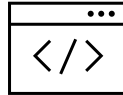


Analysis of ESG Disclosure in Corporate Annual Reports Through Natural Language Processing

Course: 55724

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Introduction

This report presents the analysis of environmental, social, and governance (ESG) disclosures from the annual reports of 500 companies. Natural language processing techniques were utilized to categorize sentences from the reports based on the level and type of ESG evidence disclosed. The goal was to assess trends in ESG reporting over time and differences between companies.

2. Methods

2.1 The Data

The raw data for this analysis consisted of a CSV file with URLs linking to the annual reports for 500 companies. The company name and year of each report were extracted from the URLs. The PDF reports were programmatically extracted from the URLs using the Python library 're', and they were converted to a Python list, where each sentence is a string element in the list. This resulted in a Pandas dataframe containing the report URL, company name, year, and “sentences” column, contains a list of individual sentences for each report.

The report years (Fig. 1a) ranged from 2000-2023, predominantly 2010-2020. Sentence counts per report (Fig. 1b) showed a right-skewed distribution with ~171 median sentences. Summary statistics (Table 1) indicate a median of 171 and mean of 467 sentences, reflecting the skew, and high variability.

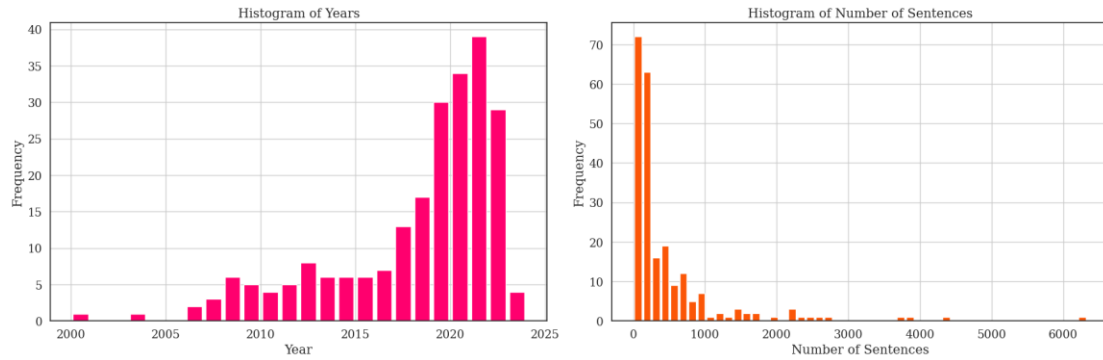


Figure 1. Histograms of report years and sentence counts. The left plot shows the distribution of report years, ranging from 2000-2022 with most dated 2010-2020. The right plot displays the distribution of sentence counts per report, demonstrating a right-skewed shape with a median of approximately 5,000 sentences.

Table 1. Summary statistics

Statistics	Number of Sentences	Year
<i>Average</i>	467	-
<i>Median</i>	171	-
<i>Standard Deviation</i>	764	-
<i>Max</i>	6327	2023
<i>Min</i>	1	2000
<i>Mode</i>	-	2021

2.2 The Model

The sentences were categorized using the *flan-T5-Large* NLP model by Google, from HuggingFace. The model classified each sentence into one of five categories:

1. **Quantitative Evidence:** The sentence contains numerical ESG data.
2. **Action Evidence:** The sentence describes ESG actions without numbers.
3. **Suggestive Evidence:** The sentence suggests but does not directly state ESG actions.
4. **Intention:** The sentence discusses plans to take future ESG actions.
5. **Other:** The sentence does not fit any of the above categories.

For each report, the number of sentences classified into each category was summed, yielding five columns in the dataframe recording the number of sentences in each category. The categorized sentences allow analysis of ESG reporting quality, trends, and differences between companies and years.

2.3 Analysis

To examine trends over time, the percentage of sentences in each category was calculated and visualized through stacked bar charts for the years 2005-2023. Differences in the percentage of Quantitative Evidence sentences across all years were analyzed to determine statistical significance.

Comparisons between companies were done by converting sentence counts to percentages and comparing differences in the combined Action and Quantitative Evidence percentages across all companies. Companies were then ranked by average Action Evidence percentage, with the top and bottom five highlighted. To evaluate company performance, the ratio of Action plus Quantitative sentences to Intention sentences was calculated. Companies were sorted by the mean ratio and visualized through bar charts, including a focused look at companies with ratios between 0-1.

All data processing, classification, and analysis was performed in Python using a Jupyter Notebook attached. The analysis and visualizations aimed to assess overall trends and company differences in ESG disclosure based on the categorized sentences.

3. Results and Discussion

The distribution of sentences classified into each category provides insights into overall trends. As shown in Figure 2, the mean percentage of sentences labeled as "Other" was 36.5%, indicating a substantial portion did not fit the primary ESG categories. Excluding "Other", Figure 3 displays the mean percentage per main category. Quantitative Evidence accounted for 21.9% while Action, Suggestive, and Intention were 5.5%, 52%, and 20.1% respectively.

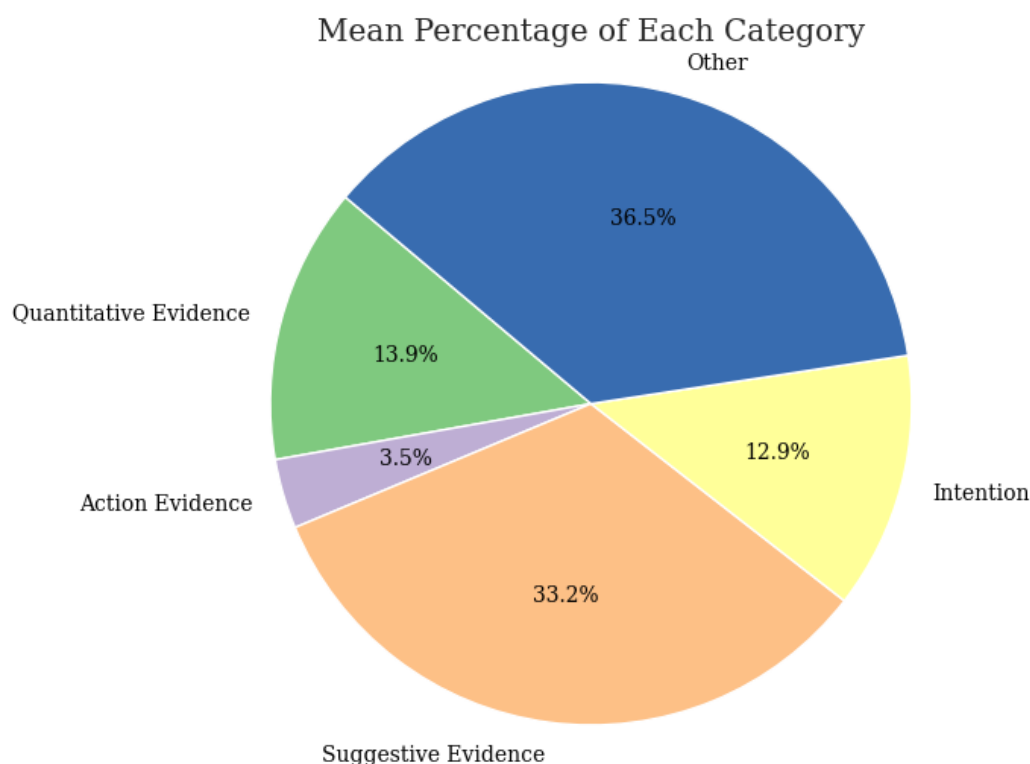


Figure 2. Mean Percentage per Sentence Category

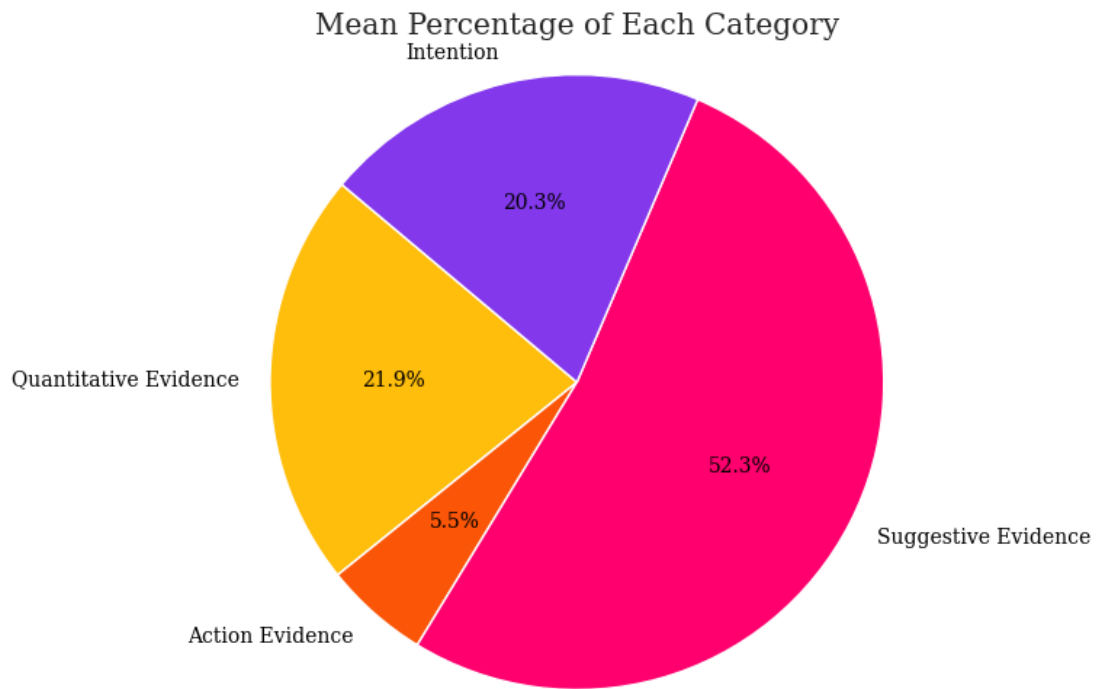


Figure 3. Percentage per Category Excluding "Other"

The stacked bar charts visualizing category trends over time reveal notable changes during the COVID-19 pandemic year of 2021 (Fig. 4). In that year, the percentages of Intention and Suggestive Evidence sentences increased, while the percentages of Quantitative and Action Evidence decreased. This shift towards future plans and suggestive language rather than concrete actions indicates that companies focused more on internal changes and adapting to crisis conditions, as opposed to implementing practical environmental and social measures during the pandemic. Excluding the outlier year of 2021, Figure 4 shows a decrease in the percentage of intent statements from 2005 to 2023. This downward trend in future plans and intentions indicates that companies have shifted a greater focus toward actualized actions and current practices when disclosing ESG information. The growing emphasis on implemented initiatives rather than ambitious goals potentially reflects the growing environmental awareness and concrete priorities.

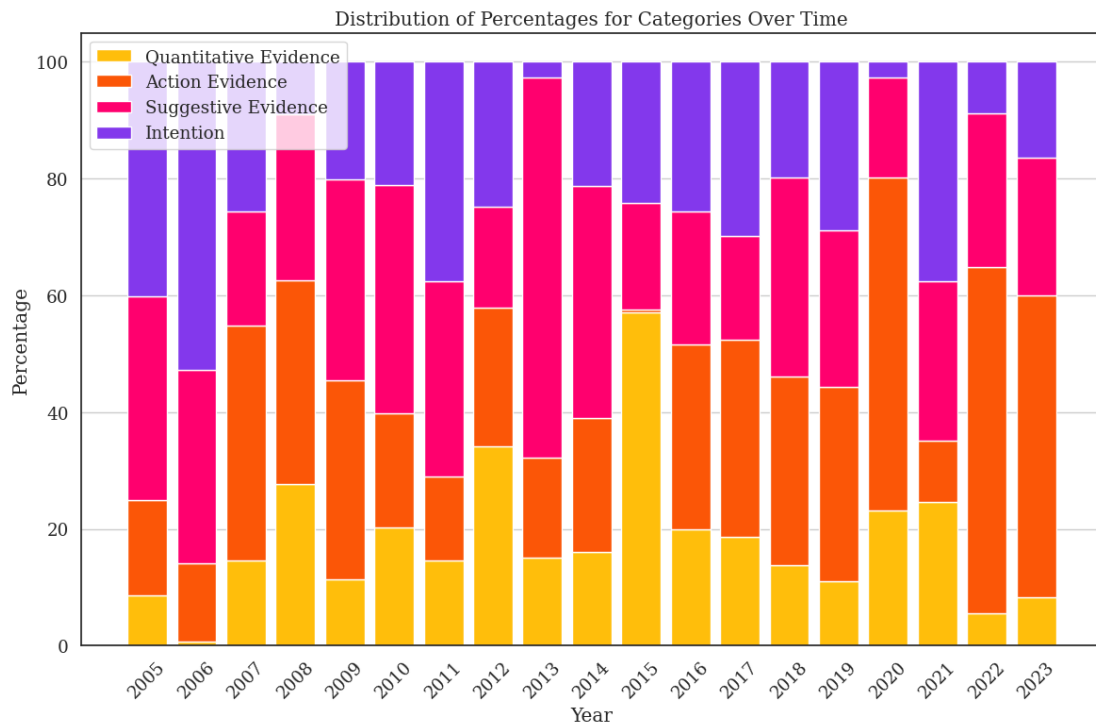


Figure 4. Category Percentages Over Time

Comparisons between companies provide further insights. The combined Action and Quantitative Evidence percentages, representing tangible ESG evidence. Figure 5 displays the Action + Quantitative rank ordering of companies, with 30.6% on average.

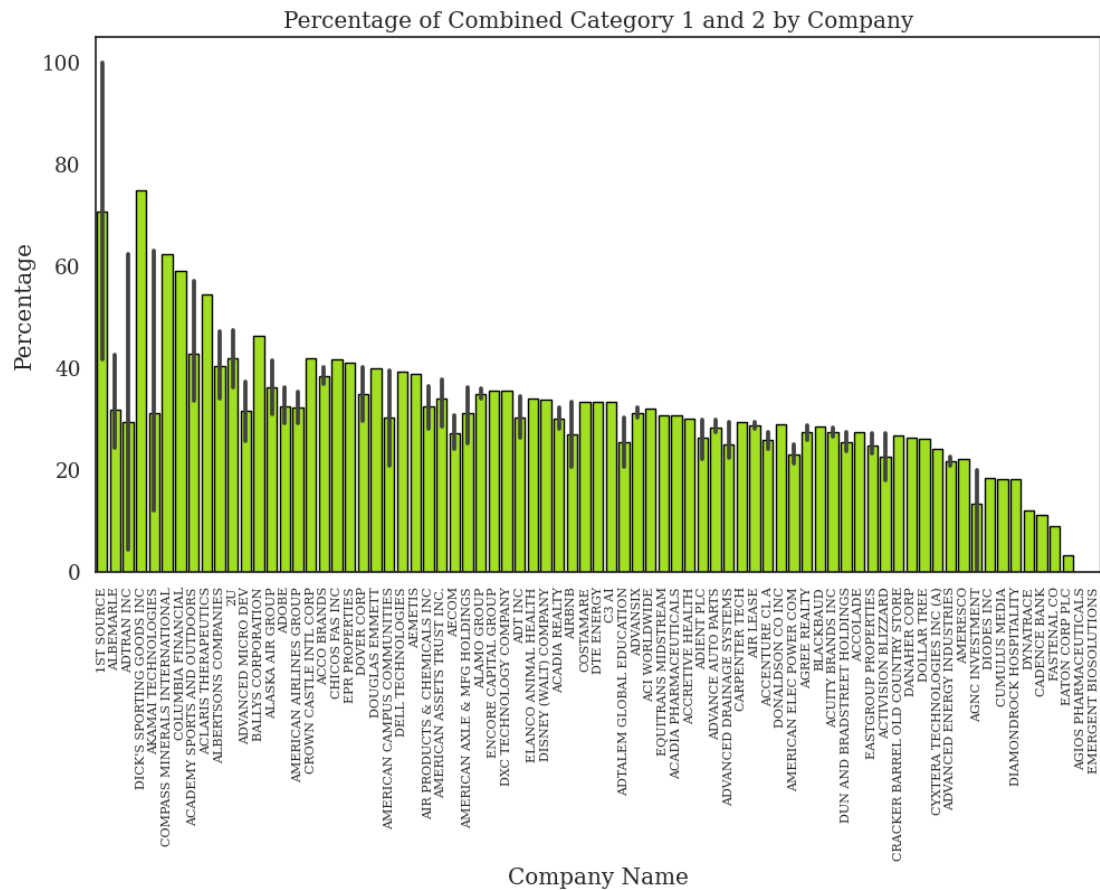


Figure 5. Companies Ranked by Action + Quantitative Evidence Percentage

The companies with the highest Action Evidence percentages specifically were determined, as visualized in Figure 6. The top five leaders ranged between 54.5%-75% Action while the bottom five ranged between 0%-11.1%.

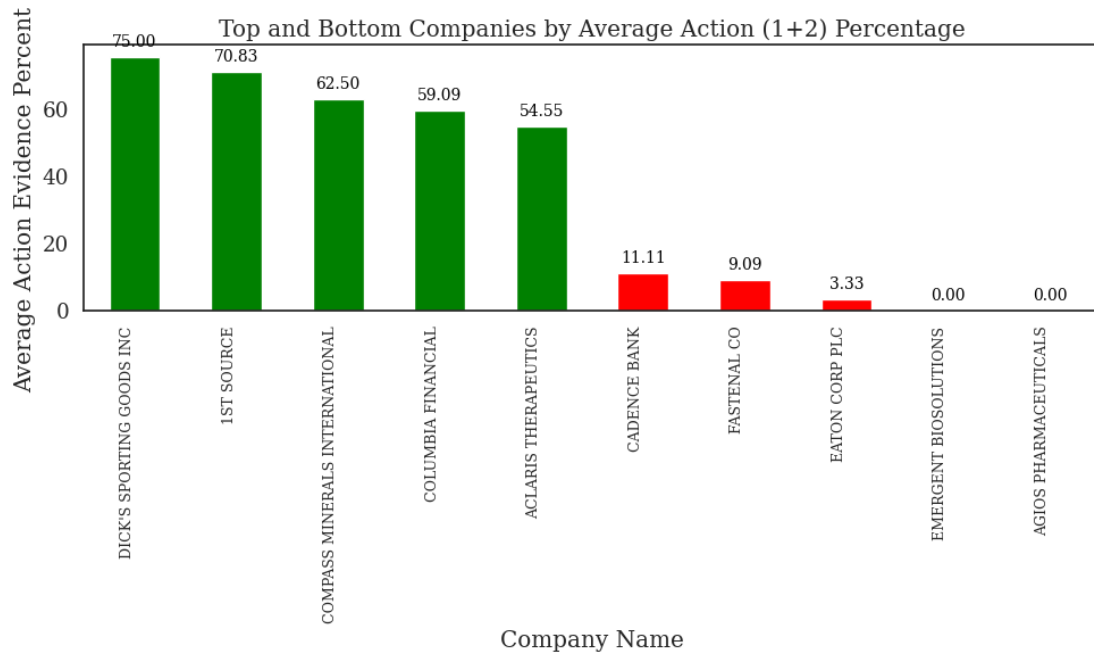


Figure 6: Companies Ranked by Action Evidence Percentage

Finally, the ratio of action + quantitative sentences to intent sentences is used as an indicator of ESG performance. Figure 7 shows the average ratios by company, sorted from highest to lowest. Companies with ratios between 0-1 (in which there is a higher relative share of intention than actions) are shown in Figure 8 (left), and the top 10 ratios appear in Figure 8 (right). Higher ratios signify greater disclosed actions relative to future intentions.

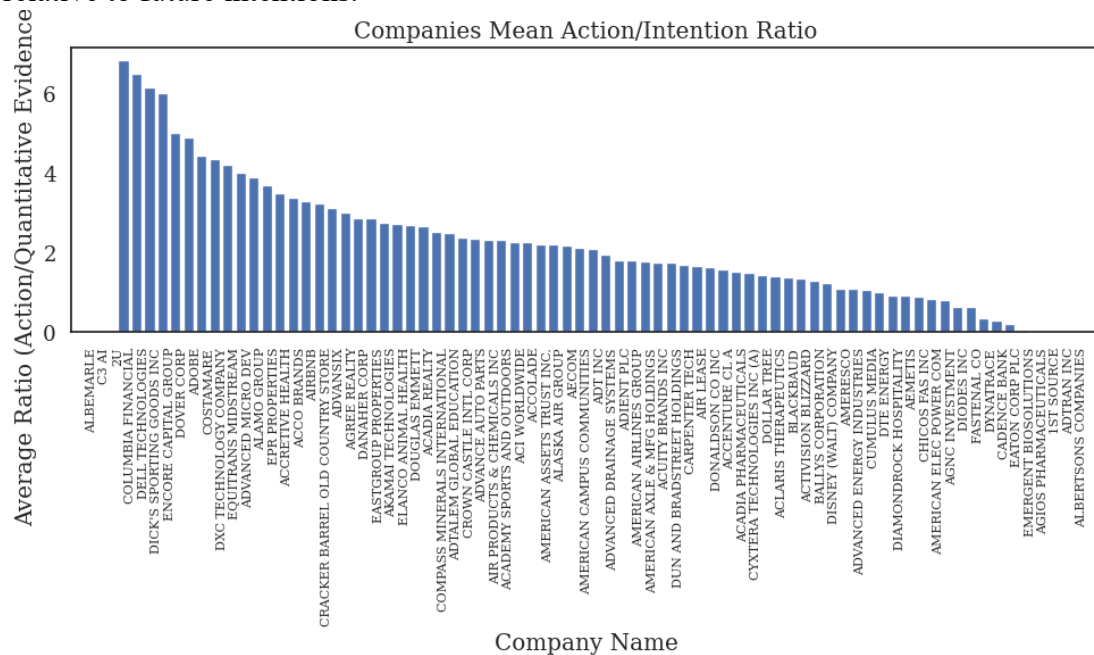


Figure 7. All Companies Ranked by Action + Quantitative to Intention Ratio

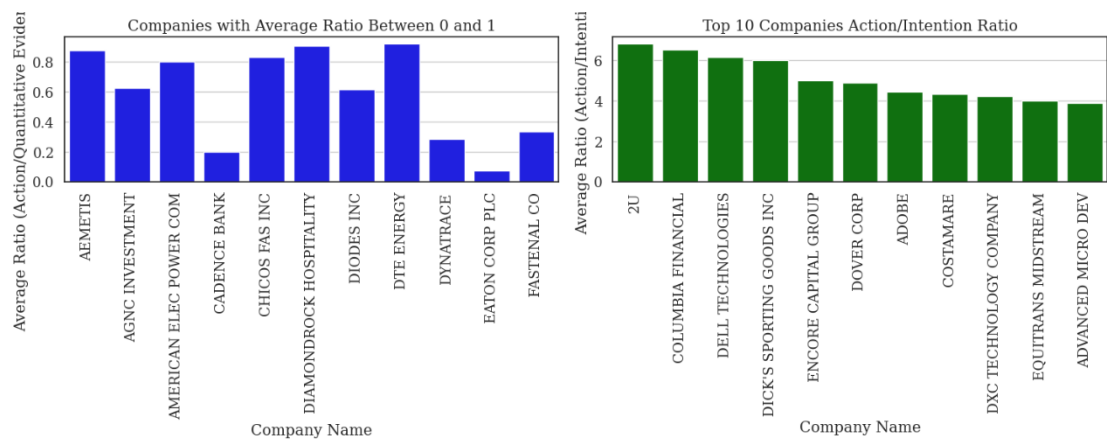


Figure 8. Top 10 and Bottom Companies by Action + Quantitative to Intention Ratio