oil, vision, petrochemical, meeting, transformation, corporation, production, price, issue	Mixed: Foxconn, NTT, TCS, Bharat Petroleum, Mitsui, Aramco	Based on keywords and document overview
Topic 5	Energy Production & Strategy Focus	production, oil, gas, datum, infrastructure, corporation, research, petrochemical, creation, refinery	Mixed: Foxconn, NTT, BP, Aramco, Mitsui	Based on keywords and document overview
Topic 6	Corporate Earnings & Fiscal Performance Focus	fiscal, realize, medium_term, earning, issue, corporation, implement, example, relate, generate	Engineering: Marubeni, Mitsubishi, Itochu	Based on keywords and document overview
Topic 7	Digital Platform & Media Focus	user, game, mobile, content, platform, nanometer, semiconductor, advertising, application, online	Technology: Tencent, TSMC, TCS	Based on keywords and document overview
Topic 8	Financial Performance and Results Focus	gas, earning, oil, issue, petrochemical, income, price, fuel, bank, fiscal	Mixed: Foxconn, NTT, BP, Aramco	Based on keywords and document overview

Topic No.	Assigned Label	Keywords	Dominant Documents (companies)	Label Source
Topic 9	Oil and Gas Production & Supply Focus	oil, gas, production, capacity, price, fuel, petrochemical, supply, refinery, chairman	Energy: Reliance, Petronas, Indian Oil	Based on keywords and document overview
Topic 10	**Agricultural Commodities & Environmental Sustainability**	food, trading, **sustainability**, commodity, agri, segment, airline, sugar, farmer, agriculture	Commodities & Agribusiness: Olam, Wilmar, Trafigura	Based on keywords, document overview, and literature (Wang et al., 2020)

4.4.3 North America LDA Results

Sustainability related terms only featured in one of the topics as can be seen in Table 22 below which shows the labels assigned for the eleven topics. From the labels assigned, CEOs discuss traditional themes such as results and financial performance and their message is often specific to their industry (e.g., banking and telecom firms discuss these themes mainly). The pandemic is another theme of CEO messaging but mainly related to pharma and healthcare companies with more documents relating to the pandemic years. Unsurprisingly, technology, big data and AI are part of CEO messages. Sustainability appears as a stand-alone topic only in the context of oil and energy companies. Moreover, even in these companies, CEOs tend to talk of sustainability as part of operations and risk management rather than concerns related to the environment.

Table 22: North America LDA: Topics and Main Themes

Topic No.	Assigned Label	Keywords	Dominant Documents (Sector/companies)	Label Source
Topic 1	Telecommunications & Data Infrastructure Focus	network, wireless, internet, content, fiber, mobile, connect, connectivity, medium, speed	Telecom: AT&T (0.284); Verizon (0.184) Automotive (Ford (0.035)).	Based on keywords, document overview

Topic No.	**Assigned Label**	**Keywords**	**Dominant Documents (Sector/companies)**	**Label Source**
Topic 2	**Energy Production and Profits Focus**	energy, project, margin, fuel, target, production, complete, facility, capacity, cash	Energy: Exxon Mobil (0.929); Marathon Petroleum (0.926); Chevron (0.914)	Based on keywords, document overview, and literature (Aflaki et al., 2013)
Topic 3	Financial Results and Reporting Focus	stock, gain, insurance, member, healthcare, purchase, tax, client, hold, news	Consumer Goods: Nike (0.0008); Home Depot (0.0006); Costco (0.0006). Entertainment (Walt Disney)	Based on keywords and document overview. While healthcare appears, it was only due to one company Elevance where the term was used frequently.
Topic 4	Pandemic and Stakeholder Care Focus	purpose, healthcare, covid, potential, patient, partnership, colleague, diversity, stakeholder, pandemic	Pharmaceuticals: Johnson & Johnson (0.774); Elevance Health (0.673); Pfizer (0.653)	Based on keywords, document overview (documents relating to 2018, 2019 and 2020 dominating).
Topic 5	Risk Management Focus	bank, government, job, economy, policy, rule, risk, economic, crisis	Finance Services: JPMorgan Chase (0.584); Berkshire Hathaway (0.140). Online (Amazon)	Based on keywords and document overview
Topic 6	Investment & Risk Management Focus	Client, bank, risk, loan, equity, firm, deposit, common, credit, expense	Financial Services: Bank of America (0.789); Wells Fargo (0.661); Goldman Sachs (0.661)	Based on keywords and document overview

Topic No.	Assigned Label	Keywords	Dominant Documents (Sector/companies)	Label Source
Topic 7	Healthcare and Patient Focus	patient, healthcare, pharmacy, specialty, provider, pharmaceutical, therapy, fiscal, guest, member	Pharmaceuticals: Cencora (0.630); CVS Health (0.601); Centene (0.453)	Based on keywords and document overview
Topic 8	Retail Sales Focus	store, category, associate, fiscal, retail, food, productivity, win, online, home	Retail: Procter & Gamble (0.646); Home Depot (0.584); Walmart (0.561)	Based on keywords and document overview
Topic 9	Software and Hardware Focus	data/datum, AI, software, design, application, computer, game, infrastructure, fast, generation	Mixed (Tech & Entertainment): Nvidia (0.666); Walt Disney (0.505); Amazon (0.439)	Based on keywords and document overview
Topic 10	Investment and Stocks Focus	insurance, stock, purchase, fund, float, gain, manager, meeting, price, tax	Mixed: Berkshire Hathaway (0.724); General Motors (0.107); Walt Disney (0.106)	Based on keywords and document overview
Topic 11	AI and Data Security Focus	cloud, client, security, fiscal, AI, datum, Azure, enterprise, application, trust	Technology: Accenture (0.459); Microsoft (0.339); IBM (0.336)	Based on keywords and document overview

4.4.4 Cross-regional comparison of sustainability themes based on LDA Results

A comparison across regions shows both similarities and differences in how sustainability is communicated by CEOs. In Europe, two distinct sustainability related topics emerged with themes labelled as *Energy Production & Renewable Energy Transition* and *Sustainable Production & Environmental Responsibility*. In Asia, three themes were identified including *Sustainable Finance, Competitiveness, Growth & Green Mobility* and *Agricultural Commodities & Environmental Sustainability*. In North America while *Energy Production and Profits* appears as a separate theme, the documents mainly related to energy companies. The distinct themes are perhaps a reflection of varying regional

concerns. In addition to differences in themes, unlike in North America, CEOs in Europe and Asia tend to refer to sustainability across multiple industries rather than only in energy-related firms. In all three regions, sustainability appears more as part of business operations rather than as a concern for the environment.

5 Discussion

The findings of this study show that while CEOs communicate sustainability in their annual statements, it is not a central focus or dominant theme. Across all regions, CEO messages are primarily focused on core business priorities such as markets, growth, strategy, and financial performance, as can be seen in the word frequency results. Even when sustainability is discussed by CEOs, it is closely linked to the economic performance of the business (co-occurring with terms such as *growth, development, transition, targets*). The LDA topic modelling confirms this, showing that sustainability appears in a few themes and often in the context of energy, production, mobility, finance, and reporting. Therefore, across the word frequency, co-occurrence, and topic modelling results, CEOs tend to frame sustainability in relation to corporate performance and business priorities, rather than as a distinct objective in its own right.

In addition to these findings, some variance across regions and over time can be seen. Across regions, sustainability-related language is more visible in Europe and Asia than in North America. While all three regions show energy as a primary concern, in Europe, sustainability is most strongly associated with energy transition, emissions reduction, and reporting; in Asia, it is more linked to growth, resource use, finance, and production. In contrast, North American CEO statements show less frequent use of sustainability language and mainly in the context of operations or energy-related activities. On the other hand, a shared vocabulary related to sustainability terms can be seen across regions with similar language being used. The findings also show a shift in the nature of sustainability communication over the ten-year period. While earlier years are characterised by more general terms such as *sustainability* and *environment*, later years show use of more specific and technical terms such as *decarbonisation, circularity*, and *emissions*.

Next, the contributions to theory and practice are discussed.

5.1 Theoretical Contribution

This study contributes to the literature on corporate sustainability communication in several ways. Complementing studies that examine sustainability and CSR reports ([CCGM17]; [SRD17]) and responding to calls to explore alternative forms of corporate communication ([DM21]), it

examines how sustainability is discussed in CEO annual statements. Although CSR reports have become more standardised, their voluntary nature may limit reliability ([BGKM19]), and so CEO statements provide a complementary perspective on corporate sustainability communication. Consistent with research showing that sustainability is increasingly integrated into business strategy (e.g., [STBMBGLP21]), the findings indicate that CEOs across all regions frame sustainability in relation to growth, development, and long-term value creation. However, in contrast to the global rise in sustainability reporting driven by regulation ([KPM24]), the results suggest that sustainability remains less prominent in CEO statements.

This study also contributes by examining how sustainability communication varies across regions and over time. Contrary to prior research suggesting more developed CSR practices in Western contexts ([Dil10]; [KSPMK20]), the findings show that sustainability themes appear more in Asian and European CEO statements and less so in North America. This may reflect differences in institutional environments, stakeholder expectations, and stages of development, which have been shown to shape CSR practices across regions ([ALF+10]; [LFA+09]; [RL18]). In particular, recent research suggests that sustainability reporting in Asia is in a "spreading out" stage, while Europe and North America may be in more mature or even declining phases ([HN21], p. 106), which may help explain the stronger presence of sustainability themes in Asian CEO communication. At the same time, the results indicate a high degree of similarity in the language used across regions, suggesting the emergence of a shared global discourse around sustainability. This is consistent with research highlighting increasing convergence in sustainability communication driven by global reporting frameworks and institutional pressures ([BdJL09]; [CB09]; [YOJC21]; [KK22]). This convergence may also reflect the focus on large multinational firms in this study, which are more likely to adopt globally aligned communication practices ([EIS14]; [MM08]). In addition, the study shows that while sustainability remains embedded within broader business priorities, the language used has changed over time, with a shift from general terms towards more specific vocabulary such as *decarbonisation, emissions,* and *circularity*. This extends prior research, which has largely focused on reporting practices within specific industries or single-country contexts ([VCF23]), by showing how sustainability communication develops over time across regions.

Finally, the study contributes methodologically by showing the value of combining text mining techniques, including frequency analysis, co-occurrence analysis, and topic modelling to give a more comprehensive picture. Pointing to the limitations of studies that tend to rely on frequency-based methods in analysing sustainability communication, Kang and Kim [KK22] suggest incorporating methods that include a more contextual approach to analyse content more accurately. In this study, frequency analysis provided insights related to differences in sustainability language across regions and over time, while word co-occurrence provided how these terms are used in the context of other

terms, as well as in the context of sustainability terms, and topic modelling went deeper into the content of CEO reports to help extract themes.

5.2 Practical Contribution

From a practical perspective, the findings suggest that CEO statements can show how firms communicate their strategic priorities around sustainability. The study may also help firms benchmark their CEO communication against companies in other regions and identify possible gaps or inconsistencies. In particular, comparing CEO statements with sustainability or integrated reports may help organisations see whether sustainability commitments are communicated consistently or whether they appear only in more formal reporting documents. Given the limited emphasis on sustainability found in many CEO statements, the findings also suggest that leaders may benefit from more clearly linking sustainability to long-term strategy and corporate priorities, especially where firms seek to present sustainability as part of their overall direction.

5.3 Limitations and Future Research

This study has several limitations that also suggest future research areas. First, the analysis focused on three regions, Asia, Europe, and North America and therefore, does not capture sustainability communication in other contexts. Future studies could extend the regional scope to examine whether the patterns identified here also hold in a wider set of institutional and cultural settings. Importantly, further work could explore the drivers behind the regional differences identified, including the role of institutional environments, regulatory pressures, and shareholder expectations. For example, studies could examine the relationship between themes in CEO statements and stakeholders by analysing stakeholder preferences through surveys and seeing the association with corporate communication patterns. Future studies could also investigate the alignment between CEO statements and other forms of corporate communication, such as sustainability or integrated reports, to check consistency in messaging. Second, the sample set comprised large firms on the Fortune 500 list, reflecting both the impact of large firms as well as the availability of publicly accessible CEO statements for these companies. Consequently, findings may not reflect the communication practices of smaller firms. Studies show that large firms are more exposed to international norms, investor expectations, and reporting pressures, which may make their language more globally aligned than other businesses ([MM08]). Future research could therefore examine small and medium-sized enterprises, or firms operating mainly in domestic markets, to see whether sustainability is framed differently in those contexts. Third, this study relies on computational text analysis. While this allows for the systematic analysis of large volumes of text, it also has limitations. Such methods focus on patterns in language and may overlook contextual nuance, tone, and the intended meaning behind statements

([BNJ03]). In addition, topic modelling involves an interpretive element, as the researcher assigns the meaning of topics. Future research could complement computational approaches with qualitative methods, such as interviews with CEOs, to provide a deeper understanding of how sustainability is communicated and give additional insights as to the reasons behind the nature of corporate sustainability communication.

6 Conclusion

Companies play an important role in addressing sustainability challenges, yet less attention has been paid to how organisational leaders frame and communicate sustainability, and how such communication varies across regions and over time. As organisational leaders, CEOs influence how sustainability is understood, prioritised, and acted upon within organisations. Drawing on CEO annual statements across regions and over time, this thesis highlights how sustainability is positioned within wider corporate communication, how sustainability discourse changes over time, and how regional contexts shape its emphasis. The findings suggest that sustainability is frequently framed in relation to growth, competitiveness, and long-term value creation, indicating that CEOs tend to position it as part of overall business priorities rather than as a central organisational concern in its own right. At the same time, similarities in sustainability language across regions point to the emergence of a shared global sustainability discourse, while differences in emphasis point to the continued importance of regional priorities and institutional contexts.

While sustainability reporting has become highly standardised, examining CEO communication offers deeper insight into how sustainability is interpreted, prioritised, and used in broader corporate narratives. As expectations around corporate sustainability continue to grow, understanding how organisational leaders frame sustainability will become increasingly important for assessing corporate priorities, commitments, and responses to wider environmental and social challenges.

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