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Use NLP to Analyze Public Sentiment After Breaches and Correlate with Brand Perception and Revenue Changes

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Citation: Chowdhury S. A., Khatun M., Mohammad A. R., Akter F. Use NLP to Analyze Public Sentiment After Breaches and Correlate with Brand Perception and Revenue Changes. American Journal of Economics and Business Management 2019, 2(2), 119 -128.

Received: 20th Apr 2019

Revised: 12th May 2019

Accepted: 06th Jun 2019

Published: 27th Jul 2019



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Abstract: The increasing occurrence of cybersecurity incidents and online discussions has created a need for analysing public sentiment to understand changes in brand perception. This research is aimed at analyzing social media opinions and assessing the perception of reputation based on sentiments using NLP techniques. In the research, a Twitter based sentiment data set is used, which consists of classified opinions about the various entities, and text analysis methods are used to extract the positive, negative and neutral sentiment patterns. The study follows quantitative exploratory research design, in which data pre-processing, sentiment distribution analysis, entity level comparison and measurement of reputation score are used in R Studio. The results show that there are differences of public response to the various entities as well as differences in opinion about the positive or negative reputation trends. The study emphasizes the need for NLP supported analysis of unstructured information from social media to make sense and provide support for reputation monitoring, business decision making and understanding the public response following critical events.

Keywords: Cybersecurity, Social Media, Sentiments, NLP Techniques, Twitter, Positive, Negative, Neutral, Reputation, Business Decision-Making.

1. Introduction

A. Background of Study

As more organizations rely on digital channels, the number of cybersecurity incidents that threaten the protection of customers' and organizations' sensitive data has grown. Data breaches are a growing issue due to their technical challenges and impact on customer confidence and brand reputation. Users may voice worries about a security incident on social media forums, where opinions, complaints and reactions can quickly proliferate and circulate through online communities. When a breach happens, negative comments might lead to a loss of confidence in the organization as people think that they won't be able to rely on it if there were not good security measures in place. The latest study by Infosys and Interbrand specifies that cyber security incidents can result in significant value loss to the brand due to the fact that after a security incident trust, customer affinity and brand perception is affected directly [1].

Social media platforms have thus emerged as significant sources in order to understand public response after cybersecurity incidents. The huge amount of UGC can be useful for understanding customer sentiments and perceptions, but it can be challenging to conduct a manual analysis of the vast amount of unstructured text data. By analyzing patterns of sentiment and public opinion in social media conversations, NLP offers a powerful solution for uncovering meaningful insights from social media. It underscores the significance of examining social media sentiment to gain insights into the impact of security breaches on their performance and reputation, as well as potential financial implications.

B. Importance of NLP in Sentiment Analysis

Conventional methods of studying customer sentiment rely on manual assessments and are unable to efficiently analyze vast volumes of social media text that is produced daily. NLP can help identify patterns in the natural language, transform it into measurable patterns, and analyze unstructured textual information automatically. NLP methods are used to detect the public sentiments, opinions and behavior patterns in online conversations. Text preprocessing: Clean and prepare the text data. Sentiment classification: Classify opinions into positive, negative, or neutral groups. These practices enable organizations to gain a better understanding of customers' perception and also are used to assess the shift in the public opinion following a significant event like a cyber security incident.

C. Problem Statement

While some organizations track financial impact and operational metrics following a cybersecurity incident, gauging public emotional reactions is never easy. There is a huge amount of textual information on social media about opinions, concerns, and reactions from customers on security failures. But, deriving useful insights from the unstructured information demands analytical approaches that are automated as manual analysis is time-consuming, and as the number of data points grows larger, manual analysis can be ineffective. Prior studies have shown that a cyber security incident can have an impact on organizational reputation and customer trust, and the impact on reputation can be difficult to quantify based on the public discourse. Hence, it is required to have NLP sentiment analysis techniques to determine public perception pattern and understand the risk of negative reactions following breaches, and how this can affect the brand's reputation and potential business consequences.

D. Research Objectives

- To analyse social media sentiment using Natural Language Processing techniques and identify public opinion patterns.
- To evaluate public perception towards brands by examining positive, negative, and neutral sentiment trends.
- To explore the influence of negative social media sentiment on brand reputation after cybersecurity-related incidents.
- To examine the relationship between sentiment patterns and financial performance indicators through exploratory analysis.

II. Literature Review

A. Social Media Sentiment Analysis

Social media has become a crucial resource to access public opinion, customer experiences and collective responses to various events. Social media like Twitter has created vast amounts of user-generated text data which can be processed and analyzed to uncover emotional trends and the collective sentiment of the public. Rodríguez Ibáñez et al. [2] analyzed different sentiment analysis techniques used with social media and noted that sentiment analysis is useful to extract meaningful information from the unstructured discussions taking place online, by discovering positive, negative and neutral opinions.

The study noted that sentiment analysis on social media is an emerging research field that is significant for organizations, as it can help them gain insights into customer behavior, make informed decisions, and track shifts in reputation.

Opinion mining is one key part of sentiment analysis in social media, as it deals with identifying opinions, emotions and attitudes from textual data. Suhaimin et al. [3] reviewed the use of opinion mining and sentiment analysis and introduced a taxonomy of previous studies on public security aspects in SMR. Opinion mining techniques allow the classification of opinions and the identification of significant patterns in the conversations on social media at large scale, the authors said. In addition, they identified some difficulties, including the complexity of language, the changing expression of users, and the analysis of informal online communication. These are just some of the challenges that highlight the importance of more sophisticated analytical methods that can handle social media data.

Due to the unstructured nature of social media data, natural language processing (NLP) has emerged as one of the key methods used in sentiment analysis. When dealing with a large number of textual data, conventional analysis techniques can be restricted due to the time and resources needed to interpret the data manually. Singh et al. [4] gave a comparative review of sentiment analysis methods and gave a description of NLP techniques for automatically extracting meaningful patterns from online opinions. The research explored a wide range of techniques, such as machine learning and deep learning, which have the potential to enhance sentiment classification accuracy by leveraging linguistic features and context.

The advent of deep learning-based NLP models has further enhanced the social media sentiment analysis by analyzing complex language patterns with greater understanding. Pimpalkar [5] proposed a multi-layer BiLSTM model with a GloVe embedding model for sentiment analysis and proved that word representation models are crucial in enhancing the sentiment classification. The study revealed that the advanced model is able to learn the semantic relations among words and also to extract the user's emotion in social media text. These methods are useful when the size of the public debate is large and keyword-based approaches are not sufficient to capture the intent behind the users' opinions.

As is reflected in the existing literature, the use of Twitter sentiment research to assess public opinion and reactions has come to be widely used due to its ability to deliver public opinion in real-time. Sentiment classification methods have been used to grasp customer satisfaction, social issues, and reputation issues. The analyzed studies showed that the NLP techniques can be utilized in conjunction with sentiment analysis to measure the attitudes of the public more effectively. These can be especially important in the context of brand perception, as a negative or positive discussion on social media can indicate how users react to organizational events and changes.

While sentiment analysis on social media is a valuable area of research, there are still issues with understanding sentiment in particular contexts. However, some contextual information is missing, and factors like sarcasm still influence classification accuracy. The reviewed literature has underlined the need to develop better NLP techniques to extract useful information from social networking information. Thus, the use of sentiment analysis for the assessment of public perception is a valuable method to grasp the nature of change in reputation and the influence of online opinions on the organization's performance.

B. Cybersecurity Breaches and Brand Reputation

The issue of cybersecurity breaches has become a major problem for organizations since not only do they pose threats to the security systems, but they also threaten to undermine customer reputation and confidence in the brand. Data leaks can make customers doubt the ability and reliability of the companies to secure their personal data. Sharma and Jain [6] talked about the significance of sentiment analysis in social media

security and analytics, where they have mentioned that online platforms can be a good source of information regarding the customer's sentiment after the security incidents. The study described how social media conversations could be used to detect shifts in the public perspective and the effect that events relating to security have on user attitudes towards an organization.

Loss of customer trust is one of the biggest issues that comes in relation to cybersecurity breaches as customers come with the high expectation of businesses to keep their collective personal and financial information secure. Gao et al. [7] analyzed the consumers' reaction to data breaches and breakdown consumer responses which are affected by their perception of error stability, brand perception, and their existing relationship with an organization. Their research showed that whether consumers experienced a breach, as well as what the organization did regarding the incident, were significant factors in their evaluation. The customer reactions can be affected by the communication and recovery response and negative reactions can lead to higher dissatisfaction and lower trust in the impacted brand.

Unlike other customer matters, a cybersecurity incident can have long-term repercussions due to "reputation damage" that can occur when a breach happens. Shankar and Mohammed [8] studied several instances of companies impacted by data breaches and found companies typically struggle to regain customer trust when there is a security incident. They found that companies must have effective recovery strategies because the reputation could continue to suffer after technical issues are resolved. Negative public perceptions, lower customer satisfaction and growing security issues may pose extra difficulties in maintaining a positive brand.

Social media is now an important platform on which consumers voice their reactions following data leaks. Customers can voice their concerns and opinions on social media platforms like Twitter, which has the ability to reach a wide audience. Sharma and Jain [6] noted that sentiment analysis could be of great assistance to organizations in tracking these conversations online and identify any risks to their reputation. Through sentiment and opinion analysis, a firm can gain insight into how a Cybersecurity incident has created negative sentiment in the public, or whether public perceptions have improved as a result of recovery efforts.

Empirical research on the link between data breaches and reputation has also been conducted. Makridis [9] studied the evidence of a number of companies to determine if cyber security incidents hurt corporate reputations. The research showed that a data breach can have effects on the public opinion and lead to a negative impact on the organization's reputation. The results showed that there are security failures that can influence the perceptions of the stakeholders and that cyber security is an important security aspect in the retention of the brand value and customer loyalty.

Cyberattacks also can affect online brand image by leaving users with the impression that a company's security capabilities affect its overall credibility. Augustyn [10] studied the consequences of cyberattacks on online brand image and emphasized that the security incident may lead to loss of confidence and negatively impact brand evaluation. The study indicated that organizations must include cybersecurity in their reputation management strategy as digital trust is an essential part of the brand identity in digital environments.

In summary, previous research has shown that security issues in cyberspace present intricate problems related to customers' loss of trust, reputation, and consumer reaction. It can be seen from the literature that sentiment analysis of social media has been proved to be a helpful method in gaining insight into the reactions of users to security incidents. It is however, important to research and measure the correlation between public sentiment, brand perception and financial implications. Hence, sentiment analysis using NLP could be helpful to understand the impact of cybersecurity incidents on the sentiment of social media and the reputation of the organizations.

C. NLP Applications in Business Analytics

Organizations have increased volumes of textual data, generated via social media, through customer reviews, feedback systems, online communication and other channels, making NLP a critical part of business analysis. Traditional analytical methods are not effective in processing unstructured text data, but NLP techniques can process textual information and get meaningful insights for the business. Pröllochs and Feuerriegel [11] pointed out that advanced text analysis techniques are relevant to strategic management because they can identify a company's problems using topic modelling methods. Their research showed that it is possible to create meaningful themes, learn about new topics and inform strategic decision making by analysing large scale textual data.

Text mining is another critical use of NLP in business analytics, as it allows businesses to uncover patterns, trends, and relationships within vast amounts of text data. The process of Text Mining includes data extraction, Text Transformation, Keyword Identification, and topics discovery. According to Kwartler [12] text analytics can give organizations the power to extract unstructured textual data into structured and reusable knowledge that can be used in business intelligence processes. By using text mining, companies can gain insights into customer sentiments, their shared issues and understand their behavior patterns, which can affect business performance.

Sentiment scoring is another key application of NLP that can benefit businesses by analyzing public sentiment and emotional reactions. Sentiment analysis assigns a sentiment label to text data, distinguishing it from positive, negative, and neutral sentiment, which helps companies gauge customer sentiments towards products, services, or brands. Kasztelnik and Delanoy [13] talked about using data analytics, social media analysis and NLP techniques as an innovative business decision model. They pointed out that sentiment analysis of social media data can offer insights into consumer sentiment and help companies gauge customer perception.

NLP techniques have been instrumental in revolutionizing business analytics, offering valuable insights from vast amounts of textual information to enhance decision-making. Knowing what customers expect, how their view of a brand develops, and how to react to market shifts can be done with information collected by using NLP techniques. In the field of business analytics, Zhai [14] gave a review of the use of machine learning and large-scale textual data; she also showed that analytical models can be enhanced by using textual data to aid in prediction and decision support. The study has pointed out that there is useful business information in the textual data which can be augmented by conventional sources of numerical data.

Another aspect of strategic management where NLP based analytics is helpful is in risk identification, understanding competitive scenarios and assessing customer behavior. With the use of topic modelling, sentiment analysis, and text classification, businesses can track public discourse and spot significant shifts in consumer sentiment. These applications are especially valuable when the organization has to grasp the impact these external incidents or events such as cyber security, service failures, or reputation problems have on the organization. Understanding the reactions of customers by analysing the content of the text enables companies to design more effective strategies and communication approaches.

In general, the studies conducted before show the utility of NLP in the business analytics field by text mining, sentiment scoring and intelligent decision making. By combining with analytical tools, NLP can turn text-based data into actionable insights for organizations. But misinterpretations of complex human language, context-specific meanings and shifting public perceptions still lie. As a result, NLP sentiment analysis in business research is an effective solution for gauging the sentiment of customers, comprehending shifts in perception, and empowering data-informed business decisions.

D. Research Gap

Previous research has been conducted on the sentiment analysis on social media, the impact of cybersecurity breaches, and NLP applications in business analytics, separately. But, the research on integrating NLP based sentiment analysis with brand reputation evaluation after an event related to security is limited. Moreover, the correlation between the sentiment patterns and possible impact to business needs to be further investigated by exploratory analysis of social media data.

2. Materials and Methods

A. Research Design

In this study, quantitative exploratory research design is used for analysing the social media data and finding patterns of public sentiment and public perception of reputation. The study aims at analyzing classified social media opinions to understand the public opinion about various entities, by examining the positive, negative, and neutral reactions. The quantitative approach allows for the measurement of the distribution of sentiment and comparison of opinion patterns using statistical analysis and visualization methods. Exploratory analysis is performed to identify any relationship between the data by using the data processing method of NLP. R Studio is used for data processing, analysis and visualization to gain insights from social media sentiment data. This is a way to measure the public opinion systematically by analyzing textual information.

B. Dataset Description

This study utilizes data from social media opinion data found in `dev_id_only.csv` which consists of social media opinion data collected from Twitter based interactions. The data is made up of three attributes: `tweet_id`, `therapy`, and `label`. The `tweet_id` column contains a unique identifier for each tweet record, and the `therapy` column contains details about the entity or topic that is being discussed in the social media content [15]. The `sentiment` column is the category of sentiment each record belongs to, including positive, negative and neutral opinions. This dataset offers a foundation for analyzing the patterns of public sentiment and reputation perception analysis using textual analysis of social media.

C. Data Preprocessing

Data Preprocessing is done using R Programming in R Studio to prepare the data for further Exploratory Analysis and NLP based Evaluation. First, the dataset is analyzed for the presence of missing data that could impact accuracy and then eliminated from the dataset. **DUPLICATED RECORDS:** Eliminated to prevent multiple entries on social media sites from affecting results. The major techniques used in text cleaning are involved in the process of removing unnecessary characters, symbols and irrelevant information from textual data to ensure data quality. The process of tokenization is used for segmenting text into meaningful individual terms for further analysis. Common words that are of little analytical value are removed; these are called stop words. The sentiment labels are then aggregated and organized for sentiment comparison and visualization.

D. NLP Analysis Approach

The research uses Natural Language Processing (NLP) techniques to analyze the sentiment trends on social media and assess the general sentiment of the public. Sentiment analysis is performed to determine the number of positive, negative, or neutral opinions in the data set. The sentiment categories are analyzed to understand overall user reactions and measure perception patterns associated with different entities. This is done through visualizations made in R Studio that give an understanding of the sentiment behavior.

Frequency analysis is also used to find out the most common words and phrases in the data set. This can be helpful to find the main topics and discussion trends seen in the

opinions expressed via social media. Furthermore, entity level sentiment comparison is carried out based on the level of sentiment change for different topics. This gives information about the level of public response to individual entities and enables the assessment of reputation perception using the social media analysis of data.

3. Results

A. Distribution Analysis of the Dataset

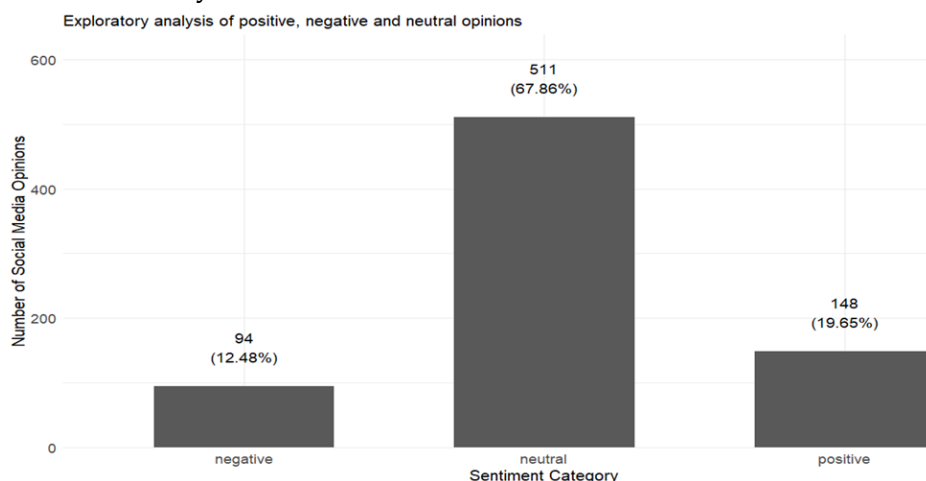


Figure 1. Distribution Pattern of Social Media Opinion Categories.

(Source: Created by learner).

The visualization displays a general distribution of public opinions across social media dataset with participants' responses segmented by negative, neutral and positive sentiments. According to the findings, the number of "neutral" sentiments was highest with 511, or 67.86 percent of the total discussions. Positive sentiment represents 148 opinions (a relatively positive sentiment among users) while negative sentiment has 94 opinions (the smallest group). Most users were clearly providing information-based opinions or opinions that were less emotional, as evidenced by the dominance of neutral responses. However, the negative sentiment signals potential risk points for possible perception/reputation issues.

B. Entity-wise Sentiment Analysis



Figure 2. Comparative Sentiment Intensity Across Discussed Entities.

(Source: Created by learner)

The heatmap presents a comparative analysis of sentiment patterns across different entities discussed in social media conversations. The results show that entities such as adderall and alprazolam received comparatively higher discussion volumes, particularly under neutral sentiment. This indicates greater public attention but limited emotional expression towards these topics. Some entities demonstrate stronger positive reactions, while others show increased negative sentiment, reflecting variations in user perception. The comparison reveals that sentiment distribution is not consistent across all entities, suggesting that public attitudes depend on the specific topic being discussed. This analysis helps identify entities associated with favorable or potentially concerning reputation perceptions.

C. Reputation Perception Analysis

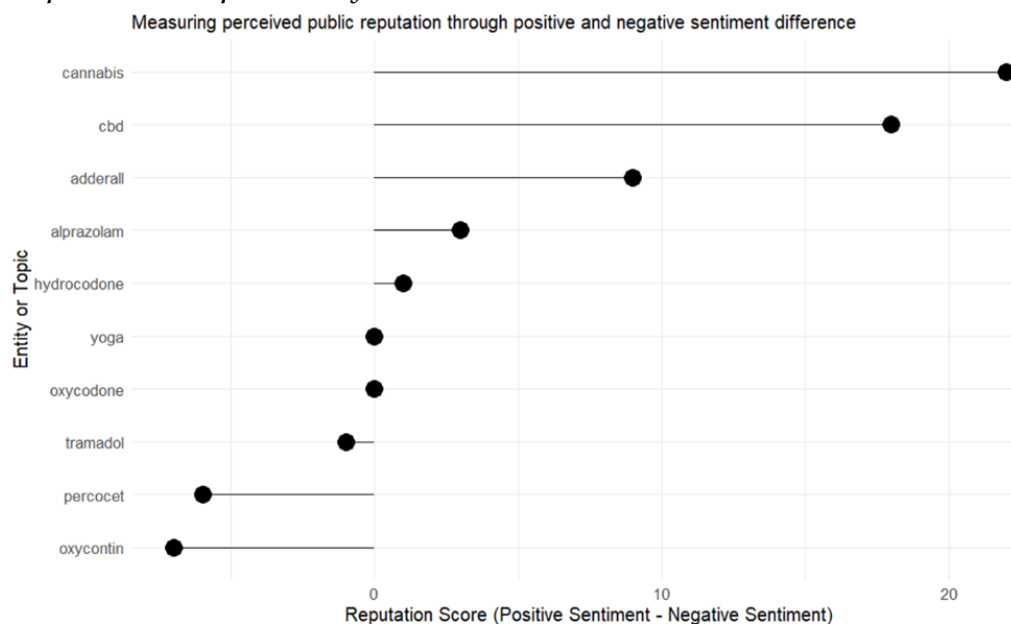


Figure 3. Sentiment Driven Reputation Assessment Across Entities.

(Source: Created by learner).

The public reputation visualization assesses the public reputation by computing the difference between positive and negative sentiment values of an entity. Results suggest that cannabis and cbd earned the top positive reputation scores, suggesting higher positive public perception in social discourse. Oxycontin and percocet, on the other hand, had negative reputation scores, suggesting more negative reactions and potential reputation concerns. Sentiment patterns were generally even for entities like yoga and oxycodone, meaning that there were not significant differences in positive versus negative. The analysis shows that sentiment-based reputation measurement can offer insights to the public discussion's impact on perceived reputation of different entities.

4. Discussion

In the exploratory analysis, there are some meaningful insights into the pattern of public sentiments, and it shows how the opinions of public sentiments could be analyzed by NLP based techniques. The sentiment distribution analysis showed that neutral sentiments make up the bulk (highest proportion) of the discussions, followed by positive and negative sentiments. This means that many users engage in social media discussions, sharing information, experiences, or observations without significant emotional responses. The negative sentiment, however, suggests possible concerns about public perception and reputation issues. The results are in sync with the literature review concept that social

media is a vital source and indicator of customer's attitudes as it captures the shift in public opinion towards entities and organizations in the online space.

The entity wise sentiment comparison also points out the differences in public sentiments in different topics. The heatmap analysis reveals that certain entities were covered more frequently, especially in the neutral sentiment category, suggesting that there was higher public interest and visibility. Meanwhile, sentiment changes among entities between positive and negative indicate that reputation perception is affected by the topic. Entities with greater negative responses could be a focus area for public trust or confidence to be impacted, while those with higher positive sentiment would suggest comparatively positive perception. The results are consistent with the previous research discussions about reputation management in the context of cybersecurity, which found that consumers' reactions to bad news can affect their assessments of the brand and their future trust.

The difference between the positive and negative sentiment values gives insight in the reputation perception analysis. The results indicate that some entities had positive reputation scores, indicating their strong favorable reactions by social media users, and some entities had negative reputation scores, indicating some reputation risks. This shows the effectiveness of sentiment scoring methods in converting textual opinions into measurable indicators to assess reputation. The results also validate the application of NLP in business analytics as it demonstrates that a vast amount of unstructured social media data can be transformed into meaningful insights for business decision-making. Overall, the findings suggest that sentiment analysis, entity level comparison and reputation scoring is an effective exploratory framework for analysing the perception of the public and determining potential reputation changes using social media data.

VI. Future Work

This study can be expanded to include larger and more diverse social media data sets from various social media platforms like Twitter, Instagram, and online review sites. A wider data set can help to get a better understanding of the shift in public opinion over various periods of time, and enhance reputation analysis reliability. In addition, future research may incorporate other real-world metrics like stock price movements, revenue fluctuations, customer retention rates, and brand valuation assessments to explore how sentiments directly correlate with organizational performance.

Advanced NLP and machine learning methods like transformer-based models, deep learning, and sentiment classification models that work in the context can further enhance the results. These techniques can also enhance the detection of complex emotions, sarcasm, and shifting expressions of users in social media. There are also opportunities for future research, including the creation of real-time monitoring systems for sentiment that assist organizations in identifying reputation threats following cybersecurity breaches and make quicker strategic decisions in response to the public response.

5. Conclusions

This paper introduced NLP using sentiment analysis to investigate the changes of perception and reputation of the public on social media. The exploratory analysis showed that sentiment classification, entity level comparison, and reputation scoring are good ways to detect patterns in online discussions. The results showed that there were differences in the public response to the various entities with positive and negative sentiment differences corresponding to changes in the public's perception of reputation. The study emphasizes the importance of social media platforms as a source of information to analyze the opinions of customers and understand reputation-related challenges. Using NLP techniques, unstructured textual data can be converted to valuable insights for business analysis and business decisions. The study makes a contribution to the

understanding of how public opinion can be measured as a way of determining reputation perception. With further advancements in NLP models and expanding datasets, the implementation of sentiment-aware reputation analysis can be optimized even more, improving the accuracy and usability of sentiment-based reputation analysis.

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