

Leveraging Text Mining for Trend Analysis and Comparison of Sustainability Reports: Evidence from Fortune 500 Companies

American Business Review
Nov. 2022, Vol.25(2) 416 - 438
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ISSN: 2689-8810 (Online)
ISSN: 0743-2348 (Print)

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<https://doi.org/10.37625/abr.25.2.416-438>

ABSTRACT

In the recent upsurge in environmental concerns, business sustainability has become more prominent than ever. Organizations worldwide are expected to function sustainably, causing the least negative impact on the environment and promoting harmony among the firm, environment, and society. Most firms report their actions related to sustainability in corporate social responsibility (CSR) reports. This research aims to understand and analyze contemporary trends in CSR reports by Fortune 500 companies using text mining. It compares how the focus of sustainability reports varies across countries and industries along key dimensions of sustainability (i.e., environmental, economic, social, and government). Findings from the study suggest variations in the focus of sustainability reports based on various factors, such as country of origin and company size, sector, and tenure, on the Fortune 500 list. Thus, it helps to gain a deeper understanding of the company's motivations for focusing on various dimensions of corporate sustainability.

KEYWORDS

Sustainability, Text Mining, Government Regulation, Sustainability Reporting, Environmental

INTRODUCTION

In recent years, issues pertaining to sustainability have become a topic of concern for regulators, businesses, and researchers (Linnenluecke and Griffiths, 2013; Perkiss et al., 2020). Firms and governments across countries have started to recognize that addressing environmental and social challenges, such as poverty and climate change, has become more critical than ever (UNDP Annual report 2021; Kumar et al., 2022). For example, rising CO₂ emissions are a major global issue (Subbaraman, 2022). To address these challenges, business organizations have started adopting sustainability-related practices in their policies and programs, either voluntarily or as a response to government regulations (Dahmann and Bullock, 2020; Lorenzoni and Benson, 2014). Moreover, organizations publish details of their activities related to sustainability through annual reports, sustainability reports, or Environmental Social Governance reports. Furthermore, several business organizations have implemented frameworks such as the Global Reporting Initiative (GRI) to understand and report sustainability-related initiatives in a structured and globally recognizable form. The structured GRI framework is conducive to performing a comparative analysis of such reports.

In addition to actions by regulators and business organizations on sustainability fronts, there has been a surge in sustainability research by academics and practitioners over the last couple of decades.

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A review article by Minutiello and Tettamanzi (2021) suggests that the disclosure quality of sustainability reporting is increasingly becoming a relevant research topic because the extent of disclosure reflects a firm's long-term performance and value creation for its stakeholders. Analyzing almost 20 years of literature, Purvis et al., (2019) discuss three primary pillars of sustainability: economic, social, and environmental. These three pillars were also explained from a triple-bottom-line perspective by Elkington (2018). Rasmussen et al., (2017) used three pillars of sustainability to track sustainability indicators in agricultural commodity production. The economic pillar pertains to profit, which is a significant determinant of a firm's success and survival, at least in the short- to medium-term. The economic pillar includes better corporate governance and does not consider "profit at any cost" to be appropriate. The social pillar emphasizes the importance of following business practices that are fair to all stakeholders and neighboring communities and not just to shareholders. The social pillar involves various responsible actions from the organization that promote *giving back*, including, but not limited to, learning and growth opportunities, maternity/paternity leave for employees, and better working conditions (Roberts, 2021). The environmental pillar refers to the firm's responsibility toward causing minimum negative externality in terms of emissions, pollution, and climate change, which are generally unaccounted for while pricing the products traditionally. It involves initiatives from the firm, such as zero-waste, zero-deforestation, water harvesting, efficient machines/equipment usage, reduced packaging and transportation, recycling, and the usage of renewable energy. Based on a review of the extant literature on sustainability and a content analysis of sustainability reports, the authors generated a list of keywords representing each dimension of sustainability. The initial list of such keywords was further refined using bigram analysis, which is discussed in detail in the methodology section of the paper. These factors are of particular interest to regulators and researchers in identifying problems concerning the variation in sustainability disclosures.

This study analyzes the sustainability reports of Fortune 500 firms from a three-pillar perspective of sustainability. Moreover, it has been reported (Lyon et al., 2018; OECD, 2001) that government regulations and policies play a critical role in enforcing organizations to take positive actions on environmental and social fronts (Dauvergne and Lister, 2012). Therefore, in our study, we included a fourth dimension: government regulation. This research proposes a framework to represent, analyze, and compare sustainability reports by firms in terms of their focus on three pillars of sustainability (economic, social, and environmental) along with government regulations. Using this framework, this study aims to answer the following questions related to sustainability. Which dimensions of sustainability are focused more on by companies in their reports? Why do companies focus on a particular sustainability dimension? What external and internal factors drive a firm's focus on these different dimensions of sustainability?

The aforementioned questions were chosen because the literature reveals that organizations are skewed in reporting on certain dimensions of sustainability (Hahn and Kühnen, 2013). Firms show such behavior as they are bound by budgetary constraints, as a result of which the firms focus on low-hanging fruits to generate relatively faster outcomes and impact. In certain cases, firms are bound by regulatory pressure. For example, the outbreak of the COVID-19 pandemic has resulted in a global health crisis. Globally, governments have pushed corporate entities to allocate their Corporate Social Responsibility (CSR) budgets to improve the overall health and safety of their employees and surrounding communities. In response, corporations across the globe have shifted their attention to the social aspects of sustainability (Klymenko and Lillebrygfjeld Halse, 2021).

To answer the aforementioned questions, this study analyzes sustainability reports of leading Fortune 500 companies on the economic, social, environmental, and government dimensions (henceforth referred to as the four dimensions). We developed a novel methodology to generate scores for the four dimensions of sustainability from sustainability reports of 360 companies in the Fortune 500. To this end, we extended the sustainability score calculation proposed by Yadava and

Sinha (2016). In addition, we automated this process through an algorithm using text-mining techniques. Based on the review of the literature, the authors synthesized the significant determinants of sustainability reporting (Farisyi et al., 2022; Haidar et al., 2021). These factors were further categorized into internal and external. Furthermore, we conducted an analysis to explore the influence of external (origin country of company, sector, etc.) and internal (company size, tenure on Fortune 500 list) factors on the sustainability scores along the four dimensions of sustainability.

Moreover, we conducted an analysis to explore the influence of external (origin country of company, sector, etc.) and internal (company size, tenure on Fortune 500 list) factors on the sustainability scores along the four dimensions of sustainability. We found that the development ranking of a firm's country of origin influences the economic and social scores reflected in the sustainability report. Companies from relatively less developed countries are likely to have more focus on economic development, while on the other hand, companies from developed countries have more focus on the environmental dimension. Furthermore, the impact of other factors such as company size, sector, and company age on the four dimensions of sustainability has also been analyzed.

The quantity of non-financially reported data is growing exponentially across sectors and geographies. Thus, it is becoming increasingly important to assess the quality and quantity of the reported data to derive meaningful insights. To bridge this gap, the present study developed a novel methodology to assess the semantics of corporate sustainability data. By developing an automated alternative to the manual evaluation of sustainability data proposed by Yadava and Sinha (2016), this study contributes to overcoming the biases associated with manual evaluation.

BACKGROUND

Content analysis of firms' non-financial disclosures has attracted the attention of researchers in both academia and industry exploring sustainability trends in various parts of the world. Many studies have focused on specific geographies. Skouloudis and Evangelinos (2009) evaluated the compliance and quality of sustainability reports from Greek companies using the GRI 2002 reporting framework. Yadava and Sinha (2016) assessed the sustainability reporting disclosures of leading Indian private- and public-sector companies based on the GRI 2011 guidelines. Loh et al., (2017) investigated how the adoption and quality of sustainability reporting disclosures are related to a firm's market value for Singaporean listed companies. Hongming et al., (2020) explored the relationship between corporate sustainability practices and firm performance in 50 publicly limited companies on the Pakistan Stock Exchange. Girón et al., (2021) investigated the relationship between sustainability disclosure and a firm's financial performance, particularly for firms in developing economies, such as Asia and Africa.

Some studies have explored sustainability reporting disclosures for a particular sector. Mahmood and Orazalin (2017) examined Kazakhstan's oil, gas, and mining companies to study the relationship between board characteristics and sustainability reporting disclosures. Buallay (2019) investigated the European banking sector to determine whether sustainability reporting disclosures are associated with bank performance. Kumar and Prakash (2019) examined the banking sector to study Indian banks' sustainability reporting. Raquiba and Ishak (2020) depicted the extent of sustainability reporting practices in 19 energy companies in Bangladesh.

Several studies have targeted the Forbes Fortune list to understand the sustainability reporting disclosures of leading firms across the globe and explore the relationship between firms' corporate sustainability (CS) reporting behavior and variables such as firm size, age, sector, ownership, country of origin, and industry type. Morhardt et al., (2002) assessed the extent of sustainability reporting using the GRI 2000, ISO 14031, and other criteria for 40 of the world's largest companies. Jose and Lee (2007) analyzed corporate environmental disclosures for the 200 largest corporations in the world on the Fortune list. Furthermore, they investigated the environmental reporting of the 200 largest

corporations in the world and found that environmental disclosures vary with respect to country and industry type. Morhardt (2010) examined the sustainability reports of 454 Fortune Global 500 companies and Fortune 1000 companies and observed that organization size has a negligible impact on the sustainability reporting of the sampled companies. Gallo and Christensen (2011) analyzed the effect of firm size and ownership on sustainability-related behavior and found that larger companies report more sustainability information. In terms of firm ownership, public companies engage more in sustainability reporting than private firms. Adler et al., (2018) specifically analyzed the corporate disclosures related to wildlife, biodiversity, and threatened species of the top 150 Fortune Global companies for the year 2014 and observed that the reporting by the sampled companies on biodiversity and threatened species is quite limited, and there is inconsistency in reporting across the index items, even among the high-scoring companies. Schreck and Raithel (2018) investigated the effects of corporate social performance (CSP), visibility, and firm size on sustainability reporting levels and observed that firm size has an inverted U-shaped relationship with sustainability reporting. Ardiana (2021) assessed stakeholder engagement in sustainability reporting by examining 646 sustainability reports of Fortune Global 500 companies from 2015 to 2017 and found a lower level of stakeholder engagement in sustainability reporting disclosures.

The aforementioned literature pertaining to the evaluation of sustainability reporting disclosures has utilized different methodologies for assessing the quality, adherence, and extent of sustainability reporting. Initial studies approached the analysis with the help of content analysis of reports using human coders (Abbott and Monsen, 1979; Aggarwal and Singh, 2018; Daub, 2007; Jose and Lee, 2007; Morhardt et al., 2002; Morhardt, 2010; Vormedal and Ruud, 2009; Yadava and Sinha, 2016; Zhang et al., 2020). Later, some studies started to explore tools and text-mining techniques for conducting a content analysis of CS reports. For instance, Székely and Vom Brocke (2017) applied a natural language processing technique using topic modeling to identify the most common topics and practices in more than 9,500 corporate sustainability reports published between 1999 and 2015. Amini et al., (2018) performed a thematic and content analysis on sustainability reports of 2,013 Fortune 500 companies using Leximancer software. Harymawan et al., (2020) examined the tone of language in sustainability reports of construction sector companies listed in the Indonesian Stock Exchange using a sentiment analysis technique in Python.

Recent studies of large firms in low- and middle-income countries in Africa and Asia have investigated the key company features that influence the adoption and reporting of sustainability practices. For instance, Kazemikhasragh et al., (2021) found that some peculiar characteristics such as the type of company, its economic performance, increased engagement in CSR initiatives, and its assurance by external parties have a positive correlation with the adoption of sustainability reporting. The study by Cicchiello et al., (2022) reported that factors such as higher market-to-book value, higher adoption of external assurance of reports, and higher representation of women and young directors in the company's board structure are positively related to the adoption of sustainability reporting.

Although scholars and practitioners have focused a great deal of attention toward the three-pillar perspective on sustainability as proposed by Purvis et al., (2019), the current study has added government regulation and compliance as the fourth pillar because the non-financial reporting motives are highly influenced by regulatory requirements (Kolk, 2003). This is also evident from the fact that sustainability reporting disclosures have entered from the voluntary to the mandatory realm, and there is growing regulatory pressure in several countries, including the G20 members (European Union and 19 countries including India, China, the UK, and the USA) that require environmental, social, and governance (ESG) disclosures (Aggarwal and Singh, 2018).

The aforementioned studies that use text mining tools for analyzing sustainability reports are limited to finding common themes, topics, and tones in sustainability reports. Our work uses automated text mining and bigram analysis to analyze the focus of Fortune 500 companies on various

dimensions of sustainability. Therefore, our contribution is twofold: Using automated text mining and bigram analysis; and developing a framework to compare Fortune 500 companies on four dimensions of sustainability with help of the EESG (Economic, Environmental, Social, Government) framework proposed in Figure 1.

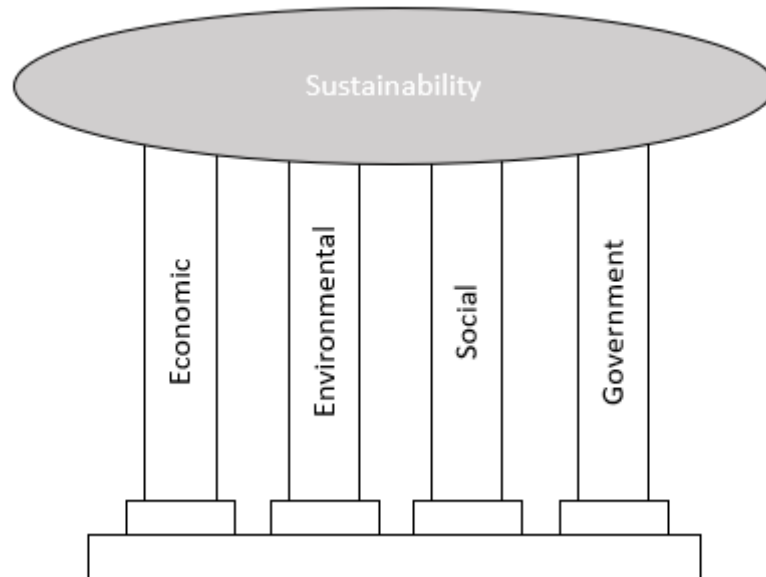


Figure 1. EESG Framework for Four Dimensions of Sustainability

METHODOLOGY

To explore the sustainability reports of corporations worldwide, this study utilized the sustainability reports of Fortune 500 companies in 2019. A sustainability report for each company was searched on the web. Companies for which the 2019 report was not available, the sustainability report for the year 2018 was considered. For most Chinese and Korean companies, sustainability reports are not available in English. The reports for these companies were not considered in further analyses. Overall, the authors found sustainability reports for 395 companies out of Fortune 500 companies in the English language. All sustainability reports were converted to a suitable format (txt format) for text mining using custom code developed in Python 3.7.

As the research was conducted in the year 2020, the most recently available data, that is, for the year 2019, were taken. Moreover, the authors wanted to avoid 2020 and 2021, as both of these years were impacted by the COVID-19 pandemic. During the pandemic, the focus shifted to certain dimensions of sustainability. For example, emissions were temporarily reduced because of the slowdown in economic activity imposed by the lockdowns. Such situations would not have resulted in estimating a true picture of the disclosures, and it may have failed to assess the long-term impact of sustainability disclosures. In addition, 2019 witnessed a surge in regulatory requirements in various parts of the world. For instance, the Securities and Exchange Board of India extended the business responsibility reporting requirements from the top 500 to the top 1000 listed companies in 2019. Similarly, the Stock Exchange of Hong Kong Limited amended the requirements for ESG reporting to shift focus from mere reporting to the board of directors' role in managing ESG-related aspects. Similarly, NASDAQ and the Athens Stock Exchange strengthened their ESG reporting requirements. The UK is legally committed to net zero by 2050, becoming the first major economy in the world (KPMG, 2020).

The primary objective of this research was to compare sustainability reports on four dimensions of sustainability: social, economic, environmental, and government. The authors generated a list of keywords representing each dimension, based on a review of the extant literature on sustainability. To identify other related keywords for each dimension, this study performed content analysis of sustainability reports and backward snowballing using studies from the initial literature review. Hence, the initial list was further refined by extracting important bigrams from the sustainability reports after performing a bigram analysis using a bigram tokenizer implemented in Python 3.7. Initially, we generated the top 1000 most frequent bigrams from all sustainability reports and manually examined each bigram. If the bigram was relevant and related to one of the four dimensions, it was added to the keyword list of that dimension. This step yielded four lists of 69, 69, 32, and 34 words representing each dimension, namely environmental, social, economic, and governmental, respectively. Table 1 lists the keywords extracted from the literature for each dimension. Similarly, a few sample bigram words for each dimension are listed in Table 2. The reader may take a note that in a bigram, two words are separated by ‘_’.

Table 1. List of Keywords Extracted from Literature

Dimension	Keywords
Environmental	<i>environment, emission, pollution, co2, carbon, green, green-energy, solar, wind power, responsible, deforestation, renewable, eco-friendly, ground water level, sustainability</i>
Social	<i>social, responsible, community, human, safety, society, living standard, health support, donation, contribution (not profit), ngo</i>
Economic	<i>profit, revenue, sales, cost, margin, market, segment, customer, promotion, price, money, economic, loss, production, units, target</i>
Government	<i>regulations, policy, rule, compliance, amendment, restrictions, relaxation, penalty, permission, law, restrictions, cap, government</i>

Table 2. Sample Bigrams for Various Dimensions of Sustainability Extracted from Sustainability Reports

Environmental (69 words)	Social (69 words)	Economic (32 words)	Government (33 words)
climate_change	social_responsibility	energy_efficiency	audit_committee
environmental_protection	health_safety	carbon_economy	audit_supervisory
clean_energy	poverty_alleviation	technological_innovation	ethics_compliance
carbon_footprint	respect_human	zero_waste	internal_audit
environmental_footprint	social_governance	reduce_waste	code_ethics
wind_power	safety_health	technology_innovation	supervisory_committee
water_consumption	gender_equality	technology_development	ethics_integrity
food_waste	food_safety	development_sustainable	legal_compliance
emission_reduction	community_development	energy_waste	environmental_compliance
energy_conservation	socially_responsible	waste_reduction	regulatory_compliance
reduce_carbon	public_welfare	open_innovation	governance_code
solar_power	human_labor	sustainable_supply	ethical_conduct
hazardous_waste	occupational_safety	fair_trade	committee_audit
global_warm	inclusion_diversity	fuel_efficiency	compliance_committee
environmentally_friendly	child_labor	drive_innovation	governance_ethics

After creating the keyword lists for each dimension, the dimensionality reduction technique and cosine similarity method were deployed to compute the similarity score of each report for all four dimensions of sustainability. This study uses latent semantic indexing (LSI) (Deerwester et al., 1990) based on singular value decomposition (Businger and Golub, 1969; Golub and Reinsch, 1971) to map the semantic structure of sustainability reports from a high-dimensional vector space model to a low-dimensional representation. This study first converted all sustainability reports into a matrix of terms by document. This term-document matrix \mathbf{X} was decomposed by Singular Vector Decomposition (SVD) to analyze the semantic association among terms in the collection of sustainability reports. We used the term frequency-inverse document frequency (a standard method used in information retrieval research) to identify the weights of the terms (Turney, 2001). Matrix \mathbf{X} of rank p was decomposed into a product of three matrices, \mathbf{U} , \mathbf{L} , and \mathbf{A} , which are called the linearly independent components of \mathbf{X} .

$$\mathbf{X} = \mathbf{U}\mathbf{L}\mathbf{A}^T$$

where the matrices \mathbf{U} and \mathbf{A} have a unit length with orthonormal columns (and are called singular vectors), and matrix \mathbf{L} is a diagonal matrix (and is called singular values) of the same rank (p) as \mathbf{X} . Most of the singular values are very small and may be removed to retrieve a new matrix \mathbf{X}' with rank k ($k < p$) that best approximates \mathbf{X} .

$$\mathbf{X}' = \mathbf{U}_k\mathbf{L}_k\mathbf{A}_k^T$$

where the matrix \mathbf{L}_k is the resultant matrix after removing $(p-k)$ diagonal nonsignificant singular values. To remain consistent, we removed the corresponding entries from matrices \mathbf{U} and \mathbf{A} to retrieve \mathbf{U}_k and \mathbf{A}_k , respectively. In this way, we map all sustainability reports to this “compressed version” of the vector space model.

To identify the similarity of these reports with the vector of the keyword list representing each dimension, we converted each keyword list into a vector of dimension k using the fold-in method (Adelman and Simina, 2004; Berry et al., 1995) of LSI. In this way, we converted each sustainability report into a vector of dimension k and each sustainability dimension (social, economic, environmental, and government) into vectors of dimension k . Finally, to assess the similarity between a particular sustainability report of a company and the four sustainability dimensions, we estimated cosine similarity (Han et al., 2012). We used the final cosine values as similarity scores to represent the focus of a report on various dimensions of sustainability.

RESULTS

In this section, we analyze the results to explain the impact of various countries' characteristics on firms' focus on various dimensions of sustainability. First, we explored the effect of the level of development of the originating country on the scores of various sustainability dimensions. Further, we explore the effects of firm size and age in the Fortune 500 list on sustainability disclosure across various dimensions. Finally, the Results section concludes by exploring interesting sustainability disclosure patterns across companies and industry sectors.

IMPACT OF THE LEVEL OF DEVELOPMENT

We segregated countries into two types – developing and developed – based on the report “World Economic Situation and Prospects 2014” by the UN¹. Table 3 presents the average scores for these countries on various dimensions of sustainability.

Table 3. Comparison Between Firms from Developed and Developing Countries

Country of Origin	No. of Firms	Social	Environmental	Economic	Government
Developed	318	0.391	0.273	0.294	0.241
Developing	77	0.313	0.241	0.340	0.245

Figure 2 graphically represents the scores (Table 3) for firms in developed and developing countries. We can observe from Figure 2 that for developed countries, the highest focus is on the social dimension, whereas for developing countries, the highest focus is on the economic dimension. This is justifiable from the fact that developed countries have already achieved economic sustainability and have focused more on social aspects. We also find that, for developing countries, the environmental dimension is the least focused one. This section is discussed in detail in the media².

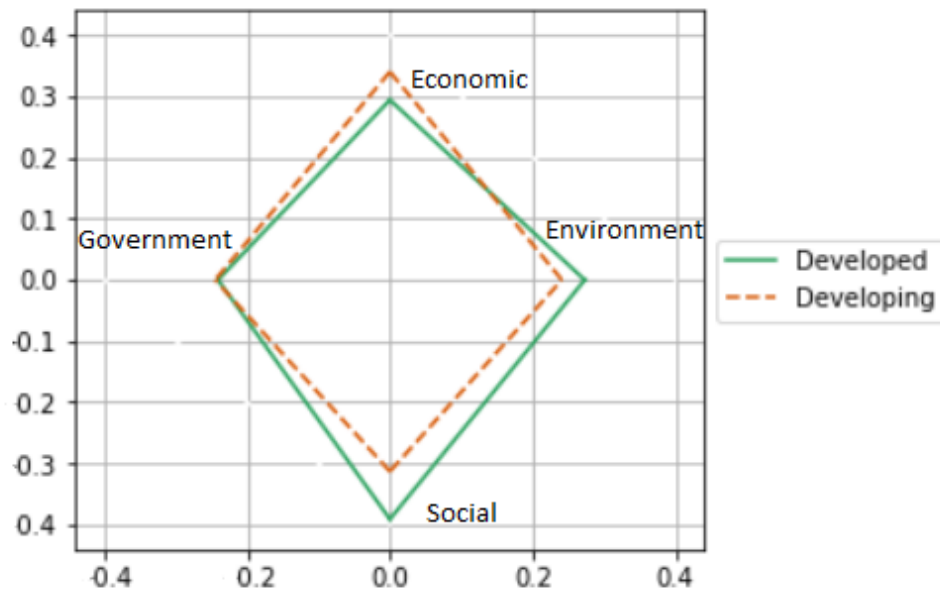


Figure 2. Comparison Between Firms Belonging to Developing and Developed Countries

We can observe from Figure 2 that the focus of firms in developed countries is skewed toward the social dimension only. However, in developing countries, the focus is skewed toward economic and social dimensions. Moreover, in the government/regulation dimension, firms in developing and developed countries seem similar in terms of their focus.

To further understand the differences between firms in developed and developing countries, we ran an independent samples t-test. Table 4 presents the results. The table shows that, except for the

¹ https://www.un.org/en/development/desa/policy/wesp/wesp_current/2014wesp_country_classification.pdf

² <https://epic.uchicago.edu/news/why-environmental-quality-is-poor-in-developing-countries-a-primer/>

government/regulation dimension, firms in developed and developing countries differ in their level of focus on various dimensions of sustainability. This is also in line with the inferences from Figure 2.

Table 4. Comparison Between Developed and Developing Countries

Feature/Dimension	Developed- Developing	Lower	Upper	p-value
Environmental	0.03	-0.001	0.07	0.06
Economic	-0.05	-0.08	-0.01	0.01
Government	-0.004	-0.04	0.03	0.81
Social	0.08	0.03	0.12	0.00

IMPACT OF FIRM CHARACTERISTICS

In this subsection, we analyze the impact of firm characteristics, such as size (with respect to the number of employees) and age (duration for which it is part of the Fortune 500 list), on their relative scores on the four dimensions. We can observe from Table 5 and Figure 3 that irrespective of firm size, their scores on the economic dimension are similar. However, firms with fewer than 50,000 employees do better than other firms in the remaining three dimensions (environmental, social, and government). This implies that it is easier for smaller firms to manage other than the economic dimensions of sustainability. Firms with more than 50,000 employees have a similar environmental score, but firms in the size range 50,000–200,000 have a better score on social dimensions. This again signifies the difficulty in managing social issues in a larger organization.

Table 5. Comparison of Sustainability Dimensions with Respect to Firm Size

Firm Size	Social	Environmental	Economic	Government
Below 50000	0.401	0.288	0.294	0.248
Between 50 K and 200K	0.373	0.257	0.308	0.243
Above 200K	0.346	0.261	0.303	0.229

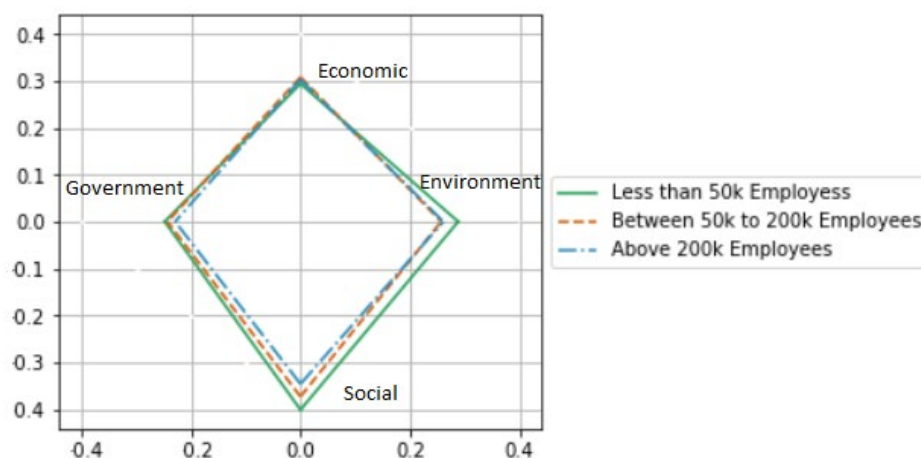


Figure 3. Comparison of Sustainability Dimensions with Respect to Firm Size

The samples t-test results presented in Table 6 confirm our earlier findings that firms larger than 200,000 (high) are significantly different from the other two categories. Moreover, firms below 50,000 (low and medium) do not differ from each other.

Table 6. Comparison of Social Score for Firms with Different Size

Size Pairs	Difference	Lower	Upper	p-value
Medium -Low	-0.03	-0.01	0.04	0.31
High-Low	-0.06	-0.11	0.00	0.08
High-Medium	-0.03	-0.05	0.001	0.07

We can observe from Table 7 and Figure 4 that the duration for which firms are part of the Fortune 500 list does not impact their score on the economic, environmental, and government fronts. However, firms with more than 20 years of experience on the Fortune list perform better on social scores than the rest. This finding, along with the finding with respect to size, indicates the sequence in which firms focus on the various dimensions of sustainability. Firms justifiably focus first on the economic dimension, followed by environmental and government regulations. The social dimension appears to be the last dimension to focus on.

Table 7. Sustainability Dimension Scores with Respect to Firm's tenure on Fortune 500 List

Years on Fortune 500 List	Social	Environmental	Economic	Government
Less than 10 years	0.347	0.257	0.314	0.236
Between 10 to 20	0.361	0.261	0.308	0.236
More than 20 years	0.395	0.273	0.296	0.247

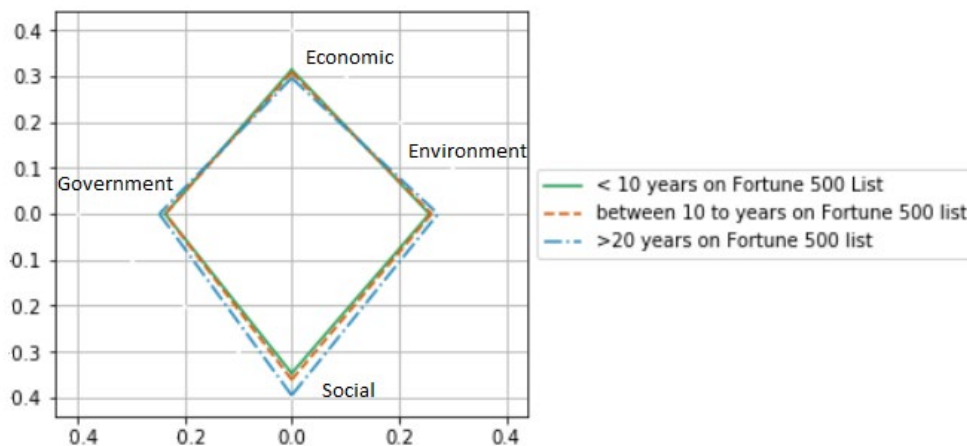


Figure 4. Comparison of Sustainability Scores with Respect to Firm's Tenure on Fortune 500 List

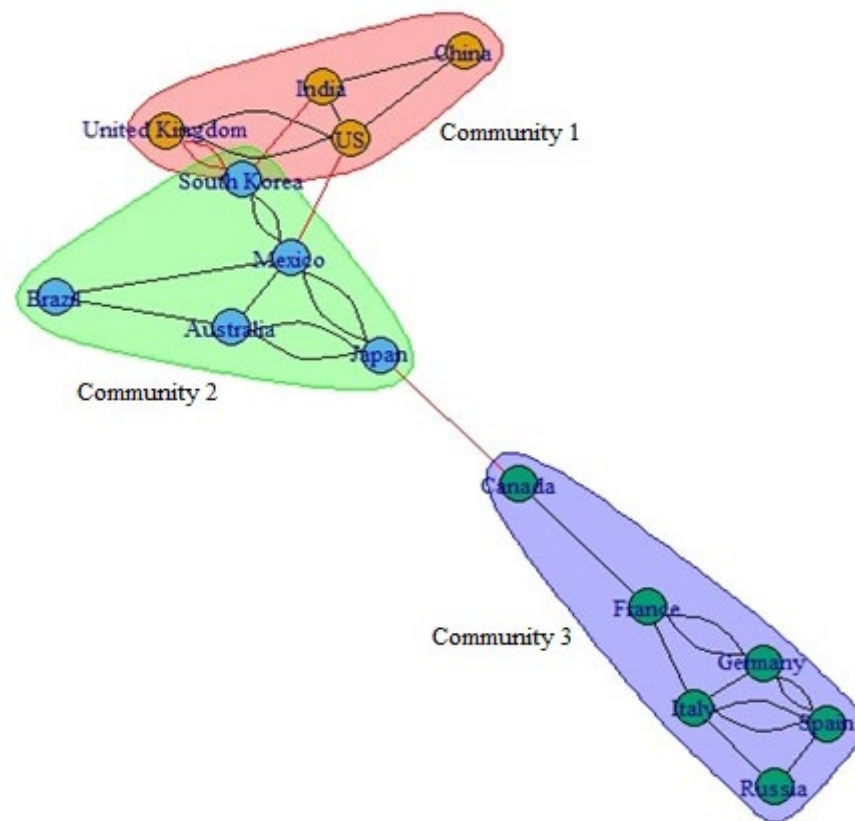
From Table 8, we observe that firms less than 10 years old (0 decade) and firms between 10 and 20 years old (1 decade) do not differ from each other. Similarly, 1-decade type firms are not different from firms with more than 20 years (2 decade) on the Fortune list. However, the 0-decade firms are significantly different from the 2-decade firms. This indicates that the transformation in these four dimensions was a relatively slow process, and differences were observed only after a couple of decades.

Table 8. Comparison of Social Scores Among Firms with Different Tenure on Fortune 500 list

Duration Pairs	Difference	Lower	Upper	p-value
1 decade- 0 decade	0.01	-0.05	0.07	0.85
2 decade- 0 decade	0.05	-0.01	0.10	0.09
2 decade- 1 decade	0.03	-0.02	0.08	0.25

ALIGNMENT BETWEEN COUNTRIES

We explored the similarity between the top-15 countries from the Gross Domestic Product (GDP) perspective to assess the alignment between countries on different dimensions of sustainability. We performed a community-based network analysis for this comparison. Network analysis is an established method for developing relational interpretation of a community-based network to yield additional insights regarding network properties (Lin et al., 2015; Maya-Jariego and Holgado, 2015). As a part of the community-based network analysis, we obtain hubs, authorities, and communities of the top-15 countries based on GDP. The hub and authority graphs are shown in Figure 5. From the community detection graph presented in Figure 5, we observe three communities in each country.

**Figure 5.** Community Detection Graph for Top-15 GDP Countries

The first community is formed by countries such as China, India, the UK, and the USA, with South Korea overlapping Communities 1 and 2. The presence of China, India, and South Korea in the same community is justifiable because of the development path and commonly understood similarities

based on dimensions such as environmental, economic, social, and government³. Firms in these countries have relatively low scores for the environmental, economic, and government dimensions of sustainability. Surprisingly, countries such as the UK and USA are in the same community. Nevertheless, from Table 9, we can observe that China, India, and South Korea score lower than the USA and UK on the environmental dimension.

The second community consisted of Australia, Brazil, Japan, Mexico, and South Korea. We can observe from Table 9 that firms in Japan have better environmental dimension scores than firms belonging to other countries in Community 2. Similarly, firms in Brazil are relatively better than other firms in Community 2. The aforementioned observations of Japan and Brazil from Table 9 are identifiable from the location of these two countries in the community detection graph shown in Figure 5.

Table 9. Comparison of Top-15 GDP Countries on Sustainability Dimensions

Country	Social	Environmental	Economic	Government	Community
US	0.361	0.262	0.235	0.214	1
China	0.249	0.231	0.317	0.203	1
India	0.344	0.203	0.303	0.262	1
United Kingdom	0.403	0.275	0.315	0.171	1
South Korea	0.421	0.236	0.361	0.227	1, 2
Japan	0.483	0.271	0.286	0.27	2
Brazil	0.499	0.217	0.415	0.345	2
Australia	0.489	0.212	0.282	0.297	2
Mexico	0.442	0.252	0.335	0.244	2
Germany	0.325	0.304	0.339	0.306	3
France	0.381	0.314	0.362	0.249	3
Italy	0.34	0.287	0.445	0.295	3
Canada	0.469	0.371	0.229	0.279	3
Russia	0.31	0.248	0.579	0.404	3
Spain	0.39	0.296	0.396	0.344	3

Canada, France, Germany, Italy, Spain, and Russia formed a third community. It is intuitive that European countries, such as France, Germany, Italy, and Spain, are part of the same community because of the similarity in their geographical, economic, and shared regulation practices. In certain ways, the presence of Russia in the cluster could also be explained, as Russia shares some of the aforementioned aspects. However, the presence of Canada in the same community is counterintuitive because of differences in policies and initiatives on sustainability. Nevertheless, we can observe from Figure 5 that Canada is relatively distant from the other countries in Community 3. Moreover, Table 9 shows that the scores of firms in Canada on the environmental, economic, and social dimensions are quite distinct from those of other firms in the same community.

³ <https://europa.eu/capacity4dev/articles/challenges-implementing-sustainable-development-goals-asia>

From Figure 6, it is evident that countries in Community 1 have lower government scores than countries in Communities 2 and 3. To determine if this is statistically true, a t-test was conducted, with the results shown in Table 10.

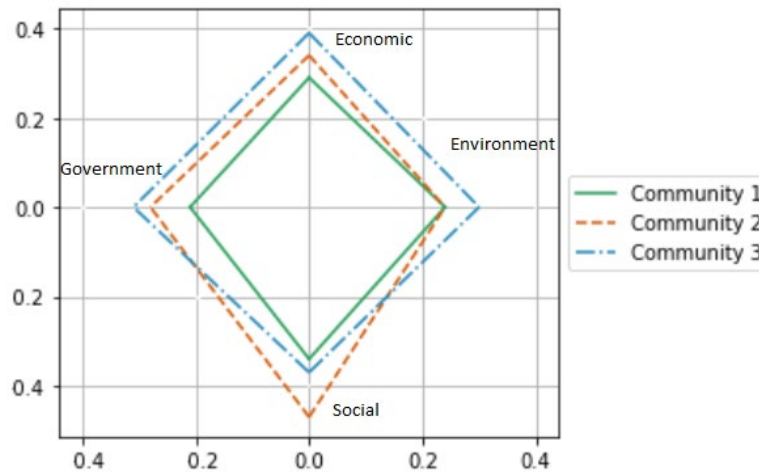


Figure 6. Alignment Among Communities with Respect to Countries

Table 10. Comparison of Government Score Among Various Country Communities

Community Pairs	Difference	Lower	Upper	p-value
Community 2-1	0.06	0.02	0.11	0.00
Community 3-1	0.09	0.05	0.13	0.00
Community 3-2	0.02	-0.03	0.07	0.72

Similarly, another interesting insight from Figure 6 is that social scores for countries in Community 2 are higher than those in the other two communities. To determine if this is statistically true, a t-test was conducted, with the results shown in Table 11.

Table 11. Comparison of Social Score Among Various Country Communities

Community Pairs	Difference	Lower	Upper	p-value
Community 2-1	0.14	0.08	0.20	0.00
Community 2-3	0.11	0.05	0.18	0.00
Community 3-1	0.02	-0.03	0.08	0.51

From Figure 6, we can also see that Community 3 has a higher environmental score than the other two communities. To determine if this is statistically true, a t-test was conducted, with the results shown in Table 12.

Table 12. Comparison of Environmental Score Among Various Country Communities

Community Pairs	Difference	Lower	Upper	p-value
Community 3-1	0.06	0.01	0.10	0.00
Community 3-2	0.05	0.00	0.11	0.05
Community 2-1	0.01	-0.04	0.05	0.96

ALIGNMENT BETWEEN SECTORS

In this section, we apply community-based network analysis to visualize the alignment among different business sectors. We can observe from the community detection graph shown in Figure 7 that five distinct communities are formed based on the sectors.

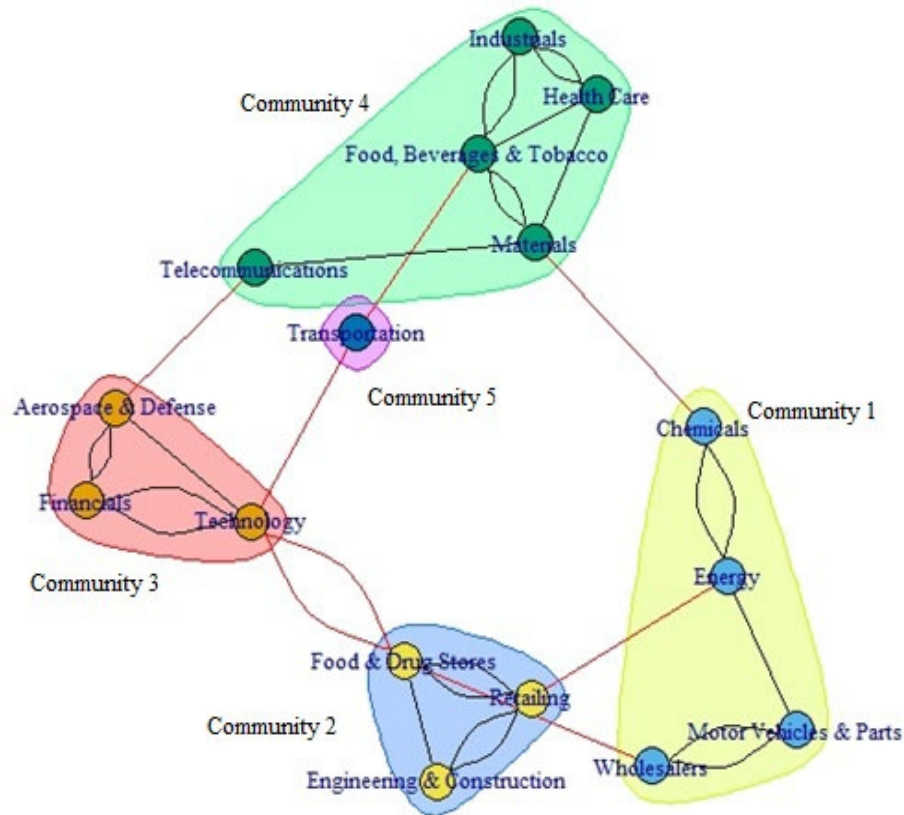


Figure 7. Community Detection Graph for Various Industry Sectors

The first community is represented by firms in the energy, motor vehicles and parts, wholesalers, and chemical sectors. It is intuitive that firms in the chemical, energy, and motor sectors fall into the same community because of the intensive raw material requirements and emissions during the manufacturing process. However, the presence of a wholesale sector in the same community is counterintuitive. Nevertheless, close observation of Table 13 reveals that wholesalers seem to be different from the rest of the firms in the community in the economic dimension. The same can be observed in the community detection graph presented in Figure 7. Unexpectedly, in the environmental dimension, firms in the wholesale sector scored lower than firms in the energy sector, while they scored higher than firms in the motor and chemical sectors. For a long time, energy sector firms (mostly thermal power-based) have been known to have high environmental emissions and take various steps, including switching to renewable energy sources. On the other hand, environmental issues related to the auto and chemical sectors have not received much attention in the past, and green initiatives in these sectors are a relatively recent phenomenon. Therefore, different stages of green focus for these sectors could explain the aforementioned counterintuitive finding. Firms are distinct from each other, except for firms in Communities 4 and 5, which appear to be similar.

Table 13. Comparison of Various Sectors on Sustainability Dimensions

Sector	Social	Environmental	Economic	Government	Group
Energy	0.20	0.16	0.17	0.10	1
Motor Vehicles & Parts	0.20	0.12	0.16	0.13	1
Wholesalers	0.22	0.14	0.12	0.12	1
Chemicals	0.19	0.12	0.17	0.08	1
Food & Drug Stores	0.21	0.16	0.12	0.08	2
Retailing	0.22	0.17	0.15	0.07	2
Engineering & Construction	0.25	0.15	0.15	0.08	2
Financials	0.17	0.14	0.11	0.09	3
Technology	0.19	0.16	0.12	0.08	3
Aerospace & Defence	0.18	0.13	0.10	0.08	3
Health Care	0.16	0.09	0.12	0.09	4
Food, Beverages & Tobacco	0.16	0.12	0.14	0.09	4
Telecommunications	0.19	0.12	0.13	0.05	4
Industrials	0.16	0.10	0.12	0.10	4
Materials	0.15	0.11	0.14	0.07	4
Transportation	0.16	0.15	0.14	0.08	5

The second community consisted of food and drug stores, retail, engineering, and construction sectors. The presence of firms in food and drug stores and retail sectors in the same community is expected; however, the inclusion of firms in the engineering and construction sectors is unexpected. However, we can observe from Table 6 that engineering and construction share similarities with other firms in the community on the economic and environmental dimensions, and therefore explain the inclusion of these three sectors in the same community. Moreover, the wholesale sector is not far from food and drug stores and retail, even though it is in a different community (Figure 7). This closeness is justified because wholesale, food and drug stores, and retail are non-manufacturing sectors and have similar business characteristics.

The financial, technological, aerospace, and defense sectors form a third community. Table 13 shows that firms in these three sectors are similar in all dimensions. However, they are relatively dissimilar on the environmental front, and technology firms have a higher score than firms in the other two sectors.

The fifth community comprises sectors such as healthcare, food, beverages and tobacco, telecommunications, industries, and materials organized into one community. All four sectors except the telecommunications sector require raw materials, and they are relatively more productive sectors than services.

Healthcare is predominantly a service but requires material management for medicine and other medical supplies. Therefore, the presence of materials, industrial, food, beverages and tobacco, and healthcare in the same sector is justifiable. However, the presence of telecommunications is counterintuitive, but we can observe from Table 13 that firms in the telecommunication sector are different from other firms in the community in terms of social and government dimensions. Moreover, the position of telecommunications in Figure 7 also indicates that it is different from other firms in the

community.

Further investigations of these communities reveal that sectors in Community 1 have higher scores for social and economic dimensions, and sectors in Community 2 have a higher score for social and environmental dimensions. Community 3 (financial, technology, aerospace, and defense sectors) has a lower score for economic and social dimensions. Sectors in Community 4 had lower environmental and social scores. Community 5 had a moderate social score and a lower score for the environmental dimension.

Figure 8 depicts the alignment among various communities of sectors on sustainability dimensions. From Figure 8, we can observe that in the environmental dimension, all communities except Community 5 are similar. Similarly, in the government dimension, all sectors except Community 1 are similar. However, in the social dimension, all communities are different from each other.

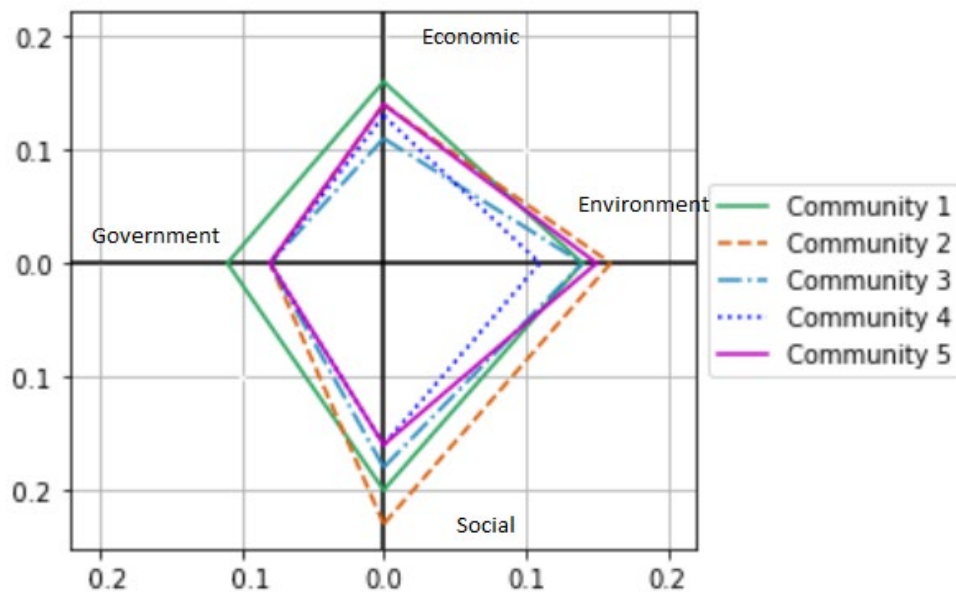


Figure 8. Alignment Among Communities Based on Industry Sectors

Figure 8 shows that sectors in Community 1 have higher scores for the government than that for other communities. However, we could not find a statistical difference in the government scores for various communities of sectors. Another striking observation is the low score for the environment dimension of Community 4 compared with other communities. Table 14 provides the statistical differences in the environmental scores for Community 4 compared with other communities. Companies belonging to sectors in Community 4 had significantly lower environmental scores than those belonging to sectors in Communities 1, 2, and 3. Thus, sectors such as materials, healthcare, telecommunications, and industries have a lower score on the environmental dimension than other sectors.

Table 14. Comparison of Environmental Score Among Various Sector Communities

Community Pairs	Difference	Lower	Upper	p-value
Community 4-1	-0.07	-0.12	-0.01	0.01
Community 4-2	-0.09	-0.17	-0.01	0.01
Community 4-3	-0.06	-0.11	-0.01	0.01
Community 4-5	-0.07	-0.17	0.03	0.26

DISCUSSION

In continuation of the research efforts to evaluate corporate sustainability reports, we derived a novel content analysis methodology to assess the sustainability reports of Fortune 500 companies and subsequently compared the scores on different dimensions with an emphasis on factors such as level of development, firm characteristics, sectors, and countrywide analysis.

The developmental status of a country has an impact on various dimensions of sustainability, except for the government dimension. In comparison, the focus of firms in developed countries is skewed only toward the social dimension, whereas firms in developing countries are skewed toward the economic and social dimensions. This is evident from the fact that developed countries have achieved economic sustenance and, as such, firms in developed countries are focusing more on social development. By contrast, developing countries have the highest focus on economic dimensions and the least focus on environmental dimensions. This is in line with the common notion that developing countries aspire to transform into developed economies, and in the process, the focus on environmental sustainability is compromised. In a similar context, Farisyi et al., (2022) investigated sustainability reporting adoption in developing countries and found that lack of training, low level of expertise, and negative attitudes toward sustainability reporting are significant determinants affecting the quality of disclosures in developing countries. Bhatia and Tuli (2018) suggested that developing nations should work more on the quality of sustainability reporting, as sustainability issues are more pertinent in developing countries than in developed countries.

Many studies have explored the relationship between the size of a company (in terms of revenue) and the different dimensions of sustainability. Gallo and Christensen (2011) analyzed the effect of firm size on sustainability-related behavior and found that larger companies report more on sustainability information, whereas Bergmann and Posch (2018) found that the size of the firm matters only in the case of mandatory sustainability reporting, while it is not a crucial factor for firms not mandated by law for sustainability reporting. However, our research did not find a significant impact of the size (in terms of revenue) on the EESG dimensions. Hence, we analyzed the impact of firms' characteristics, such as size (in terms of the number of employees), on their relative scores on the EESG dimensions. This adds a new perspective to the body of literature with regard to company size and sustainability disclosures. In comparison, we observed that large firms (more than 200,000 employees) are significantly different from small (below 50,000) and medium firms (50,000–200,000). We observed that as company size increased, the score on the social dimension decreased, signifying ignorance of managing social issues in larger organizations. At the same time, it poses great opportunities for large organizations to tackle these issues by utilizing employee engagement in CSR activities.

We further observe that the longevity of the firm for which it is part of the Fortune 500 list does not have much impact on the economic, environmental, and government dimensions. However, as the number of years on the Fortune 500 list increased, the score on the social dimension also increased. We also observed that firms below 10 years old (0-decade type) are significantly different from those

with more than 20 years old (2-decade type), which indicates that the transformation of the EESG dimensions is a relatively slow process, and differences are observed only after a couple of decades. When the two dimensions (size and age) are combined, old small firms have a greater focus on the social dimension, whereas big new firms have a comparatively lesser focus on the social dimension. This is in line with a study by Badulescu et al., (2018) that observes that newer (young) firms are less involved in social responsibility actions than older firms that have dedicated departments or people to manage social responsibility actions. Our findings also aligned with the finding by Prashar (2021), which found that large and mature firms engage more in sustainability reporting because they have a comparatively better presence of institutional investors in their corporate board composition.

IMPLICATIONS

As the pandemic was a big setback for sustainable development, it would be interesting to understand the future trajectories of firms in both developed and developing countries. The Sustainable Development Report 2021 reveals that sustainable development has been severely impacted by the COVID-19 pandemic, leading to a downward trend in the global average SDG index score for 2020 since the adoption of the SDGs in 2015 (Sachs et al., 2021). The United Nations have announced the 2020-30 decade as the Decade of Action, and 17 SDGs have to be achieved by 2030. As part of the Paris Climate Agreement, the majority of countries have made climate-related commitments, and firms located in these countries are also increasingly taking net-zero pledges to achieve carbon neutrality commitments. Against the backdrop of this scenario, the current research provides a framework and methodology to scrutinize communicated sustainability data with the help of technological interventions.

THEORETICAL IMPLICATIONS

Sustainability reporting frameworks are evolving and will continue to evolve over time (Minutiello and Tettamanzi, 2021). This necessitates the assessment of the information provided by these frameworks. At this crucial juncture, the current study provides a technological intervention by developing a novel content analysis methodology through digitalized means to assess various dimensions of sustainability. Furthermore, this study contributes to sustainability disclosure research and aligns with the findings of previous studies by suggesting that there are variations in sustainability reporting with respect to organizational size, origin, age, and sector (Bergmann and Posch, 2018; Gallo and Christensen, 2011; Prashar, 2021). The findings and observations from this study may serve as a premise for future inquiries into the sustainability reporting behavior of firms across the globe. This study adds a new EESG framework and automated text mining methodology using bigram analysis to the body of literature to analyze corporate sustainability disclosures. The developed framework and methodology have wide applications across various sectors and geographies for assessing longitudinal data pertaining to corporate sustainability.

PRACTICAL IMPLICATIONS

This research reveals that there is a lack of a uniform set of standards for disclosing, measuring, and reporting a company's progress on various dimensions of sustainability. The need for a globally recognized standard that integrates all previous standards and frameworks was recognized at the COP 26 summit. In response, the International Sustainability Standards Board is developing a standard for sustainability reporting similar to the financial reporting standard developed by the International

Accounting Standards Board (Eccles and Mirchandani, 2022). Toward this end, the present study would help stakeholders understand the underlying behavior of firms in a variety of contexts with the robust methodology developed in this study. In particular, it would be helpful to generate insights into the relative focus of firms on different dimensions of sustainability. Such information would be of greater interest to regulators and evaluators in taking corrective measures to ensure long-term impacts and outcomes in maintaining an equitable planet and just society. Community graphs would particularly be of interest to policymakers in assessing the variation and similarities in reporting between different countries.

LIMITAIONS AND CONCLUSION

This study has several limitations. First, the present research was restricted to analyzing the sustainability reports of 395 out of Fortune 500 companies in the English language. Future research could address this shortcoming by incorporating a large sample and including sustainability reports written in other prominent international languages. Second, this study generated a list of limited keywords by reviewing the literature pertaining to different dimensions of sustainability. The keywords extracted from the literature were subjective in nature. Thus, future research may consider analyzing other linguistic versions of sustainability reports using the automated text mining methodology applied in the current study. In addition to limiting the analysis to keywords and bigrams, future studies may also incorporate semantic analyses to extract deeper trends and patterns from sustainability reports. Third, this study leverages the state-of-the-art LSI technique to project reports to vectors. Future studies may utilize the latest advancements in natural language processing, such as word embeddings and text encoders, for the effective analysis of sustainability reports.

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