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Examining logistics developments in post-pandemic Japan through sentiment analysis of Twitter data☆

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ABSTRACT

The objective of this study is to utilize natural language processing technologies to examine data gathered from Twitter related to logistics in Japan during the COVID-19 pandemic. The Bidirectional Encoder Representations from Transformers (BERT) machine learning model is utilized to assess the sentiment of the content. The findings suggest a positive outlook on logistics during time frame analyzed. This research has four key implications: (1) the sentiment towards the term "logistics" is generally positive as per our analysis; (2) there is a trend of increasing interest in logistics in western Japan in 2022; (3) social media can be utilized as a tool to address the challenges faced by the logistics industry; and (4) our research highlights the potential of using social media data to provide a more timely and comprehensive analysis of logistics and transportation trends.

1. Introduction

The outbreak of COVID-19 has significantly affected transportation and logistics worldwide, primarily due to labor shortages that have led to constraints in supply, for example, a lack of truck drivers and dock workers under the pandemic, cargo processing in port have been disrupted and it damaged supply chains globally. Also, because of immigration restraint in many countries, the global air freight industry had faced to considerable supply constraint in traffic. Demand shifts had appeared for various goods in as well. One illustration of this is the increased demand for surgical masks in early 2020, followed by a rise in demand for furniture and appliances in the latter half of the year. As reported by UNCTAD COMTRADE, importing surgical masks (HS 630790) in world increased by 83.7% in the first half of 2020 compared to the previous year.

Additionally, data from Container Trades Statistics showed a 6.7% decrease in global containerized cargo transport volume during the first half of 2020. However, in the latter half of the year, transport volume experienced an increase of 4.5% year on year. This can be attributed to manufacturers and distributors expediting shipments to make up for delays in sales and production plans, and an increase in inventory respond to uncertainties brought on by the COVID-19 pandemic. Akakura et al. (2022) highlight that, offshore waiting and increased terminal dwell time at terminals, resulting from the COVID-19 outbreak in North America and Europe, caused delays in transport, resulting in higher freight costs and an increase in air transport as an alternative.

In Japan, trucks are a major mode of transportation, accounting for 91.6% of all domestic transportation by tonnage in 2020. Additionally, for international logistics, over 90% of domestic import/export containerized cargo is transported using trailers. However, prior to the outbreak of COVID-19, the shortage of domestic transportation services were already an issue (MLIT, 2022). This shortage is primarily caused by the significant increase in number of parcels handled by parcel delivery services. The increase in shipments is a result of the expansion of e-commerce in B2C and C2C businesses, leading to an increase in small-lot transportation from sellers to buyers.

In comparison to other jobs, truck drivers continue to face extended working hours and low wages. Due to the aging of society and decrease in working-age population, it is challenging to secure human resources (Hirata et al., 2022). The severe shortage and long working hours in the industry have gained increased attention. As a result, a bill was passed to limit overtime work to maximum 960 h per year starting April 2024 in Japan. However, the stringent enforcement of labor standards to reduce driver overwork will lead to a decrease in the supply of service provided

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by truck drivers, which may result in an inability to meet domestic transportation demand. This problem has come to be known as "the logistics 2024 problem". Not only practitioners, policy makers and journalists, but also academicians have focused on the issue. For example, Hirata et al. (2022) and Kato (2021) have pointed out the need to find solutions to this problem, such as the development of automation technology and modal shifts.

Social networking services (SNS) have played a role in how people in the logistics industry interact with each other. SNS have been gaining attention as a tool for information exchange since the Great East Japan Earthquake in 2011. However, at that time, the use of the system was mainly for disaster victims to get information from the accounts of the local government and the mass media (Ministry of Internal Affairs and Communications, 2011). Today, more than a decade later, its role has expanded. People in various professions, including truck drivers, seafarers, experienced professionals, and analysts, share real-time opinions on SNS platforms such as Twitter, Instagram and LinkedIn. Often, information shared on SNS is available earlier than in the trade press or official statistics, and has been used as a source of industry information.

There are three main reasons why SNS is gaining increased attention. The first reason is that it provides real-time information, the second reason is that it allows for easy collection of users' actual opinions, and the third reason is that it enables access to information not only related to one's working company but also about other companies, including competitors. For example, Nagaiwa et al. (2021) analyzes the lifestyle patterns of domestic shipping crews through their tweets. In today's business environment, the ability to utilize big data has a significant impact quickly and efficiently on a company's competitiveness, and companies are using a wide range of data in various situations, such as improving and developing services and products, and streamlining production and sales operations.

The present research examines the utilization of social media data for the analysis of logistics scenarios, considering the ongoing COVID-19 pandemic and the growing significance of social media as a source of information. We employ sentiment analysis is to investigate logistics trends in Japan, with the findings being discussed to reveal insights into logistics-related concerns and potential remedies in the country.

The remainder of this paper is organized as follows: Section 2 provides an overview of the literature on the application of NLP method to analyze SNS data. Sections 3 details the characteristics of the data used and explains the selected analysis methods. Section 4 visualizes the key findings. Section 5 presents discussions of the key findings. Section 6 concludes the study and emphasizes the significance of this work for both practical applications and future research.

2. Literature review and research motivation

This study reviews several recent studies that have employed social media data, specifically Twitter data (such as Dutt et al., 2019; Pourebrahim et al., 2019), for disaster emergency management. Some studies have used sentiment analysis techniques, such as Karami et al. (2020); Xu (2020) to extract insights from the data.

After the 2011 Great East Japan Earthquake, Twitter, LINE and other social platforms were found to be an effective means of communication during power outages. Sakamaki and Kamei (2014) used a simple Bayesian classifier to extract keywords from Twitter data and suggested that the classification ability of Bayesian model is comparable to that of Support Vector Machine (SVM). Shishido (2017) conducted text mining of Tweets related to disasters and found that a Recurrent neural network (RNN) model performed better than SVM.

In terms of sentiment analysis, Toriumi et al. (2020) analyzed the emotional changes in the COVID-19 using Twitter data and applied a model called ML-Ask to evaluate the changes of "scared" emotion. Toriumi (2020) used Latent Dirichlet Allocation (LDA) topic model analysis to identify differences in information sharing behavior between the first and second waves of infection of COVID-19 in Japan. Ihara et al. (2021) analyzed Twitter data associated with COVID-19 and its relationship to infection status.

Significant progress has been made in the field of sentiment analysis using task-specific models such as BERT (Devlin et al., 2018), which is currently one of the most popular and highest performing models available in multiple languages. Many systems proposed for sentiment analysis utilize BERT and its variants, achieving excellent results. For example, Sun et al. (2019) performed extensive experiments to examine different fine-tuning methods of BERT on text classification, resulting in state-of-the-art results in review sentiment analysis. Additionally, Song et al. (2020) investigated the potential of BERT intermediate layers to improve BERT fine-tuning and achieved a new state-of-the-art for aspect-based sentiment analysis. Due to these reasons, this study employs the BERT model for sentiment analysis.

Most research in the field of sentiment analysis of tweets utilizes an approach of training language models directly from scratch using corpora made up exclusively of tweets. This approach allows the models to handle the unique syntax and grammar found in tweets, such as the use of contracted or elongated words, keywords, hashtags, emoticons, and emojis. This approach has been successful in not only English, but also in other languages such as Dutch (de Vries et al., 2019), Spanish (Polignano et al., 2019) and Italian (González-Barba et al., 2020; Gonzalez et al., 2021). However, this approach imposes two constraints: the need to build large corpora of tweets for training and the need for significant resources, both hardware and time, to train the models from scratch.

This study presents an alternative approach that aims to mitigate these constraints. The approach includes a pre-processing phase to convert Twitter jargon, including emojis and emoticons, into plain text using language-independent techniques that can be applied to different languages. Additionally, the study utilizes the pre-trained version of BERT[1] on plain text rather than tweets for two reasons: the availability of pre-trained models in multiple languages eliminates the need for time-consuming and resource-intensive model training on tweets, and the use of plain text corpora results in improved performance due to their larger size.

In Japan, following the economic recession of the 1990s, companies began to reduce operating costs, including logistics-related costs, and this has not stopped (Hirata et al., 2022). However, continued cost cutting has resulted in lower incomes for logistics workers, and now there are fewer job seekers, especially truck drivers, which has become a larger problem. Understanding the sentiment on logistics issues in Japan is of great significance for policy applications and practical responses, particularly in increasing awareness of the supply-demand situation of logistics services. This is the motivation behind our research.

3. Methodologies

The research methodologies applied in the study is summarized in Fig. 1. In the data preparation step, we used Google trends to determine the time period for detailed analysis. Then, we employed Web API technology to gather data from Twitter. In the data analysis step, we primarily applied Natural Language Processing techniques. Specifically, we employed Mecab[2] to tokenize sentences in Japanese, and BERT model for sentiment analysis. In data visualization, we mainly used most common word and word cloud (see Fig. 2).

The research is divided into three stages: (1) Identifying time frame using Google Trends; (2) Retrieving data from Twitter; (3) Analyzing the data. These three stages are described as follows.

[1] https://metatext.io/models/daigo-bert-base-japanese-sentiment.
[2] https://taku910.github.io/mecab/.

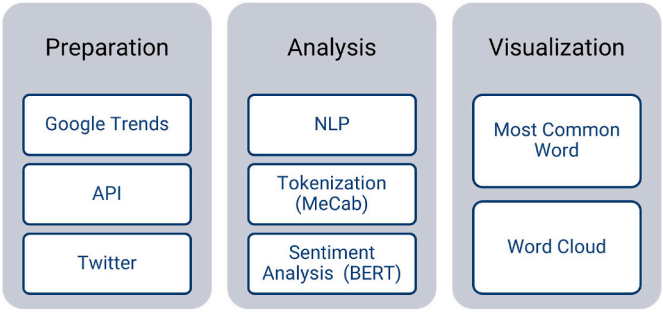


Fig. 1. Overview of research methodologies.

3.1. Identifying time frame using Google Trends

The study began by determining the time frame for analysis and identifying broad geographic trends using Google Trends, which provides information on the number of searches for specific words. We employed Google Trends popularity trend data to achieve this. The popularity trend number reflects the relative search interest for a specific term within a specific geographic region and time period, in relation to the highest research result on the graph (Fig. 2).

The search criteria employed were: (1) key word: “物流” (which means “logistics” in Japanese); (2) Region: Japan; (3) Time period: January 2020 - April 2022. This was the period when COVID-19 began to spread around the world, when international logistics were disrupted, and when things began to get back to normal. The graph illustrates the relative search interest for keyword “logistics” in the Japanese language.

Based on the data, it is observed that the peak of search interest occurred during the week of April 12 to April 18, 2020, and this period in 2020, 2021 and 2022 was chosen as the time frame for analysis. We utilized a Python script to visualize the Google trends data on a map to understand geographic trends, as shown in Fig. 3. The warm colors indicate high interest and the cold colors indicate low interest. The maps reveal that in 2020, the areas with high interest were Tokyo and Ishikawa. In 2022, the areas with the highest interest shifted to the mid and west of Japan, specifically Okayama in west Japan.

Examining the geographical trends of searches, it was found that interest in logistics was high in Tokyo and Saitama Prefecture in 2020, followed by Chiba, Tokyo, and Okayama Prefectures in 2021, and Saitama, Okayama, and Ibaraki Prefectures in 2022. This suggests that the number of searches and trends may fluctuate in correlation with recent developments in logistics centers. In the second half of the 2010s, the construction of logistics facilities in Japan has been on the rise. According to the Ministry of Land, Infrastructure, Transport and Tourism’s Warehouse Statistics Quarterly, the area of Class 1–3 warehouses, which store regular consumer goods, increased 31.5% over the five-year period from March 2016 to March 2021. The increase can be attributed to increased demand to handle the increase in home delivery cargo due to the spread of e-commerce, as well as the diversification of financing for logistics real estate (Ministry of Land, Infrastructure, Transport and Tourism, 2020). It should be noted that each of the prefectures mentioned in this analysis has seen a greater increase in logistics warehouses or distribution centers in recent years than the surrounding areas. One of the reasons for this is that logistics centers generate a lot of employment in their construction and operation, and they are large facilities that attract a lot of media attention.

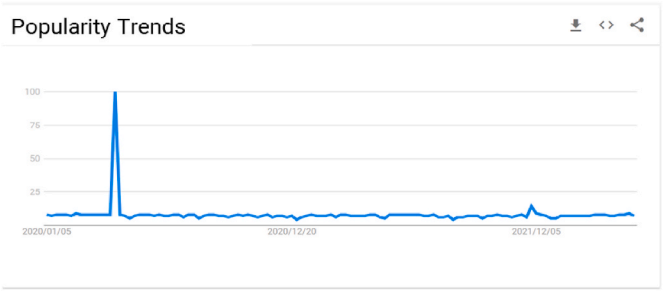


Fig. 2. Trend of popularity of the word “logistics”.

3.2. Retrieve data from twitter

Since Twitter does not offer retrospective search capabilities for historical data, we initiated additional data collection from Twitter beginning in March 2022, accumulating approximately two months’ worth of data for our research. Our criteria for selecting tweets were that they were posted between March 11th and April 11th, 2022, and contained the keyword "logistics" in Japanese. After eliminating retweets and invalid tweets, our dataset consists of 17,597 tweets. The data was obtained through the use of a key word search via Web API (Application Programming Interface) technology. Fig. 4 illustrates the functioning of the web API.

3.3. Data analysis

3.3.1. Tokenization

Initially, we employ MeCab to tokenize sentences in Japanese. MeCab is an open-source text library for segmenting text written in the Japanese language. Tokenization is the process of obtaining the smallest unit of a coherent word in which words have meaning. The output of the processing is to obtain the smallest unit of word as well as part of speech.

3.3.2. Stop word removal

Subsequently, we eliminate stop words from the text. Stop words are the common occurring words in a language that are typically unnecessary for analysis. Examples of stop words in English include "I," "you," "it," "what," "this," "am," "is," "be," "has," "a," "but," "because," and "no." Similarly, we remove stop words specific to the Japanese language as well as other non-language specific stop words such as emoji, “https” and the hashtag symbol (#).

3.3.3. Sentiment analysis

Sentiment analysis is a crucial aspect of NLP analysis. It is utilized to comprehend the individuals’ perceptions and emotions towards products, services, foods, and other such entities, whether they hold positive, negative, or neutral views. Sentiment analysis enables companies and other relevant entities to understand their products/services and work on improvements. It can also generate insights on social events, such as capturing people’s perspectives on social phenomena and epidemics. In this study, we analyze individuals’ sentiments towards logistics in the post-pandemic era based on tweets.

In order to perform sentiment analysis, we employed the BERT model. BERT, stands for Bidirectional Encoder Representations from Transformers, is a NLP model introduced by Google’s Jacob Devlin et al. (2018). BERT is noteworthy for its ability to take context into account by simultaneously learning word-by-word and predicting adjacent sentences. We utilized this approach for sentiment analysis to determine whether the word "logistics" is perceived positively within the context of a tweet.

This study employs a pre-trained version of BERT on plain text, as opposed to tweets. The use of a pre-trained model on plain text corpora offers the advantage of enhanced performance due to its larger size. The specific pre-trained model employed in this study is the daigo BERT base Japanese-sentiment model. The results of the daigo model are presented in the form of "pipeline-analysis" and "sentiment-analysis".

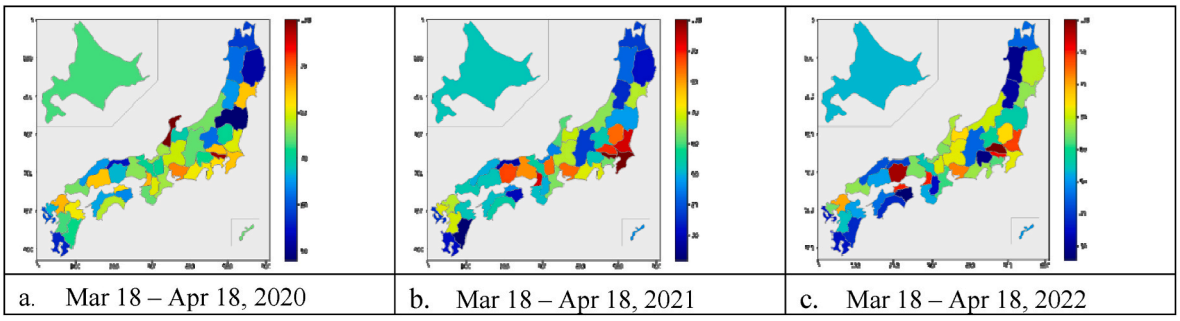


Fig. 3. Visualization.

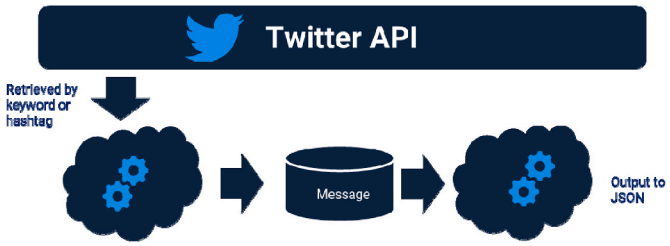


Fig. 4. Retrieval of Twitter data using web API.

4. Visualization

4.1. Most common words

The most common words are depicted in Fig. 5. They can be grouped into three categories. The first category includes words related to companies or industry (company, enterprise, industry, warehouse, center, location, sales, facility). The second category include words related to job (driver, job, cost, management, product, truck, transportation, raise, price). The third category includes words related to socioeconomics (news, Russia, corona, chaos, problem, economy).

The results show that the term "logistics" is often used in Japan to describe trends in the logistics industry and companies. The simultaneous use of words related to labor, as mentioned earlier, may reflect the fact that the logistics industry continues to focus on reducing costs, while labor problems of truck drivers are rapidly becoming a growing concern. The appearance of words related to socio-economic related words in Most Common Words may reflect the strong recognition since the coronavirus outbreak that supply chain disruptions are caused by social conditions.

4.2. Word cloud

We employ a word cloud to visually display the most common words (Fig. 6). A word cloud is a collection of words presented in varying sizes. The larger and bolder a word appears, the more frequently it is mentioned within a given text and the more significant it is. The larger/bolder words in the translated version include,

a. Location related words such as: Saitama, Hidaka, Osaka, Kobe
b. Logistics activity related words such as: Warehousing, cardboard, packaging, inspection, sorting, operations
c. Job related words such as: Manufacturer, Manufacturing, Labor Union Issues, Employees, Drivers, Hi-Ace Drivers, Driver Emergencies
d. Socioeconomic-related words such as: Cost, price increase, inflation, World, China, Russia

The largest/boldest words include “influence”, “issue”, “job”, “relationship”.

As with Most Common Words, socioeconomic-related words and job-related words tend to be more prevalent in Word cloud, while the type and location of work tended to be more specific.

4.3. Sentiment analysis results

The sentiment analysis results, as shown in Fig. 7, indicate that the overall sentiment toward logistics in Japan is positive, as indicated by the red bars. This positive sentiment may be attributed to a variety of factors, including supportive measures implemented by relevant government agencies in Japan, such as the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), the promotion of "white logistics". Also, the result reflects a lack of awareness of the challenging conditions facing the logistics industry in Japan.

5. Results and discussions

5.1. Supportive measures implemented by relevant government agencies

In response to the impact of rising fuel prices on the business conditions of motor freight operators, in order to ensure the sustainability of logistics by collecting appropriate freight rates, MLIT published advice[3] in 2021 based on the Act on the Promotion of Subcontractors and Small and Medium Enterprises. This advice encourages prime contracting transport operators to pass on costs, including those related to labor, vehicle renewal, and equipment necessary for improving business operations and logistics efficiency, to subcontractors and to negotiate prices appropriately.

5.2. Promotion of "white logistics"

White logistics[4] is an initiative that aims to create a more inclusive and welcoming workplace, particularly for young people, women, and the elderly, in order to ensure stable logistics that are essential for people’s lives and industrial activities. The initiative is promoted by shipper companies, truck operators, and other relevant parties working together. There are no specific financial incentives provided, but companies that participate in the voluntary "White Logistics" promotion campaign will be considered in the evaluation of the MLIT’s "Modal Shift Promotion Project." The campaign will conclude on April 1, 2024."

5.3. Lack of awareness of the challenging conditions facing the logistics industry in Japan

The PERSOL Group, a temporary staffing agency in Japan has

[3] https://www.mlit.go.jp/common/001430891.pdf.
[4] https://white-logistics-movement.jp.

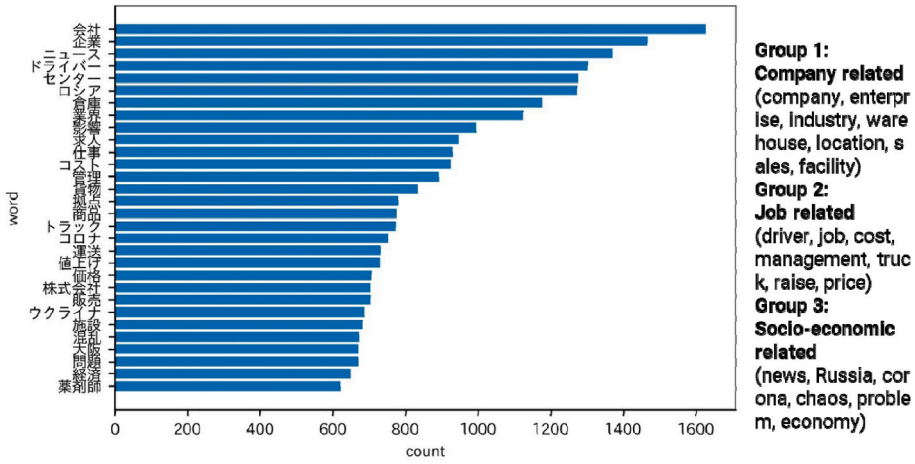


Fig. 5. Most common words.

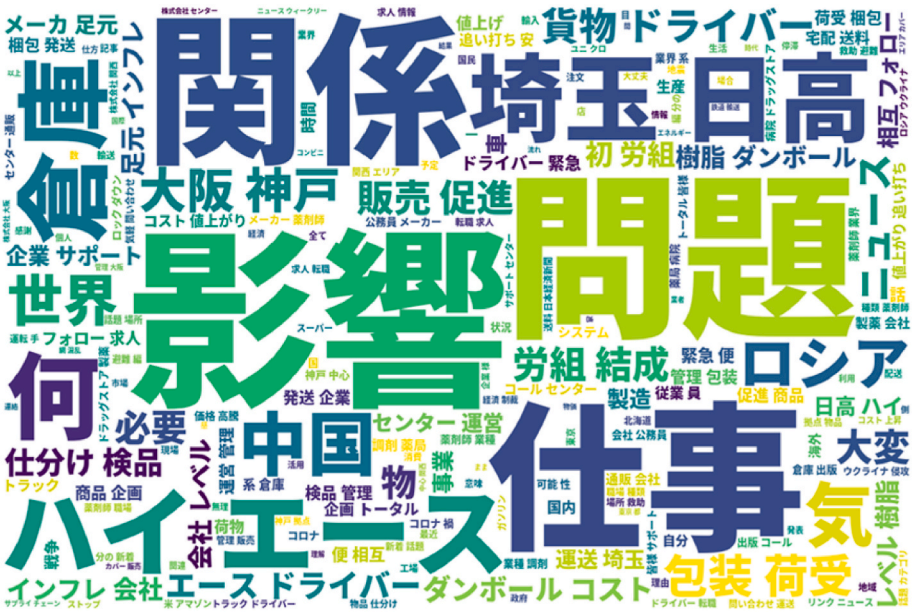
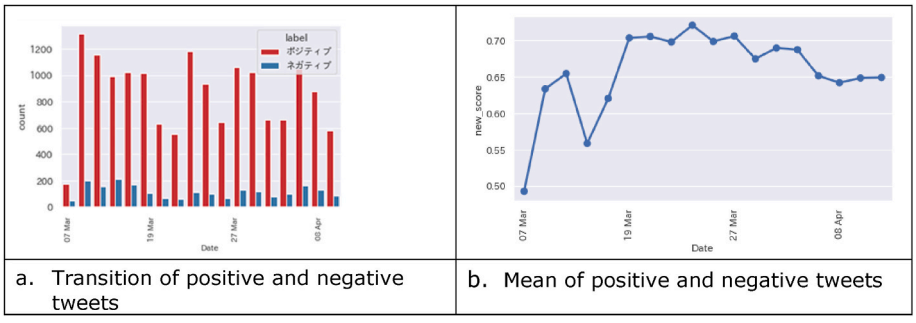


Fig. 6. Word cloud.



a. Transition of positive and negative tweets

b. Mean of positive and negative tweets

Fig. 7. Results of sentiment analysis.

conducted a survey[5] on the "2024 problem" in the logistics industry, and produced the "2024 Problem Fact-Finding Report." The report shows that among industry sectors, 59.8% of respondents from the transport and postal industry, which is most likely to be directly impacted by the 2024 problem, were aware of the issue. Of these, 19.6% said they "fully understand the content," which is higher than in other industries, indicating a high level of awareness of the issue. Conversely, recognition of the issue among other sectors indirectly affected by the problem is less than 50%.

[5] https://www.persol-group.co.jp/service/business/library/4487/.

6. Conclusions

This study delves into the analysis of Twitter posts related to the topic of logistics in Japan, with the aim of understanding behavioral and emotional changes towards the logistics service and industry port the COVID-19 pandemic.

Our findings are fourfold. Firstly, the analysis reveals that the sentiment towards the word of "logistics" is generally positive. The main reasons for this positive sentiment are the supportive measures implemented by relevant government agencies and the promotion of white logistics. To expand the scope of these measures could have a positive impact on logistics developments in Japan. Additionally, our research highlights that nearly 60% of companies in the transport sector are unaware of the current challenges facing the logistics industry, indicating a need for strengthened communication to improve awareness.

Secondly, the geographic trend analysis shows that there was a trend of increasing interest in logistics in western Japan in 2022. Regions such as Hidaka City, Saitama Prefecture, near the outer ring road, and Okayama Prefecture, near the port of Mizushima, where several logistics centers with advanced facilities are planned to be constructed, are gaining popularity in logistics. This trend reflects the nationwide expansion of logistics center development, particularity as logistics facilities become more decentralized and storage functions become more important.

Thirdly, our research suggests that social media can be used as a tool to alleviate the challenges facing the logistics industry. Social media is found to be used as a tool for recruitment and job search, which may indicate a shortage of truck drivers, a situation that has been attracting attention in recent years. In the post-pandemic era, the first area where analysis using social media is likely to contribute in domestic transportation is the worker shortage issue, known as the "logistics 2024 problem". Without proper measures taken, it could lead to various problems in the transportation and logistics industry when the rule of "maximum overtime work hours limit for automobile driving operations" comes into force from April 1, 2024. In Japan, truck drivers are active on social media, and there are examples of truck drivers using social media to exchange information about their work and to find employment (Hashimoto, 2020). Since the upper limit on working hours will also apply to coastal seafarers from 2024, analysis of social media data can identify the employment needs of coastal seafarers in the same way as for truck drivers.

Finally, our research highlights the potential of using social media data to contribute to a more real-time and detailed analysis of logistics and transportation trends. Since many truck drivers use social media to exchange information, social media data can be used to directly gather geographic and current information on tweets and search trends to quickly determine the geographic location and spread of a problem, as well as the location of the problem in context. While issues such as position talk and strategic manipulation must be addressed, social media data can also be used to take what has been known as anecdotes among practitioners and parties as evidence and combine it with other evidence to make more effective recommendations for logistics policy in Japan. This will also lead to more effective recommendations for logistics policy in Japan.

The literature review has shown that Twitter data has been utilized in analyzing natural disasters such as the 2011 Great East Japan Earthquake and overall sentiments towards COVID-19. However, there has been a lack of research on the sentiment towards logistics during the COVID-19 pandemic. This study provides a new contribution to the existing literature by visualizing the impact of COVID-19 on logistics and sentiment towards it. Furthermore, it is the first study that applies the BERT model to investigate logistics-related issues through Twitter data, to the best of our knowledge.

In future research, we aim to examine the distribution of interest in logistics by location and industry in the context of the COVID-19 pandemic. Additionally, we plan to delve deeper into the analysis of events that cannot be quantified by leveraging the capabilities of natural language processing techniques.

Declaration of competin interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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