Supply Chain Forum: An International Journal

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/tscf20

Effects and challenges of the COVID-19 pandemic in supply chain management: a text analytics approach

Mohammad Reza Khodoomi, Marzye Seif & Thomas Hanne

To cite this article: Mohammad Reza Khodoomi, Marzye Seif & Thomas Hanne (2024) Effects and challenges of the COVID-19 pandemic in supply chain management: a text analytics approach, Supply Chain Forum: An International Journal, 25:4, 486-503, DOI: 10.1080/16258312.2023.2253523

To link to this article: https://doi.org/10.1080/16258312.2023.2253523

Published online: 15 Oct 2023.

SUPPLY CHAIN FORUM: AN INTERNATIONAL JOURNAL
2024, VOL. 25, NO. 4, 486–503
https://doi.org/10.1080/16258312.2023.2253523

Taylor & Francis
Taylor & Francis Group

Effects and challenges of the COVID-19 pandemic in supply chain management: a text analytics approach

Mohammad Reza Khodoomi [a], Marziye Seif [a] and Thomas Hanne [b]

[a]Department of Systems and Supply Chain Engineering, School of Industrial Engineering, Iran University of Science and Technology, Tehran, Iran; [b]Institute for Information Systems, University of Applied Sciences and Arts Northwestern Switzerland, Olten, Switzerland

ABSTRACT

The coronavirus has had many effects on supply chains and logistics, most of which are negative. Due to the importance of logistics and supply chain in the world, any disruption or mismanagement causes many problems not only in the countries directly affected but also globally. In this article, new textual data are collected from reputable commercial and news websites related to the effects of COVID-19 on logistics and supply chains. After collecting textual data, valuable information about the impact of the coronavirus is extracted using various text mining techniques performed with R programming. Finally, issues related to COVID-19 and supply chains are identified and divided into five categories: suppliers and products, governments and organisations, health, evaluation, problems, and barriers. Also, categorising the problems and limitations of supply chains and logistics will provide managerial insights to minimise obstacles and disruptions. In particular, managers should consider several suppliers to reduce dependencies and also focus on domestic suppliers because of transportation limitations. Moreover, companies should pay attention to the health of societies and employ new policies, as well as pay attention to consumer behaviour such as their tendency to buy online.

KEYWORDS

COVID-19; supply chain; logistics; text mining; managerial insights

Introduction

Today, we are dealing with an emerging disease incidence called COVID-19 that has swept the world. As of December 2019, the time of the coronavirus diagnosis in Wuhan, China, to March 2021, the disease has infected more than 460 million people and caused more than six million deaths worldwide. The coronavirus outbreak is one of the biggest challenges worldwide and certain measures and rules have been considered to prevent the spread of the virus. For instance, cities and countries worldwide have been quarantined, which has temporarily led to a standstill in transportation, and the closure of markets and borders (Liu, Yue, and Tchounwou 2020). One of the areas most affected by the coronavirus outbreak is logistics and supply chain management, not only on a national but also on a global level (Lemke, Apostolopoulos, and Sönmez 2020; Queiroz et al. 2020). For example, serious recommendations should be made to isolate carriers suspected of carrying the virus and to control the transport of products, but these transport restrictions will have evident consequences for goods and products (L. Marek 2020).

Such restrictions have disrupted domestic and international supply chains and led to a severe economic crisis (De Vito and Gómez 2020). The economic consequences of COVID-19 have affected all countries (Nicola et al. 2020), which is devastating for many emerging economies and companies (Evans 2020). COVID-19 has had adverse effects on the industry, agriculture, animal husbandry, etc (Rozelle et al. 2020). Producers faced unforeseen challenges whose survival depends on the application of management strategies. The right decision at the time of the coronavirus outbreak relates to confronting fluctuations in demand (Del Rio-Chanona et al. 2020), costs, rising raw material prices due to a reduction in the number of suppliers (Wen, Wei, and Wang 2020), and also adjustment of workforces (Coibion, Gorodnichenko, and Weber 2020). Fortune magazine reported in a survey that 94% of businesses have been affected by supply chain disruptions caused by the coronavirus outbreak (Grida, Mohamed, and Zaied 2020).

Because of COVID-19 and its effects on supply chains, involved companies and consumers were affected (Wang, Dong, and Liu 2022). The response time has increased by COVID-19 disruptions because many companies have barriers in their supply chains (Chen, Jin, and Huo 2020). Many companies have faced material shortages and cannot produce and fulfill demands due to supply chain quarantine rules (Sarkis et al. 2020). It is notable to mention that customer behaviour has changed during the pandemic. For

CONTACT Thomas Hanne thomas.hanne@fhnw.ch Institute for Information Systems, University of Applied Sciences and Arts Northwestern Switzerland, Olten, Switzerland

instance, they have shown a stronger tendency towards online purchases (Zwanka and Buff 2021). Moreover, countries' policies have changed to protect their people, so the global supply chain has been affected by these regulations, such as quarantine (Kazancoglu et al. 2023).

News agencies and online social media have evolved into an important channel for the public and organisations due to their up-to-date and divers news releases (Kietzmann et al. 2011). Accordingly, news articles are an effective approach to learn the news about the coronavirus (Brownstein, Freifeld, and Madoff 2009; Freifeld et al. 2008). The news agencies have given particular importance to the COVID-19 pandemic, and it can be said that the unprecedented scale of the articles relates to this issue (Hamzah et al. 2020). Useful information extraction from online newspapers via text mining can indeed increase the ability to monitor supply chain risks and provide decision-makers with the ability to link data to provide the right information at the right time (Shah, Lütjen, and Freitag 2021).

In recent years, data science has emerged as a powerful tool for data collection, storage, management, and analysis (Davenport 2014). Text mining concentrates on solving particular problems, such as document retrieval or information extraction from text documents. In the text mining process, different techniques are used for information extraction, information analysis, categorisation, etc (Ananiadou, Kell, and Tsujii 2006; Cohen and Hersh 2005; Kilicoglu 2018). Text mining is the process of discovering unknown patterns and knowledge by automatic information extraction from large volumes of unstructured text. In a classic web search, people are looking for something that is already known, while with text mining, obscure and new data is discovered that cannot be understood directly by reading the data separately in unstructured text documents (Kim, Hahn, and Zhang 2000; Aggarwal 2015; Tandel, Jamadar, and Dudugu 2019). Text mining techniques are used all the time in industrial applications, at universities, on the internet, and in other fields (Liao, Chu, and Hsiao 2012). Text mining is used in various operational domains such as search engines, customer relationship management systems, product suggestion analysis, fraud detection, and social media analysis for feature and emotion extraction, as well as in prediction and trend analysis of the future (He 2013).

The present study is designed to analyse the texts of news articles to evaluate the impact of the coronavirus on logistics and supply chains and provide management solutions to better handle and manage these conditions. As online news and articles address the latest events all around the world, they can provide valuable information about the effects of COVID-19 on logistics and supply chains. Thus, the best way to find the patterns of these articles is text mining which is used in this study to identify the pandemic's impacts and provide precious suggestions to mitigate negative impacts and solve supply chain problems.

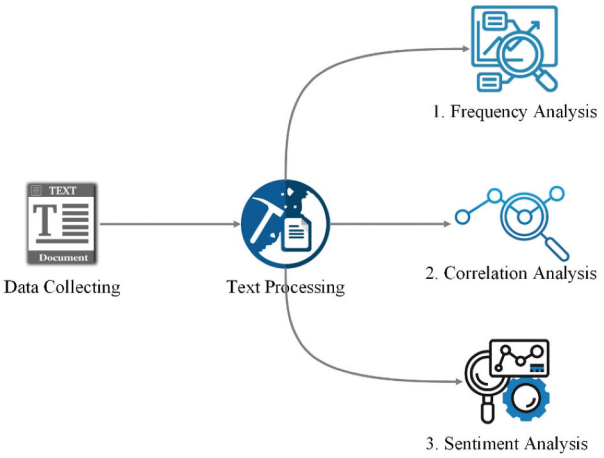

Figure 1. The process performed to analyze the textual data.

Various text mining methods are used for the research, the analysis mechanisms of which are described below. Figure 1 illustrates the research phases.

The rest of this paper is structured as follows: Section 2 reviews the literature on the impact of COVID-19 and text analysis on supply chains. The study method and text analysis approach are addressed in Section 3. Section 4 discusses the results and Section 5 provides managerial insights to tackle the effects of COVID-19 on supply chains. Finally, Section 6 presents the overall conclusions and suggests some routes for further investigation.

Literature Review

This section is separated into two subsections. First, we review literature related to using text mining and data analysis. The second subsection deals with the effects and challenges of COVID-19 in supply chains.

Data analysis

The text mining technique has been applied by many researchers for different purposes, and the impact of COVID-19 on supply chains has also been analysed. Jahanbin et al. (2019). mined text data from Twitter related to influenza, HIV/AIDS, malaria, measles, polio, tuberculosis, plague, Ebola and cholera. The analysis of the data collection also identified where the most tweets were posted about each of these infectious diseases. Han et al. (2020) used social media posts in China during the initial COVID-19 outbreak to gauge public opinion about the disease. The authors classified the data into seven themes. They then investigated the relationship between the themes and the severity of the disease outbreak. Eventually, the

authors found that the Chinese government's timely release of information was helpful in reassuring public opinion at the time of the COVID-19 outbreak. Using text mining of Twitter data, Ngo and Nguyen (2021) concluded that the fear triggered by COVID-19 is having an extreme impact on financial markets.

Anderson (2021) analysed 83,264 abstracts from research papers related to COVID-19, clustered them, and identified hidden research topics in the literature. Textual data were analysed using singular value decomposition and the Expectation-Maximization (EM) algorithm. Jelodar et al. (2020). used the Linear Discriminant Analysis (LDA) to extract hidden topics in comments related to COVID-19 and used the Long Short-Term Memory (LSTM) technique to categorise emotions. Krawczyk et al. (2021) analysed online news outlets related to COVID-19 news using text mining. They analysed and categorised the emotions contained in the texts and formulated some suggestions for improving public health communication. Albahli et al. (2021) used semantic analysis of three levels (negative, neutral, and positive) to gauge emotions in Persian Gulf countries regarding the coronavirus pandemic and quarantine, based on a Twitter 2-months dataset. People's emotions towards the pandemic were almost 50.5% neutral, 31.2% positive, and 18.3% negative. Dunajeva et al. (2021) identified the emotions of students in quarantine during the first and second waves of the COVID-19 pandemic and identified potential influences using textual analysis. Then they made recommendations to improve online learning, motivation, and the emotional status of the students.

Using text mining, Carracedo et al. (2021) investigated the effects of the coronavirus on companies and presented solutions for future businesses facing uncertain conditions. Also, Yang and Han (2021) addressed the impact of the coronavirus on industry and businesses with text mining of tweets. In another research, Barnes et al. (2021) examined the purchasing behaviour of customers in a supply chain with the text mining of tweets.

Chu et al. (2020) classified the risks that threaten the supply chain by analysing the text of articles in the supply chain field, as well as providing solutions for dealing with these risks. Kim and Kim (2017) reviewed trends in the development of sustainable supply chain management in the textile and garment industry, according to news articles. Text mining analysis was used to identify companies' strategies, positive outcomes, values, and the feasibility of implementing sustainability in the supply chain. Shah et al. (2021) have conducted a comprehensive list of text sources to analyse the text to assess the risk of the garment industry's supply chain, identifying and classifying them. Meyer et al. (2021) investigated the effects of the coronavirus on supply chain stability at the beginning of the coronavirus outbreak and classified the risks.

Wu et al. (2022). reconfigured a hierarchical supply chain using text mining as the coronavirus affected the global supply chain with a bullwhip effect. Zhou and Tian (2020) investigated the impact of COVID-19 on China's cereal production using text collected from two social networks WeChat and Sina Weibo. They predicted that COVID-19 would not have a significant effect on cereal production throughout the year, and that supply could essentially be guaranteed. Nevertheless, due to transportation blocking and workforces' deficiency caused by urban quarantine, the cereal processing industry cannot resume production soon and is severely affected. Sharma et al. (2020) studied the impact of the coronavirus on supply chain decisions using text mining of tweets and then classified themes based on iterative words.

Supply chains during the COVID-19 pandemic

The COVID-19 pandemic has affected supply chains globally; thus, many studies have been conducted to investigate this issue. Remko (2020) had interviews with managers regarding COVID-19's effects on supply chains. This study found that supply, as well as demand, have changed significantly, and the resilience of the supply chain needs to be improved. Pujawan and Bah (2022) reviewed different studies that have addressed supply chain problems during the COVID-19 pandemic. They mentioned some concepts, such as redundancy, flexibility, digitalisation, and localisation to mitigate supply chain disruptions.

Sarkis (2020) pointed out that although organisations have faced a shock during the COVID-19 pandemic, improving the sustainability of the supply chain can tackle this crisis. Meier and Pinto (2020) showed that the supply chain crisis due to COVID-19 has affected countries' economies in terms of production, employment, imports, and exports. These effects need to be tackled, and supply chains should recover after COVID-19 effects. Respective recovery challenges of supply chains were analysed by Paul et al (2021). As the demand has changed during the pandemic, Çetindaş et al. (2023) showed that supply chain agility can positively affect demand stability and firm performance.

In a number of studies, specific aspects of food supply chains during the COVID-19 pandemic were analysed. Hobbs (2020) investigated the demand side which has suddenly changed because of consumers'

behaviour; the demand for some products increased, while for other products demand persisted or decreased. Sharma et al. (2020) investigated agriculture supply chains during the COVID-19 pandemic which changed in different aspects such as supply, demand, finances, logistics, infrastructure, management, and policies. Seif et al. (2023) showed that governments and companies should pay attention to food supply chains in order to prevent the further spread of the coronavirus in societies.

Modgil et al. (2021) conducted interviews to investigate the role of artificial intelligence in the supply chain during the pandemic. Their results showed that artificial intelligence can improve the resilience of the supply chain. Modgil et al. (2021) analysed qualitative data collected from 35 participants involved in supply chain information to study social media-induced polarisation during the pandemic. Rajak et al. (2022) identified the factors of a sustainable supply chain and the stakeholders' requirements after COVID-19 outbreak. They used quality function deployment and best-worst methods to analyse supply chains. Khodoomi et al. (2023) analysed the effects of COVID-19 on the price of products that are sold through both in-person and online shops.

Alam et al. (2021) used the Intuitionistic Fuzzy DEMATEL method to explore fifteen challenges of COVID-19 vaccine supply chains. These challenges were classified and ranked to point out priorities for decision-makers. Alizadeh-Meghrazi et al. (2022) designed a new sustainable and resilient supply chain network for mask distribution during COVID-19. Moreover, Raj et al. (2022) employed the Grey-DEMATEL method to analyse ten main challenges of supply chains during the COVID-19 pandemic. Some examples of these challenges are labour scarcity, material scarcity, and inconsistency of supply. Montoya-Torres et al. (2021) reviewed different studies to find the effects of COVID-19 on logistics and supply chains. They mentioned various affected aspects of supply chains such as economic, social, and environmental issues. In addition, they highlighted some topics, such as collaboration, technology, and knowledge, needing to be investigated. Chowdhury et al. (2021) analysed 74 papers that were related to supply chains and the COVID-19 pandemic. They found changes in demand in the supply chain and also the need for more research on this issue.

Table 1 provides a comparison of studies and their methods that have investigated the impacts of COVID-19 on supply chains.

According to a review of the literature, it is known that no research has yet been conducted using data mining based on current and valid texts such as news and online news articles to identify the impact of the coronavirus on logistics and supply chain. Consequently, this article has some innovations, which are explained: (i) Data mining on authentic online news texts as well as a wide range data collection from the onset of the coronavirus to the latest news and information; (ii) Utilization of different text mining techniques, including frequency analysis, correlation analysis, and sentiment analysis; (iii) Determining components of the supply chain affected by the coronavirus; (iv) Classifying the effects, problems, and obstacles caused by the coronavirus outbreak on logistics and supply chain; (v) Presentation of management strategies to minimise the problems and obstacles in logistics and supply chain.

Methodology and data analysis

Text mining techniques can be divided into the following main areas: (i) categorisation of text, (ii) topic detection, (iii) summarisation, and (iv) concept extraction. Some non-trivial information can be found through these techniques. Different areas such as marketing, healthcare, and research (Do Prado et al. 2007) used text mining to leverage its advantages (Hashimi, Hafez, and Mathkour 2015) such as: (i) extracting useful information and patterns from large amount of data, (ii) predicting and forecasting, and (iii) performing analyzes with high efficiency in a short time.

Figure 2 describes the text-mining process and methodology. The first step of our study involves data collection, retrieval, and textual data preprocessing. Afterward, text transformation and feature selection are done in order to identify patterns of the COVID-19 pandemic impact on supply chains. Finally, we suggest some managerial insights to mitigate the negative pandemic effects on supply chains.

The impact of the coronavirus on the logistics and supply chain following the pandemic outbreak has been widely reported in the news media, which describe the different effects and emotions caused at different levels. In this research, we extract and analyse these effects and emotions. In this study, we use the R programming language for processing textual data, analysis, and plotting the results. Various analyses make on the data are described in the following sections.

Data collection

First, we identified a set of reputable news and business websites that combine two terms in their titles or text, the first being 'supply chain' or 'logistics' and the second being 'COVID-19' or 'coronavirus' or 'pandemic' or 'lockdown' or 'endemic' or 'quarantine'.

Table 1. Comparison of studies regarding the effects of COVID-19 on supply chains.

		Methods						
Authors	Year	Operation Research	MCDM	Text Mining	Literature Review	Interviews	Simulation	Managerial Insights
Sarkis (2020)	2020				●	●		
Ivanov (2020)	2020						●	●
Xu et al. (2020)	2020				●			●
Shi et al. (2021)	2021				●			●
Hosseini et al. (2021)	2021	●						●
Ivanov and Dolgui (2021)	2021	●			●			●
Moosavi et al. (2022)	2022				●			●
Magableh and Mistarihi (2022)	2022		●			●		
This Study	2023			●	●			●

Table 2. The collected data.

Dimension	Item
Number of websites (articles)	546
Number of terms	1135064
Number of terms (after pre-processing)	101297
Unique stemmed terms	100884

Various global supply chain aspects are discussed in business magazines and news articles, and such articles are usually updated at very short intervals. Accordingly, online news and business articles appear as good sources for analysing the impact of the coronavirus on different aspects of logistics and supply chain management on a global scale. One of the positive aspects of using online articles and news in comparison with research articles is that they are published quickly and updated. In addition, they cover different latest news regardless of geographical boundaries. Thus, these online articles are related to areas all around the world as shown in Figure 3.

The present research uses Google News (API) to search for the relevant websites and focuses on these sources. Online articles in English from related news and business sites published between 2019 and 2022 are collected. A total of 546 online articles are gathered as input for this study. Figure 4 shows the publication date of the considered articles which provides some important insights: First of all, related news were published during the whole pandemic which shows the importance of the pandemic for supply chains. Secondly, when a new wave of the pandemic occurred, the number of news increased.

Basically, we need to review and clean up the text to remove additional information before the analysis phase. There are several measures for data preprocessing in text mining: (i) Removing punctuations; (ii) Removing meaningless phrases such as numbers and stop words; (iii) Removing symbols; (iv) Eliminating extra spaces; (v) Converting all letters to lowercase.

After cleaning and preparing the analysable texts, the word roots are identified (stemming). These roots will be examined so that all the words to be examined will be included in the analysis. For example, the words 'chain' and 'chains' have the same meaning in the review; however, due to the existence of 's', these two words are considered distinctively. Thus, using their roots assumes both words to be the same.

The information gathered can be seen in Table 2. As shown in Table 2, the number of terms has decreased significantly after the preprocessing phase.

The data are analysed after cleaning the data and texts.

Zipf's law

Zipf's law (Zipf 1932), which was originally formulated in quantitative linguistic expressions, states that the 'frequency' of any word is inversely proportional to its 'rank' in the frequency table (Saichev, Malevergne, and Sornette 2009). It implies that the most frequent word occurs almost twice as often as the second most frequent word, and three times as often as the third most frequent word, and so on, which can be expressed as follows; in this equation c is a constant number, and N is the total number of words:

$$\frac{word\ rank \times term\ frequency}{N} = c$$

As $\frac{term\ frequency}{N}$ indicates the probability of that word occurring among all words, the above equation can be modified as follows:

$$word\ rank \times word\ probability = c$$

This equation can also be defined logarithmically; the logarithmic form of this equation and the diagram create by it give good information.

$$\log(word\ rank) + \log(word\ probability) = \log(c)$$

This simple rule occurs in many complex environments. The law has been used to detect fraud in financial and accounting resources (Huang et al. 2008), and has also been used to simulate users' visits to web pages, predict site rankings, and detect viral emails (Adamic and Huberman 2002; Jauhari, Saxena, and Gautam 2007). Thus, this paper uses this law to prove the validity of the data. Zipf's law is often plotted by drawing word rank on the x-axis and word frequency

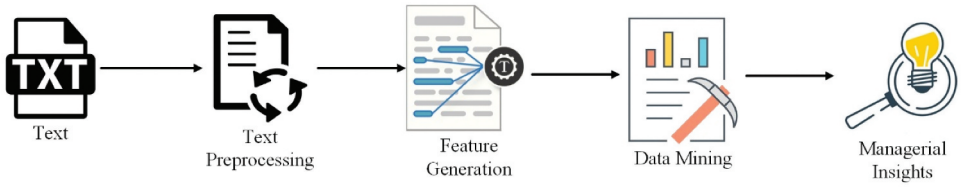

Figure 2. Text mining process.

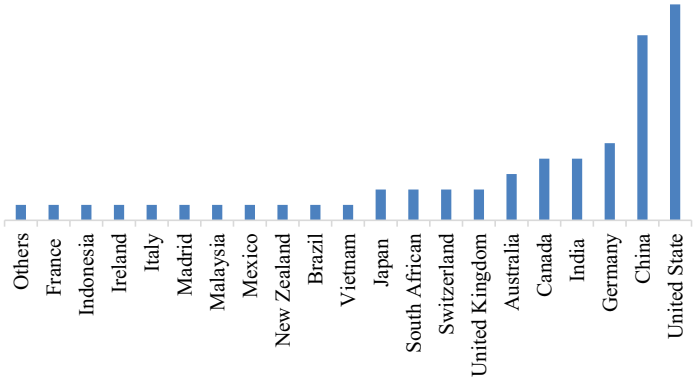

Figure 3. The sources of considered news and online articles.

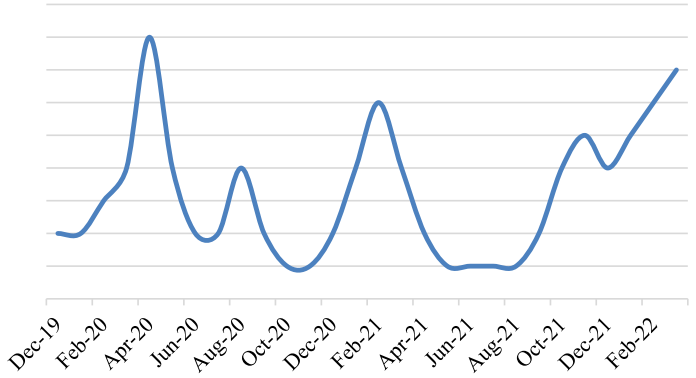

Figure 4. The number of investigated articles based on the publication date.

on the y-axis on logarithmic scales. By drawing this law, a proportional inverse relationship will have a fixed and negative slope, shown in Figure 5.

Based on Figure 5, we have:

$$\log(word\ probability) = -0.61 \log(word\ rank) - 1.64$$

The distribution can be compared to drawing a regression line. Despite the use of many and varied articles, it is still shown that there is a conclusion close to Zipf's law in the examined text.

Term frequency

Each word frequency in the text is one of the processible items referring to the importance of each word and providing good insight through various approaches of analysis. Phrases are counted throughout the text to determine how many times each word has been repeated. The number of repetitive words is shown in the form of a bar chart in Figure 6 and words cloud in Figure 7.

The first concept to be deduced from the frequency of the words is that there are many identical words in all the collected articles and texts, indicating that the content is well-chosen and included the common subject of 'corona' and 'supply chain'.

In general, the words containing the most information in a text are the words that appear frequently in that document. The frequency of the words can be useful for understanding the context of the text and general emotions. Thus, the number of frequently

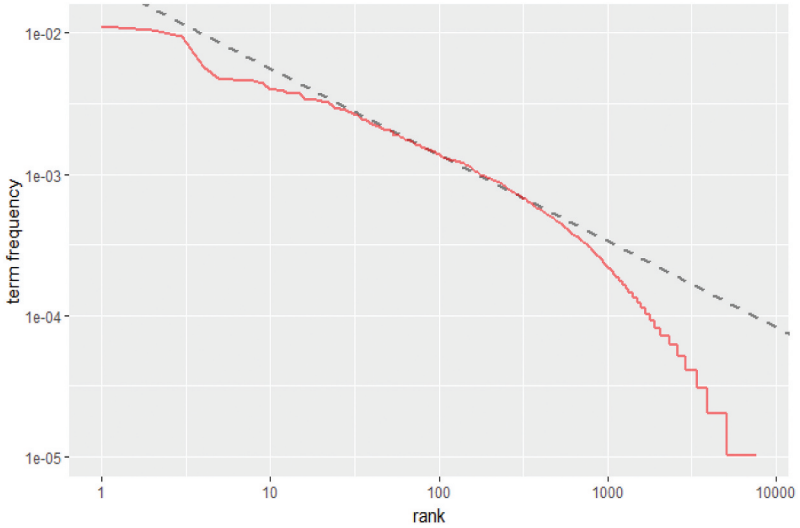

Figure 5. Zipf's law.

Table 3. Analysis and assortment the highest frequency words.

Categorization	Repetitive Words	Description
Factories and products	business,market,product,company,price,industry market,product,company,price,industry	Factories and companies are the subjects most related to supply chains, which include produced goods, distribution and flow of goods, and the product prices (Aday and Aday 2020; Coluccia et al. 2021; Mahajan and Tomar 2021; Rizou et al. 2020).
Governments and organizations	government,policy,nation,global,OECD,office policy,nation,global,OECD,office	Governments and organizations making key decisions and policies have a significant impact on supply chains (De Vito and Gómez 2020; Grida, Mohamed, and Zaied 2020).
Hygiene and health	pandemic,health health	The issue of health and compliance with health protocols is an important factor that has directly influenced supply chains by leading to restrictions and quarantines at the national and international level (Control, C.f.D. and Prevention 2020; Naja and Hamadeh 2020).
Analysis and evaluation	report,evaluate,management,response evaluate, management,response	The agility of organizations and the supply chain depends on continuous analysis and evaluation and is required to maintain survival under these conditions, which illustrates the importance of this issue (Sarkis, Cohen, Dewick, and Schröder 2020).
Problems and obstacles	disruptcrisis,risk,shortage,time crisis,risk,shortage,time	The impact on supply chains of problems caused by the outbreak of the coronavirus on supply chains cannot be denied, and the pandemic has been a major challenge for organizations and supply chains (Barman, Das, and De 2021; Stephens et al. 2020).

repeated words may lead us to find out about the most frequently repeated topics. After the terms 'covid' and 'supply chain', other repetitive words are analysed in Table 3.

The *n*-grams and correlations

In the previous section, words were examined individually by understanding their frequency and distribution throughout the text. However, many text analyses rely on the relationships between words. What sequence of words is common in the text? What words have the strongest relationship with each other?

One of these analyses is to evaluate the words that appear next to each other in the text. We first examined the pairs of words or the so-called bi-grams that have appeared one after the other. By finding out how many times two words are repeated together, we can build a model of the relationships between them. Some repeated bi-grams have a special meaning and are usually common terms or idioms. The supply chain bi-grams have the highest frequency (853 times) in the texts, which shows a huge difference compared to other words. The other twenty most repetitive bi-grams are shown in Figure 8.

N-gram tokenisation appears as a useful method to discover adjacent bi-grams. However, the words that appear together may not necessarily be exactly next to each other. The bi-grams with the highest frequency

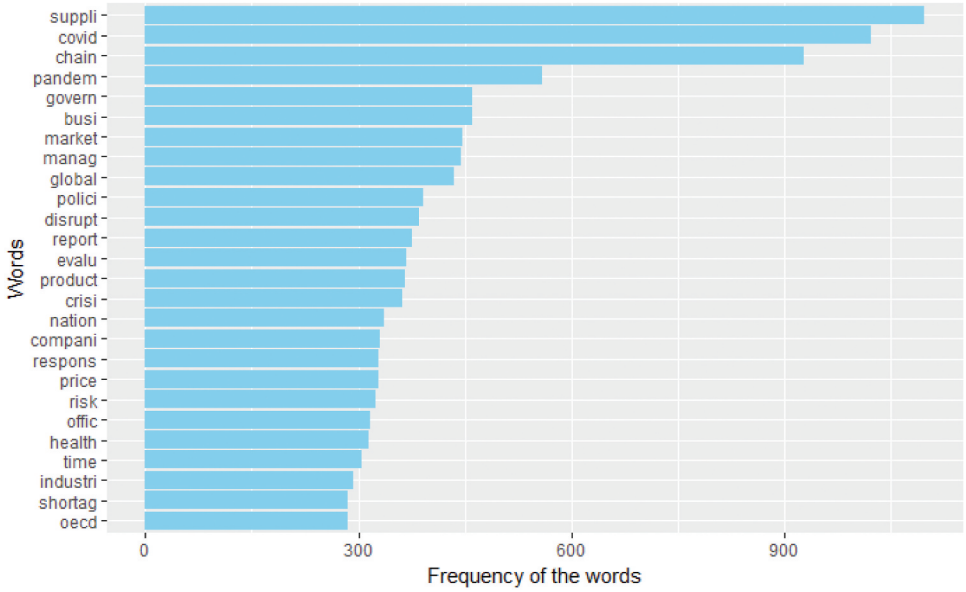

Figure 6. The most frequently occurring words.

Figure 7. High-frequency words cloud.

rate in the previous section are drawn in Figure 8. Yet, this does not give us much insight into the multiple relationships between words. We can use a network diagram to understand better the multiple relationships that may exist.

We may also want to know how many words appear together compared to the number of times they appear separately, i.e. what is the correlation rate between the words? Figure 9 shows clusters of words that examined the networks of words with a correlation between them (correlation >0).

For example, what is the highest correlation rate of the words that appear with 'chain'? Interestingly, in addition to 'supply', words such as 'health', 'social', and 'covid' also correlate with this word, although they are not exactly one after the other. Moreover, following a word and finding strings attached to it, you can find out the most repeated words that appear next to it. For example, across the network, a cluster indicates 'covid', 'anticipate', 'crisis', 'scheme', 'health', 'policy', 'critic', 'chain', and a few more are more likely to appear together. This type of chart provides a perfect starting point for finding the content relationships within the text.

In this way, the connection between words that are close to each other can generally be found. For example, as mentioned above, the word 'supply chain' as it is associated with words such as 'health', 'covid' and 'society', indicates the connection of the supply chain with health issues in society.

Sentiment analysis

Sentiment analysis is a method for determining emotions from words. One way to analyse the feelings expressed in a text is to consider the text as a combination of words, each of which is associated with an emotion, and then consider the whole text feeling as the sum of the emotional content of each of the words. Sentiment analysis is often made based on predefined dictionaries. Hence, in these dictionaries, every word is attributed to a feeling. Table 4 lists several emotional words.

These dictionaries are implemented separately on the texts to identify the results of different emotions within the texts. Naturally, the analysis results may vary since the words and emotions assigned to each word are different in each dictionary. For example, words with negative and positive emotions are defined in both 'nrc' and 'bing' dictionaries. Both vocabularies have the same total number of words. Still, the ratio of negative to positive words in the 'bing' vocabulary (4782 negative words) is higher than the 'nrc'

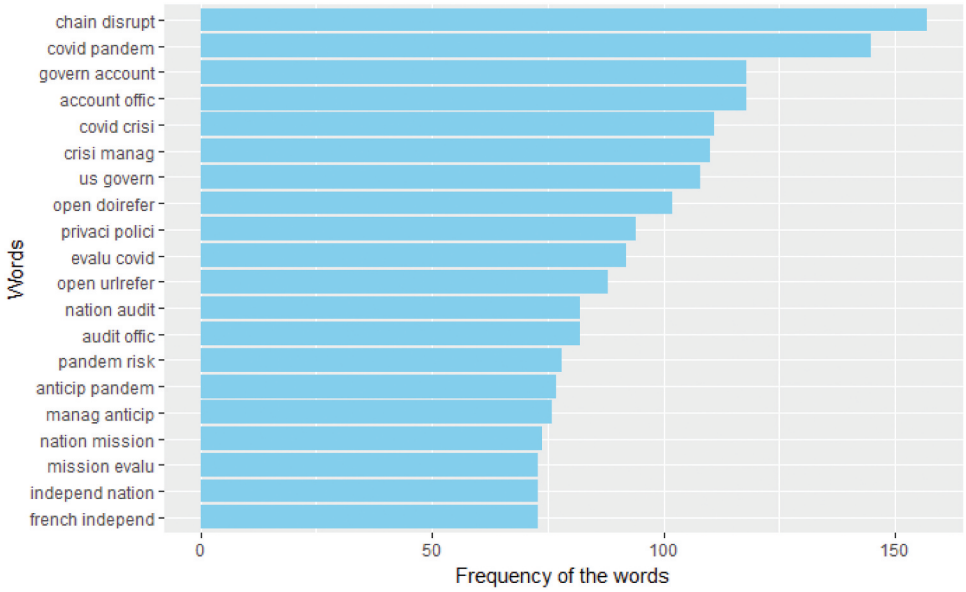

Figure 8. Bi-gram frequency.

vocabulary (3324 negative words). First, all the words in the texts are separated individually and examined with the four dictionaries mentioned.

We initially evaluated the negative or positive orientation of the text using the 'bing' dictionary, which is shown in Figure 10.

As it turns out, the negative orientation of the text is greater than the positive orientation, which is understandable, as the coronavirus has evoked negative emotions and negatively affected logistics and supply chains (Sontake, Jain, and Singh 2021; Tan and Aviso 2021). The ten most frequently repeated positive and negative words are identified using the same 'bing' dictionary, shown in Figure 11.

The most frequently repeated words result in understanding the problems and needs. The word 'disrupt' is the most repeated negative word and indicates a disruption in the processes related to logistics and supply chain management caused by the coronavirus. Moreover, the word 'risk' represents a risk for the supply chain in the pandemic period (Barman, Das, and De 2021; Grida, Mohamed, and Zaied 2020; Mahajan and Tomar 2021; Rowan and Galanakis 2020; Sharma et al. 2020). The high frequency of other words such as 'delay', 'restrict', 'loss', and 'limit' reflects the problems encountered during this period (Barman, Das, and De 2021; De Vito and Gómez 2020; Stephens et al. 2020). On the other hand, 'support' from governments and organisations is needed to improve the situation (Manzini and Accorsi 2013).

Figure 12 shows more words separated by positive and negative themes to better understand the problems and positive tips mentioned in the text. The supply chain problems created by the COVID-19 pandemic can thus be better identified.

We then use other dictionaries to check the texts with them as well. First, using the 'afinn' dictionary, the

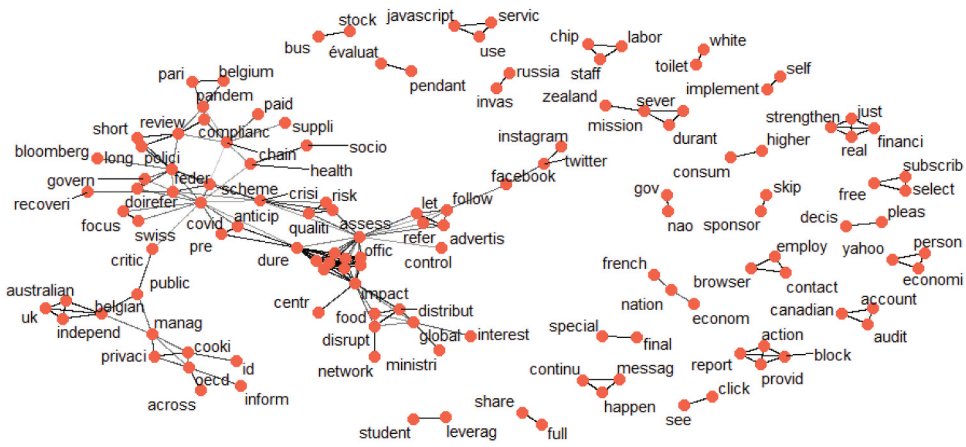

Figure 9. Bi-gram network.

Table 4. Dictionaries of sentiments.

lexicons	from	Sentiment analysis attitude
nrc	Saif Mohammad and Peter Turney	"positive", "negative", "anger", "anticipation", "disgust", "fear", "joy", "sadness", "surprise", or "trust"
bing	Bing Liu and collaborators	binary values of "positive" or "negative"
AFINN	Finn Årup Nielsen	numerical scores, ranging from −5 to 5, representing "positive" and "negative"
Loughran	The Loughran and McDonald dictionary	"litigious", "uncertainty", "constraining", and "superfluous"

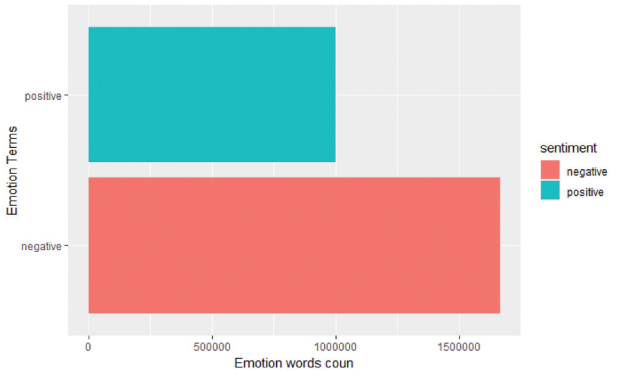

Figure 10. Corpus negative or positive sentiments (bing).

text's general sense is examined to evaluate the density of words in the range of −5 to + 5. The output of this analysis is depicted in Figure 13.

As it can be concluded, this dictionary has a higher density of words in the texts indicating a more negative sense. Continuing the process, we perform the same procedure using the 'Loughran' dictionary. As mentioned, the 'Loughran' dictionary has different categories for the emotions of words. After examining the text with this dictionary, the number of words included in each category is shown in Figure 14.

As with the previous two dictionaries, the negative bias of the text is clearly evident in this dictionary. Words like 'disrupt' and 'risk' represent this negative sense. The second feeling conveyed by the text is a positive one, which is due to the existence of words such as 'good', 'best', and 'better'. Since these words are adjectives, we cannot draw any definite conclusions; however, they have created a positive feeling in the text. The third feeling most evoked is the sense of 'uncertainty' conveyed by the text, resulting from the existence of words such as 'risk', 'variant', and 'different'. 'Litigious' and 'constraining' emotions are also observed in the text, which is expected due to the subject of the text and the existence of words such as 'pray', 'legal', 'restrict', 'limit', and 'prevent' (Barman, Das, and De 2021; De Vito and Gómez 2020; De Vos 2020; Senthilkumar et al. 2020).

We achieve a different result by continuing the analysis using the 'nrc' library. Like the 'Loughran' dictionary, it has divided the emotions of words into different categories. The results of analysing the review with the 'nrc' dictionary are shown in Figure 15.

Based on Figure 15, this dictionary shows the positive aspect of the text more than other sentiments. The reason is that the frequently repeated words such as 'government', 'food', and 'share' are put by this dictionary in the category of positive words. After positive emotions, the second emotion is associated with a negative feeling, which can be derived from words

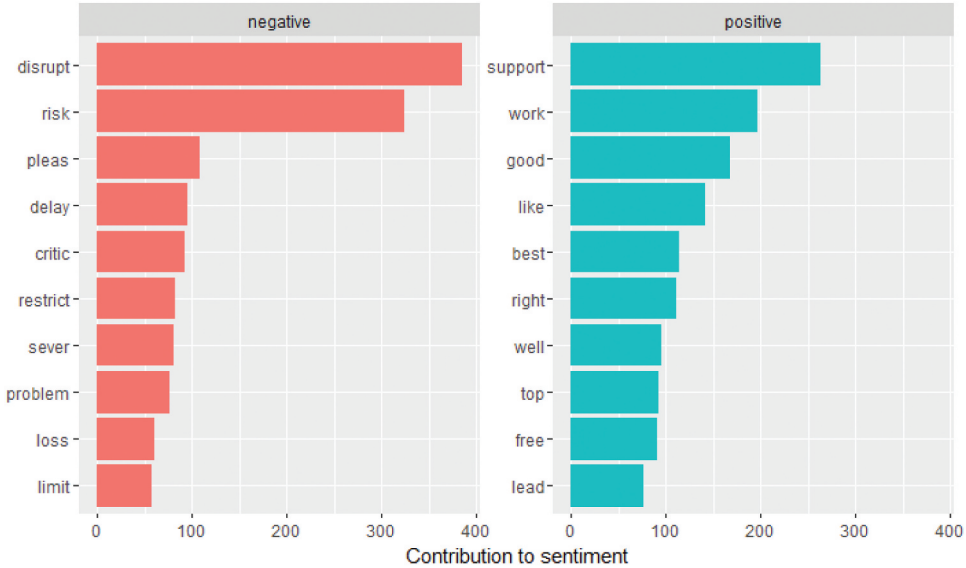

Figure 11. The ten most frequently repeated positive and negative words (bing).

Figure 12. Word cloud of positive and negative words (bing).

such as 'disrupt', 'delay', and 'problem'. Besides, the presence of emotions such as 'trust' and 'anticipation' indicates that a large portion of news articles would convey a promising perception of the financial and operational aspects. These sections include words such as 'nation', 'risk', and 'time' (Sontake, Jain, and Singh 2021). On the other hand, the feeling of fear also suggests that words like 'risk', 'watch', 'case', and 'delay' played a role in the development of this feeling (Anton and Miller 2005).

Suppose we eliminate the positive and negative feelings from the text and look at other feelings in the text using the 'nrc' dictionary. In that case, the results of different emotions can be seen in Figure 16.

We use three different dictionaries to understand the emotions of the text, which results are slightly different from each other, and each evaluated the text from a different aspect. However, it turns out what emotions exist in the text in general. Negative feelings are highly visible in the text, suggesting the problems created on the logistics and supply chain at a global level.

Various and useful analyzes can be made at the word level, but sometimes it is useful and necessary to look at larger units such as sentences. At the end of this section, the text emotions are examined not in words but as text sentences. The sentence-level analysis allows us to evaluate the emotions of the text with a different approach. We initially broke down the text into sentences and then matched it using the 'AFINN' dictionary to calculate the score of emotions for the whole text in terms of sentences. The output of this analysis is plotted as a thermal map representing different sentiments as different colours throughout the text as shown in Figure 17.

Results and discussion

In this study, we used text mining analysis to explore and evaluate the impact of the coronavirus on processes in logistics and supply chain management. We conducted various analyses, including term frequency, n-grams, correlation analysis, and sentiment analysis of the textual data from articles on news and business websites on the topic of supply chains and coronavirus. We then grouped the frequently recurring topics in the area of coronavirus and supply chain into five categories based on the results obtained: (i) Factories and products; (ii) Governments and organisations; (iii) Hygiene and health; (iv) Evaluation and analysis; (v) Problems and obstacles.

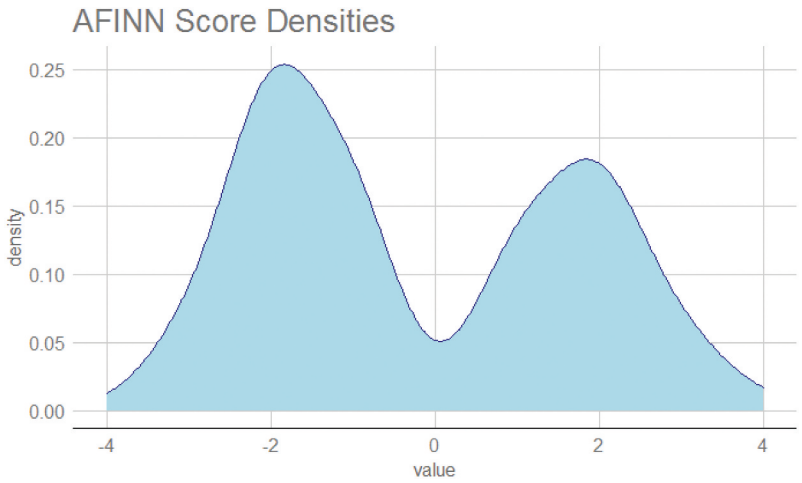

Figure 13. Density of negative or positive sentiments (AFINN).

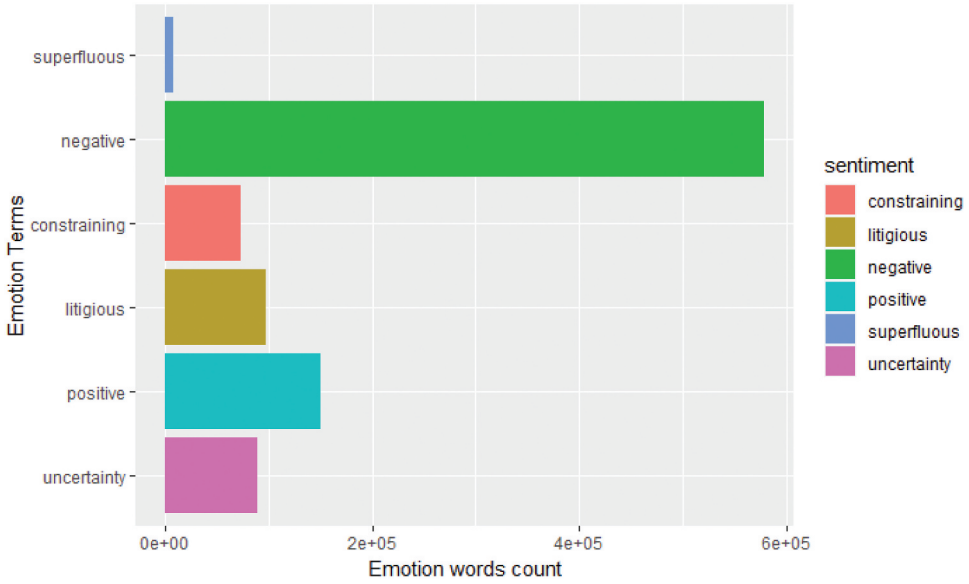

Figure 14. Corpus level sentiments (Loughran).

The classification shows the sections and issues in the supply chain that are affected by the coronavirus. Suppliers and factories are the first levels of the supply chain that faced many problems, including labour shortages, reduced production capacity, quarantine, compliance with health protocols, and changes in the demand of the products. On the other hand, governments and organisations played a crucial role during this period in determining preventive policies for protection against the COVID-19 disease and the survival of the industry and economy of countries. For example, restricting the import and export of goods from the country directly affects the global supply chain. Moreover, it seems indispensable that each member of the supply chain examines and evaluates the supply chain and makes the right decision depending on the circumstances, as such problems and obstacles have never been encountered in the global supply chain at this level.

The most obvious observation from the sentiment analysis of the texts is the presence of many negative emotions. The analysis of negative words can reveal the problems that occurred to the logistics and supply chain due to the spread of the coronavirus. The seven problems and obstacles are listed in Table 5.

In the proposed classification, the impact of the coronavirus on global supply chains is categorised into the dimensions of break and failure, instability, slowness and delay, restrictions and disruptions,

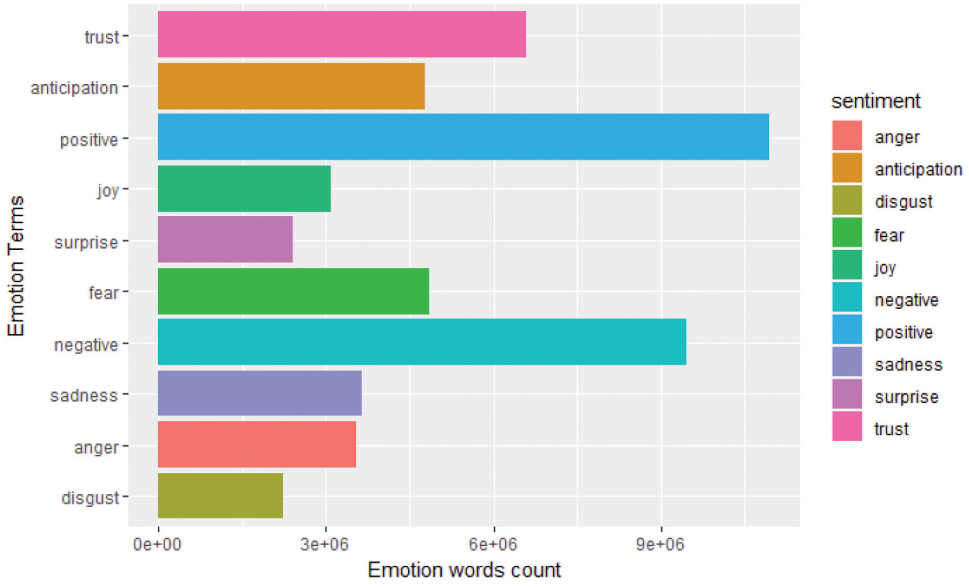

Figure 15. Corpus level sentiments (nrc).

Table 5. Challenges for supply chains due to COVID-19 pandemic.

No.	Problems and Obstacles	Keywords	Description
1	break and failure	disrupt, break, interrupt	The coronavirus not only broke supply chains but caused them to stop completely in some cases. Many countries completely shut down the ongoing global supply chain due to applying quarantine and banning the import of goods (Barman, Das, and De 2021; Sarkar, Debnath, and Reang 2021; Sontake, Jain, and Singh 2021).
2	instability	risk, threat, tension	Due to the different and widespread waves of the coronavirus outbreak and the identification of new virus strains, the adoption of policies by individual countries and the application of different restrictions during different time intervals constantly created instability and uncertainty in supply chains (Grida, Mohamed, and Zaied 2020).
3	slowness and delay	delay, slow	The timely supply of goods faced troubles in the pandemic period since applying restrictions and reducing capacity, and creating social distancing and other enforced policies to reduce the prevalence of the coronavirus slowed down supply chain processes (Barman, Das, and De 2021; De Vito and Gómez 2020; Sontake, Jain, and Singh 2021; Stephens et al. 2020; Tan and Aviso 2021).
4	restriction and disruption	restrict, limit, outbreak	Many constraints involved the supply chains, ranging from the lack of human resources for production and transportation to freight restrictions inside or outside countries, all of which disrupted the supply chains (Barman, Das, and De 2021; Sarkar, Debnath, and Reang 2021; Sontake, Jain, and Singh 2021; Stephens et al. 2020; Tan and Aviso 2021).
5	shortage	lack, shortage	The quarantine decreased working hours and reduced the use of the manufacturers' capacity. On the other hand, the additional customer demand for some products during the quarantine period caused shortages in all industries (Barman, Das, and De 2021; De Vito and Gómez 2020; Sarkar, Debnath, and Reang 2021; Stephens et al. 2020).
6	poor performance	fear, shock, panic, stress, concern, nervous	When people work in supply chain management or related activities, their emotions affect it. Thus, supply chain operated outside their previous patterns during this period, and performance was frequently insufficient. For example, online sales of products received much more attention, while many restaurants and hotels were closed (Barman, Das, and De 2021; Mahajan and Tomar 2021; Rizou et al. 2020).
7	spoilage and loss	loss, miss	The pandemic greatly affected perishable products, such as food. This problem was observed from the beginning to the end of related supply chains and resulted in product loss. It is noteworthy that in many cases agricultural products were not collected due to labor shortages and were left to rot on the agricultural lands. On the other hand, the slowness, disruption, and lack of demand led to product loss throughout the supply chain (Aday and Aday 2020; Barman, Das, and De 2021; De Vito and Gómez 2020; Rowan and Galanakis 2020; Sarkar, Debnath, and Reang 2021).

shortage, poor performance, and spoilage and loss. Each dimension has its keywords of choice as problem and obstacle. It is worth noting that each of these problems, at a specific time and in a given area, can potentially affect the entire global supply network and influence the performance of the relevant stakeholders. Also, these problems may not be independent; in other words, several factors have chain reactions that affect all or part of a global supply chain. The causes of these problems and obstacles are different. For example, a pandemic outbreak directly leads to transportation disruption; this would affect the stages of the supply chain that are more dependent on transportation, such as distribution and supply.

Figure 16. Corpus level sentiments without positive and negative (nrc).

Managerial insights

The results of this study are relevant to supply chain managers and business owners. These findings allow them to identify possible damage in their supply chains and make the right decisions in the event of similar circumstances. This study could also be of interest to government officials and policymakers. In general, this study presents several practical concepts:

Given the interconnectedness and interrelationship of factors and units of a supply chain, managers need to consider all aspects of a chain from the upstream to the downstream to make better decisions. With product supplies being disrupted due to transportation restrictions and reduced production, managers need to consider several suppliers to procure the required goods. Supplier selection depends on shipping route decisions.

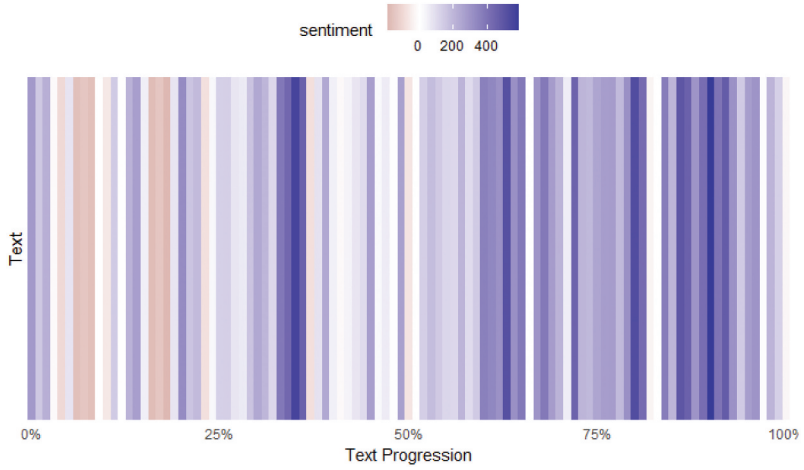

Figure 17. Heat map of sentences level sentiments (AFINN).

In general, the coronavirus pandemic and its effects have challenged production and distribution systems. Thus, these should be revised, and new and more interconnected management forms are also needed. Due to the many exports and imports restrictions, countries are better off being less dependent on external factors and should focus on domestic producers.

The survival of jobs and businesses depends on their ability to deal with this situation as a turning point. Therefore, accurate decision-making seems to be highly important to strengthen companies. Adapting to new features and consumer habits seems essential. Virtual acquisitions have become very common during the pandemic and are unlikely to lose their status. Hence, it is crucial to pay attention to this issue.

As the market has been dramatically affected by the outbreak of this disease, government officials need to support producers so they can reach their full potential. Government interventions and supports can help to maintain the balance in the markets. Governments can also use the capabilities of communications media to control rumours that create tensions in market demand.

Some of the problems and risks are related to hygiene and health issues in the supply chain. Thus, the required facilities should be carefully disinfected to prevent infections and thus reduce the impact of the coronavirus on employees. This will prevent the spread of the virus and reduce the number of human resource illnesses. These measures would enhance the consumers' confidence to make purchases at these stores. In general, organisations and governments need to pay more attention to improving the quality of life of citizens and the general health of society.

Conclusions

This study was done based on online articles and news that contained the latest news about the effects of the COVID-19 pandemic on logistics and supply chains all around the world by using text mining. The text mining approach contributed to finding the patterns and features in the articles, so that we could identify different aspects of the pandemic's impacts. After finding the impacts, we suggested some managerial insights to mitigate the negative impacts of coronavirus in order to manage the supply chain.

Although this research suggested valuable insights, there are some limitations. This paper did not analyse the publication dates of the articles, which could lead to further information and discussion if the time track is taken into account. Moreover, English online articles were analysed, while incorporating other databases and non-English contexts could provide broader results and investigate some local problems. Using further tools for text mining including other programming languages such as Python can provide some more findings. Furthermore, this study focused on an overview of all impacts of COVID-19 on supply chains and logistics; further research could address specific issues such as economics and manufacturing or focus on specific members of the supply chain such as retailers and customers.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Mohammad Reza Khodoomi http://orcid.org/0000-0002-7362-5162
Marziye Seif http://orcid.org/0000-0001-5095-250X
Thomas Hanne http://orcid.org/0000-0002-5636-1660

References

Adamic, L. A., and B. A. Huberman. 2002. "Zipf's Law and the Internet." *Glottometrics* 3 (1): 143–150.

Aday, S., and M. S. Aday. 2020. "Impact of COVID-19 on the Food Supply Chain." *Food Quality and Safety* 4 (4): 167–180. https://doi.org/10.1093/fqsafe/fyaa024.

Aggarwal, C. C. 2015. *Mining Text Data*. in *Data mining*. Springer. https://doi.org/10.1007/978-3-319-14142-8.

Alam, S. T., S. Ahmed, S. M. Ali, S. Sarker, G. Kabir, and A. Ul-Islam. 2021. "Challenges to COVID-19 Vaccine Supply Chain: Implications for Sustainable Development Goals." *International Journal of Production Economics* 239:108193. https://doi.org/10.1016/j.ijpe.2021.108193.

Albahli, A. S., A. Algsham, S. Aeraj, M. Alsaeed, M. Alrashed, H. Tayyab Rauf, M. Arif, et al. 2021. "COVID-19 Public Sentiment Insights: A Text Mining Approach to the Gulf Countries." *CMC-Computers Materials & Continua* 67 (2): 1613–1627. https://doi.org/10.32604/cmc.2021.014265.

Alizadeh-Meghrazi, M., B. M. Tosarkani, S. H. Amin, M. R. Popovic, and P. Ahi. 2022. "Design and Optimization of a Sustainable and Resilient Mask Supply Chain During the COVID-19 Pandemic: A Multi-Objective Approach." *Environment Development and Sustainability* 1–46. https://doi.org/10.1007/s10668-022-02604-z.

Ananiadou, S., D. B. Kell, and J.-I. Tsujii. 2006. "*Text Mining and Its Potential Applications in Systems Biology*. Trends in Biotechnology." *Trends in Biotechnology* 24 (12): 571–579. https://doi.org/10.1016/j.tibtech.2006.10.002.

Anderson, B. S. 2021. "Using Text Mining to Glean Insights from COVID-19 Literature." *Journal of Information Science* 49 (2): 373–381. https://doi.org/10.1177/01655515211001661.

Anton, S. D., and P. M. Miller. 2005. "Do Negative Emotions Predict Alcohol Consumption, Saturated Fat Intake, and Physical Activity in Older Adults?" *Behavior Modification* 29 (4): 677–688. https://doi.org/10.1177/0145445503261164.

Barman, A., R. Das, and P. K. De. 2021. "Impact of COVID-19 in Food Supply Chain: Disruptions and Recovery Strategy." *Current Research in Behavioral Sciences* 2:100017. https://doi.org/10.1016/j.crbeha.2021.100017.

Barnes, S. J., M. Diaz, and M. Arnaboldi. 2021. "Understanding Panic Buying During COVID-19: A Text Analytics Approach." *Expert Systems with Applications* 169:114360. https://doi.org/10.1016/j.eswa.2020.114360.

Brownstein, J. S., C. C. Freifeld, and L. C. Madoff. 2009. "Digital Disease Detection—Harnessing the Web for Public Health Surveillance." *The New England Journal of Medicine* 360 (21): 2153. https://doi.org/10.1056/NEJMp0900702.

Carracedo, P., R. Puertas, and L. Marti. 2021. "Research Lines on the Impact of the COVID-19 Pandemic on Business. A Text Mining Analysis." *Journal of Business Research* 132:586–593. https://doi.org/10.1016/j.jbusres.2020.11.043.

Çetindaş, A., İ. Akben, C. Özcan, İ. Kanuşağı, and O. Öztürk. 2023. "The Effect of Supply Chain Agility on Firm Performance During COVID-19 Pandemic: The Mediating and Moderating Role of Demand Stability." In *Supply Chain Forum: An International Journal*, 1–12. Taylor & Francis.

Chen, H., Y. Jin, and B. Huo. 2020. "Understanding Logistics and Distribution Innovations in China." *International Journal of Physical Distribution & Logistics Management* 50 (3): 313–322. https://doi.org/10.1108/IJPDLM-04-2020-403.

Chowdhury, P., S. K. Paul, S. Kaisar, and M. A. Moktadir. 2021. "*COVID-19 Pandemic Related Supply Chain Studies: A Systematic Review*. Transportation Research Part E." *The Logistics and Transportation Review* 148:102271. https://doi.org/10.1016/j.tre.2021.102271.

Chu, C.-Y., K. Park, and G. E. Kremer. 2020. "A Global Supply Chain Risk Management Framework: An Application of Text-Mining to Identify Region-Specific Supply Chain Risks." *Advanced Engineering Informatics* 45:101053. https://doi.org/10.1016/j.aei.2020.101053.

Cohen, A. M., and W. R. Hersh. 2005. "A Survey of Current Work in Biomedical Text Mining." *Briefings in Bioinformatics* 6 (1): 57–71. https://doi.org/10.1093/bib/6.1.57.

Coibion, O., Y. Gorodnichenko, and M. Weber. 2020. *Labor Markets During the COVID-19 Crisis: A Preliminary View*, (No. w27017). Cambridge, MA, USA: National Bureau of Economic Research.

Coluccia, B., G. P. Agnusdei, P. P. Miglietta, and F. De Leo. 2021. "Effects of COVID-19 on the Italian Agri-Food Supply and Value Chains." *Food Control* 123:107839. https://doi.org/10.1016/j.foodcont.2020.107839.

Control, C.f.D. and Prevention. 2020. *COVID-19 Critical Infrastructure Sector Response Planning*.

COVID-19 CORONAVIRUS PANDEMIC. 2022; Available from: https://www.worldometers.info/coronavirus/.

Davenport, T. 2014. *Big Data at Work: Dispelling the Myths, Uncovering the Opportunities*. Boston, Massachusetts, USA: Harvard Business Review Press.

Del Rio-Chanona, R. M., P. Mealy, A. Pichler, F. Lafond, and J. D. Farmer. 2020. "Supply and Demand Shocks in the COVID-19 Pandemic: An Industry and Occupation Perspective." *Oxford Review of Economic Policy* 36 (Supplement_1): S94–S137. https://doi.org/10.1093/oxrep/graa033.

De Vito, A., and J.-P. Gómez. 2020. "Estimating the COVID-19 Cash Crunch: Global Evidence and Policy." *Journal of Accounting and Public Policy* 39 (2): 106741. https://doi.org/10.1016/j.jaccpubpol.2020.106741.

De Vos, J. 2020. "The Effect of COVID-19 and Subsequent Social Distancing on Travel Behavior." *Transportation Research Interdisciplinary Perspectives* 5:100121. https://doi.org/10.1016/j.trip.2020.100121.

Do Prado, H. A., E. Ferneda, H. A. Do Prado, and E. Ferneda. 2007. *Emerging Technologies of Text Mining: Techniques and Applications: Techniques and Applications*. IGI Global. https://doi.org/10.4018/978-1-59904-373-9.

Dunajeva, O., A. Pentel, and N. Maksimova. *COVID-19's Impact on the Quality of Educational Process and the Academic Performance as Viewed by IT Students: A Case Study in Text Mining*. in *International Conference on Interactive Collaborative Learning*, Dresden, Germany. 2021. Springer.

Evans, O. 2020. "Socio-Economic Impacts of Novel Coronavirus: The Policy Solutions." *BizEcons Quarterly* 7:3–12.

Freifeld, C. C., K. D. Mandl, B. Y. Reis, and J. S. Brownstein. 2008. "HealthMap: Global Infectious Disease Monitoring Through Automated Classification and Visualization of Internet Media Reports." *Journal of the American Medical Informatics Association* 15 (2): 150–157. https://doi.org/10.1197/jamia.M2544.

Grida, M., R. Mohamed, and A. N. H. Zaied. 2020. "Evaluate the Impact of COVID-19 Prevention Policies on Supply Chain Aspects Under Uncertainty." *Transportation Research Interdisciplinary Perspectives* 8:100240. https://doi.org/10.1016/j.trip.2020.100240.

Hamzah, F. A. B., Lau, C. H., Nazri, H., Ligot, D. V., Lee, G., Tan, C. L., Mohd Shaib, M. K. B., Binti Zaidon, U. H., Abdullah, A. B., Chung, M. H., Ong, C. H., et al. 2020. "CoronaTracker: Worldwide COVID-19 Outbreak Data Analysis and Prediction." *Bulletin of the World Health Organization* 1 (32): 1–32.

Han, X., J. Wang, M. Zhang, and X. Wang. 2020. "Using Social Media to Mine and Analyze Public Opinion Related to

COVID-19 in China." *International Journal of Environmental Research and Public Health* 17 (8): 2788. https://doi.org/10.3390/ijerph17082788.

Hashimi, H., A. Hafez, and H. Mathkour. 2015. "*Selection Criteria for Text Mining Approaches*. Computers in Human Behavior." *Computers in Human Behavior* 51:729–733. https://doi.org/10.1016/j.chb.2014.10.062.

He, W. 2013. "Examining students' Online Interaction in a Live Video Streaming Environment Using Data Mining and Text Mining." *Computers in Human Behavior* 29 (1): 90–102. https://doi.org/10.1016/j.chb.2012.07.020.

Hobbs, J. E. 2020. "Food Supply Chains During the COVID-19 Pandemic." *Canadian Journal of Agricultural Economics/ Revue Canadienne D'agroeconomie* 68 (2): 171–176. https://doi.org/10.1111/cjag.12237.

Hosseini, S. M., M. M. Paydar, M. Alizadeh, and C. Triki. 2021. "Ecotourism Supply Chain During the COVID-19 Pandemic: A Real Case Study." *Applied Soft Computing* 113:107919. https://doi.org/10.1016/j.asoc.2021.107919.

Huang, S.-M., D. C. Yen, L.-W. Yang, and J.-S. Hua. 2008. "An Investigation of Zipf's Law for Fraud Detection (DSS# 06-10-1826R (2))." *Decision Support Systems* 46 (1): 70–83. https://doi.org/10.1016/j.dss.2008.05.003.

Ivanov, D. 2020. "*Predicting the Impacts of Epidemic Outbreaks on Global Supply Chains: A Simulation-Based Analysis on the Coronavirus Outbreak (COVID-19/SARS-CoV-2) Case*. Transportation Research Part E." *Transportation Research Part E: Logistics & Transportation Review* 136:101922. https://doi.org/10.1016/j.tre.2020.101922.

Ivanov, D., and A. Dolgui. 2021. "OR-Methods for Coping with the Ripple Effect in Supply Chains During COVID-19 Pandemic: Managerial Insights and Research Implications." *International Journal of Production Economics* 232:107921. https://doi.org/10.1016/j.ijpe.2020.107921.

Jahanbin, K., F. Rahmanian, V. Rahmanian, and A. S. Jahromi. 2019. "Application of Twitter and Web News Mining in Infectious Disease Surveillance Systems and Prospects for Public Health." *GMS Hygiene and Infection Control* 14:14. https://doi.org/10.3205/dgkh000334.

Jauhari, M., A. Saxena, and J. Gautam. 2007. Zipf's Law and Number of Hits on the World Wide Web. *Annals of Library and Information Studies* 54 (June 2007): 81–84.

Jelodar, H., Y. Wang, R. Orji, and S. Huang. 2020. "Deep Sentiment Classification and Topic Discovery on Novel Coronavirus or COVID-19 Online Discussions: NLP Using LSTM Recurrent Neural Network Approach." *IEEE Journal of Biomedical and Health Informatics* 24 (10): 2733–2742. https://doi.org/10.1109/JBHI.2020.3001216.

Kazancoglu, Y., E. Ekinci, S. K. Mangla, M. D. Sezer, and M. Ozbiltekin-Pala. 2023. "Impact of Epidemic Outbreaks (COVID-19) on Global Supply Chains: A Case of Trade Between Turkey and China." *Socio-Economic Planning Sciences* 85:101494. https://doi.org/10.1016/j.seps.2022.101494.

Khodoomi, M. R., S. Yaghoubi, and M. Seif. 2023. "Effects of COVID-19 Outbreak in Pricing and Collaboration of a Health-Social Dual-Channel Supply Chain." *Environmental Science and Pollution Research* 30 (19): 1–20. https://doi.org/10.1007/s11356-023-25849-1.

Kietzmann, J. H., K. Hermkens, I. P. McCarthy, and B. S. Silvestre. 2011. "Social Media? Get Serious! Understanding the Functional Building Blocks of Social Media." *Business Horizons* 54 (3): 241–251. https://doi.org/10.1016/j.bushor.2011.01.005.

Kilicoglu, H. 2018. "Biomedical Text Mining for Research Rigor and Integrity: Tasks, Challenges, Directions." *Briefings in Bioinformatics* 19 (6): 1400–1414. https://doi.org/10.1093/bib/bbx057.

Kim, Y.-H., S.-Y. Hahn, and B.-T. Zhang. *Text Filtering by Boosting Naive Bayes Classifiers*. in *Proceedings of the 23rd Annual International ACM SIGIR Conference on Research and Development in Information Retrieval*, Athens, Greece. 2000.

Kim, D., and S. Kim. 2017. "Sustainable Supply Chain Based on News Articles and Sustainability Reports: Text Mining with Leximancer and DICTION." *Sustainability* 9 (6): 1008. https://doi.org/10.3390/su9061008.

Krawczyk, K., T. Chelkowski, D. J. Laydon, S. Mishra, D. Xifara, B. Gibert, S. Flaxman, et al. 2021. "Quantifying Online News Media Coverage of the COVID-19 Pandemic: Text Mining Study and Resource." *Journal of Medical Internet Research* 23 (6): e28253. https://doi.org/10.2196/28253.

Lemke, M. K., Y. Apostolopoulos, and S. Sönmez. 2020. "A Novel COVID-19 Based Truck Driver Syndemic? Implications for Public Health, Safety, and Vital Supply Chains." *American Journal of Industrial Medicine* 63 (8): 659–662. https://doi.org/10.1002/ajim.23138.

Liao, S.-H., P.-H. Chu, and P.-Y. Hsiao. 2012. "Data Mining Techniques and Applications." *Science Direct Expert Systems with Applications* 39 (12): 11303–11311. https://doi.org/10.1016/j.eswa.2012.02.063.

Liu, W., X.-G. Yue, and P. B. Tchounwou. 2020. Response to the COVID-19 epidemic: the Chinese experience and implications for other countries. *International Journal of Environmental Research and Public Health* 17 (7) : 2304.

Magableh, G. M., and M. Z. Mistarihi. 2022. "Applications of MCDM Approach (ANP-TOPSIS) to Evaluate Supply Chain Solutions in the Context of COVID-19." *Heliyon* 8 (3): e09062. https://doi.org/10.1016/j.heliyon.2022.e09062.

Mahajan, K., and S. Tomar. 2021. "COVID-19 and Supply Chain Disruption: Evidence from Food Markets in India." *American Journal of Agricultural Economics* 103 (1): 35–52. https://doi.org/10.1111/ajae.12158.

Manzini, R., and R. Accorsi. 2013. "The New Conceptual Framework for Food Supply Chain Assessment." *Journal of Food Engineering* 115 (2): 251–263. https://doi.org/10.1016/j.jfoodeng.2012.10.026.

Marek, L. 2020. "CME Closing Trading Floors Indefinitely Amid Coronavirus Concerns." *Chicago Business*. Accessed March 11, 2020. https://www.chicagobusiness.com/finance-banking/cme-closing-trading-floors-indefinitely-amid-coronavirus-concerns.

Meier, M., and E. Pinto. 2020. "Covid-19 Supply Chain Disruptions." *Covid Economics* 48 (1): 139–170.

Meyer, A., W. Walter, and S. Seuring. 2021. "The Impact of the Coronavirus Pandemic on Supply Chains and Their Sustainability: A Text Mining Approach." *Frontiers in Sustainability* 2:3. https://doi.org/10.3389/frsus.2021.631182.

Modgil, S., S. Gupta, R. Stekelorum, and I. Laguir. 2021. "AI Technologies and Their Impact on Supply Chain Resilience During COVID-19." *International Journal of Physical Distribution & Logistics Management* 52 (2): 130–149. https://doi.org/10.1108/IJPDLM-12-2020-0434.

Modgil, S., R. K. Singh, S. Gupta, and D. Dennehy. 2021. "A Confirmation Bias View on Social Media Induced Polarisation During Covid-19." *Information Systems Frontiers* 1–25. https://doi.org/10.1007/s10796-021-10222-9.

Montoya-Torres, J. R., A. Muñoz-Villamizar, and C. Mejia-Argueta. 2021. "Mapping Research in Logistics and Supply Chain Management During COVID-19 Pandemic." *International Journal of Logistics: Research & Applications*

26 (4): 1–21. https://doi.org/10.1080/13675567.2021.1958768.

Moosavi, J., A. M. Fathollahi-Fard, and M. A. Dulebenets. 2022. "Supply Chain Disruption During the COVID-19 Pandemic: Recognizing Potential Disruption Management Strategies." *International Journal of Disaster Risk Reduction* 75:102983. https://doi.org/10.1016/j.ijdrr.2022.102983.

Naja, F., and R. Hamadeh. 2020. "Nutrition Amid the COVID-19 Pandemic: A Multi-Level Framework for Action." *European Journal of Clinical Nutrition* 74 (8): 1117–1121. https://doi.org/10.1038/s41430-020-0634-3.

Ngo, V. M., and H. H. Nguyen. 2021. "Are Fear and Hope of the COVID-19 Pandemic Responsible for the V-Shaped Behaviour of Global Financial Markets? A Text-Mining Approach." *Applied Economics Letters* 29 (11): 1–11. https://doi.org/10.1080/13504851.2021.1904105.

Nicola, M., Z. Alsafi, C. Sohrabi, A. Kerwan, A. Al-Jabir, C. Iosifidis, M. Agha, et al. 2020. "The Socio-Economic Implications of the Coronavirus Pandemic (COVID-19): A Review." *International Journal of Surgery* 78:185–193. https://doi.org/10.1016/j.ijsu.2020.04.018.

Paul, S. K., P. Chowdhury, M. A. Moktadir, and K. H. Lau. 2021. "Supply Chain Recovery Challenges in the Wake of COVID-19 Pandemic." *Journal of Business Research* 136:316–329. https://doi.org/10.1016/j.jbusres.2021.07.056.

Pujawan, I. N., and A. U. Bah. 2022. Supply chains under COVID-19 disruptions: literature review and research agenda. *Supply Chain Forum: An International Journal* 23 (1): 81–95.

Queiroz, M. M., D. Ivanov, A. Dolgui, and S. Fosso Wamba. 2020. "Impacts of Epidemic Outbreaks on Supply Chains: Mapping a Research Agenda Amid the COVID-19 Pandemic Through a Structured Literature Review." *Annals of Operations Research* 319 (1): 1159–1196. https://doi.org/10.1007/s10479-020-03685-7.

Rajak, S., K. Mathiyazhagan, V. Agarwal, K. Sivakumar, V. Kumar, and A. Appolloni. 2022. "Issues and Analysis of Critical Success Factors for the Sustainable Initiatives in the Supply Chain During COVID-19 Pandemic Outbreak in India: A Case Study." *Research in Transportation Economics* 93:101114. https://doi.org/10.1016/j.retrec.2021.101114.

Raj, A., A. A. Mukherjee, A. B. L. de Sousa Jabbour, and S. K. Srivastava. 2022. "Supply Chain Management During and Post-COVID-19 Pandemic: Mitigation Strategies and Practical Lessons Learned." *Journal of Business Research* 142:1125–1139. https://doi.org/10.1016/j.jbusres.2022.01.037.

Remko, V. H. 2020. "Research Opportunities for a More Resilient Post-COVID-19 Supply Chain–Closing the Gap Between Research Findings and Industry Practice." *International Journal of Operations & Production Management* 40 (4): 341–355. https://doi.org/10.1108/IJOPM-03-2020-0165.

Rizou, M., I. M. Galanakis, T. M. S. Aldawoud, and C. M. Galanakis. 2020. "Safety of Foods, Food Supply Chain and Environment within the COVID-19 Pandemic." *Trends in Food Science & Technology* 102:293–299. https://doi.org/10.1016/j.tifs.2020.06.008.

Rowan, N. J., and C. M. Galanakis. 2020. "Unlocking Challenges and Opportunities Presented by COVID-19 Pandemic for Cross-Cutting Disruption in Agri-Food and Green Deal Innovations: Quo Vadis?" *Science of the Total Environment* 748:141362. https://doi.org/10.1016/j.scitotenv.2020.141362.

Rozelle, S., H. Rahimi, H. Wang, E. Dill. 2020. "11. Lockdowns are Protecting China's Rural Families from COVID-19, but the Economic Burden is Heavy." Accessed March 30, 2020.

Saichev, A. I., Y. Malevergne, and D. Sornette. 2009. *Theory of Zipf's Law and Beyond*. Vol. 632. Springer Science & Business Media. https://doi.org/10.1007/978-3-642-02946-2.

Sarkar, P., N. Debnath, and D. Reang. 2021. "Coupled Human-Environment System Amid COVID-19 Crisis: A Conceptual Model to Understand the Nexus." *Science of the Total Environment* 753:141757. https://doi.org/10.1016/j.scitotenv.2020.141757.

Sarkis, J. 2020. "Supply Chain Sustainability: Learning from the COVID-19 Pandemic." *International Journal of Operations & Production Management* 41 (1): 63–73. https://doi.org/10.1108/IJOPM-08-2020-0568.

Sarkis, J., M. J. Cohen, P. Dewick, and P. Schröder. 2020. "*A Brave New World: Lessons from the COVID-19 Pandemic for Transitioning to Sustainable Supply and Production*. Resources." *Conservation and Recycling* 159:104894. https://doi.org/10.1016/j.resconrec.2020.104894.

Seif, M., S. Yaghoubi, and M. R. Khodoomi. 2023. "*Optimization of Food-Energy-Water-Waste Nexus in a Sustainable Food Supply Chain Under the COVID-19 Pandemic: A Case Study in Iran*. Environment." *Environment Development and Sustainability* 1–35. https://doi.org/10.1007/s10668-023-03004-7.

Senthilkumar, V., K. Reddy, U. Subramaniam, V. Mudgal, M. T. Arif, T. Jamal, and S. Subramanian. 2020. "COVID-19: Impact Analysis and Recommendations for Power and Energy Sector Operation." *Applied Energy* 279:115739. https://doi.org/10.1016/j.apenergy.2020.115739.

Shah, S. M., M. Lütjen, and M. Freitag. 2021. "Text Mining for Supply Chain Risk Management in the Apparel Industry." *Applied Sciences* 11 (5): 2323. https://doi.org/10.3390/app11052323.

Sharma, A., A. Adhikary, and S. B. Borah. 2020. "Covid-19' S Impact on Supply Chain Decisions: Strategic Insights from NASDAQ 100 Firms Using Twitter Data." *Journal of Business Research* 117:443–449. https://doi.org/10.1016/j.jbusres.2020.05.035.

Sharma, R., A. Shishodia, S. Kamble, A. Gunasekaran, and A. Belhadi. 2020. "Agriculture Supply Chain Risks and COVID-19: Mitigation Strategies and Implications for the Practitioners." *International Journal of Logistics: Research & Applications* 1–27. https://doi.org/10.1080/13675567.2020.1830049.

Shi, X., W. Liu, and J. Zhang. 2021. "Present and Future Trends of Supply Chain Management in the Presence of COVID-19: A Structured Literature Review." *International Journal of Logistics: Research & Applications* 26 (7): 1–30. https://doi.org/10.1080/13675567.2021.1988909.

Sontake, A., N. Jain, and A. Singh. 2021. "Sustainable Supplier Selection and Order Allocation Considering Discount Schemes and Disruptions in Supply Chain." In *Operations Management and Systems Engineering*, 61–94. Springer Singapore. https://doi.org/10.1007/978-981-15-6017-0_5.

Stephens, E. C., G. Martin, M. van Wijk, J. Timsina, and V. Snow. 2020. "Editorial: Impacts of COVID-19 on Agricultural and Food Systems Worldwide and on Progress to the Sustainable Development Goals." *Agricultural Systems* 183:102873. https://doi.org/10.1016/j.agsy.2020.102873.

Tan, R. R., and K. B. Aviso. 2021. "On Life-Cycle Sustainability Optimization of Enhanced Weathering Systems." *Journal of Cleaner Production* 289:125836. https://doi.org/10.1016/j.jclepro.2021.125836.

Tandel, S. S., A. Jamadar, and S. Dudugu. *A Survey on Text Mining Techniques*. in *2019 5th International Conference on Advanced Computing & Communication Systems (ICACCS)*, Coimbatore, India. 2019. IEEE.

Wang, Z., Y. Dong, and A. Liu. 2022. "How Does China's Stock Market React to Supply Chain Disruptions from COVID-19?" *International Review of Financial Analysis* 82:102168. https://doi.org/10.1016/j.irfa.2022.102168.

Wen, H., Y. Wei, and S. Wang, *Survey on Impact of COVID-19 No. 2: Report on the Impact of COVID-19 Crisis on the Business Management*. 2020.

Wu, K. J., Bin, Y., Ren, M., Tseng, M. L., Wang, Q., and Chiu, A. S. 2022. Reconfiguring a hierarchical supply chain model under pandemic using text mining and social media analysis. *Industrial Management & Data Systems* 122 (3): 622–644.

Xu, Z., A. Elomri, L. Kerbache, and A. El Omri. 2020. "Impacts of COVID-19 on Global Supply Chains: Facts and Perspectives." *IEEE Engineering Management Review* 48 (3): 153–166. https://doi.org/10.1109/EMR.2020.3018420.

Yang, M., and C. Han. 2021. "Revealing Industry Challenge and Business Response to Covid-19: A Text Mining Approach." *International Journal of Contemporary Hospitality Management* 33 (4): 1230–1248. https://doi.org/10.1108/IJCHM-08-2020-0920.

Zhu, X., and X. Tian. 2020. "New Crown Pneumonia Epidemic Will Not Have a Big Impact on Annual Grain Production." *Farmers Daily* 03–05. Accessed March 5, 2020.

Zipf, G. 1932. *Selected Studies of the Principle of relative Frequency in Language*. Cambridge, Massachusetts, USA: Harvard university press.

Zwanka, R. J., and C. Buff. 2021. "COVID-19 Generation: A Conceptual Framework of the Consumer Behavioral Shifts to Be Caused by the COVID-19 Pandemic." *Journal of International Consumer Marketing* 33 (1): 58–67. https://doi.org/10.1080/08961530.2020.1771646.