Capturing Public Response on Social Media Regarding the Implementation of Sustainable Supply Chain Management using Natural Language Processing

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Abstrak

The concept of Sustainable Supply Chain Management (SSCM) attracts the attention of academics and practitioners with the triple bottom line concept (economic, social, environmental). In carrying out supply chain management, economic performance considers environmental and social factors through economic performance. Efforts to reduce negative impacts on social life and the environment are things that are considered in SSCM by applying this concept to the entire supply chain network. The application of SSCM becomes very complicated because it considers many things, and research that develops revolves around operational management. While the discussion from the consumer side is not much discussed. This study aims to discover the topics the public discusses regarding SSCM. Using the Natural Language Processing (NLP) method, public discussions on the Twitter platform were abstracted to obtain a list of topics and public sentiment towards SSCM. The results of extracting discussion topics on the Twitter platform show that economic and environmental discussions are more widely discussed than social factors. This can happen because there is a possibility that the concept of Green SCM has already been known. This concept discusses environmental factors that need to be considered in SCM. Meanwhile, public discussions were dominated by positive and neutral sentiments indicating optimism in the SSCM discussions.

Keywords*: sustainable supply chain management; natural language processing; logistics management*

Kelompok BoK yang bersesuaian dengan artikel: *Supply Chain Management*

1. Introduction

The discussion on Supply Chain Management increasingly involves many factors and makes the SCM system more complex. One of the factors currently being highlighted is the discussion on the concept of sustainability. This discussion arose out of increased awareness of environmental and social factors. The demand for implementing the concept of sustainability is also applied to SCM. This change is a challenge to implement Sustainability Supply Chain Management (SSCM) in traditional SCM systems by taking into account environmental, social,

and economic elements. In SCM there is uncertainty, if there is a change in one of the parameters it will affect the other parameters (Carter & Rogers, 2008). The discussion on SSCM as a triple bottom line (environmental, social, and economic) is an extension of the discussion in the previous era (green supply chain management) which only focused on discussing the environment in an effort to achieve sustainability (Ahi & Searcy, 2013; Karthik et al., 2015).

Intense competition arises because of efforts to fulfill diverse customer demands and the complexity of product components, where the fulfillment of these needs integrates environmental considerations, social performance, and economic contributions which is called SSCM (Karthik et al., 2015). SSCM is one strategy in ensuring product delivery to customers is guaranteed and of the highest quality so that it can give the company a good reputation (Asha et al., 2023). The application of SSCM in companies is still experiencing various debates from the business context. Changing from conventional SCM to SSCM requires careful consideration because it will involve long-term managerial issues (Mastroeni et al., 2023); (Panigrahi & Rao, 2018); (Massaroni et al., 2020). Cooperation is needed from all partners in the SCM chain to achieve sustainability goals and commit to sustainability standards (Panigrahi & Rao, 2018).

Managerial considerations by companies certainly need to take into account consumer opinions so that decisions made can meet public expectations. Apart from summarizing the voice of the customer, understanding public discussions is also necessary to know what topics are being discussed by the public. Understanding public discussions can assist in decision-making considerations. Discussions on social media are a medium that is easy to analyze to extract information that is being discussed by the public. Social media can be a place for the massive development of opinions on various issues because users can connect with each other and share media content in real-time (Mastroeni et al., 2023). Twitter is one of the most widely used social media S. Dixon (2023), with the advantage of the text-based posting feature which has the advantage of allowing public discussions. Relational mechanisms by increasing credibility and consumer satisfaction through emotional relationships with consumers on social media are investments that companies need to make to strengthen brands (Dwivedi et al., 2019).

Research on SSCM that has been conducted so far tends to depart from an operational perspective. In other words, the research was conducted from an internal perspective involved in supply chain management. While research from an external or consumer perspective has not been widely carried out. Twitter is one of the social media that provides features for discussion because its main orientation is text-based. Analyzing data through discussions on social media can provide an overview of public discussions that are being widely discussed because social media users can exchange ideas in real-time. The SSCM analysis on social media using the natural language processing method has been carried out and the results obtained are that economic and environmental analysis is more widely discussed than social aspects (Setiyawati et al., 2022). However, discussions about SSCM based on public discussions, sentiment analysis, and topic modelling, especially based on discussion data on social media, have not been carried out by previous researchers. This research was conducted by extracting data from Twitter regarding SSCM and analyzing it based on the output of existing text mining data processing. From this study data analysis can be obtained based on public discussion to be considered in making decisions regarding the implementation of SSCM. Both industry and policymakers need to consider public acceptance of the concept of sustainability in SCM.

The discussion regarding SSCM was developed to accommodate supply chains for sustainable products whose entire supply chain network applies standards that prioritize economic, social, and environmental aspects (Seuring & Müller, 2008). However, the qualitative

analysis carried out by Ashby et al. (2012) found that apart from economic aspects which are already part of SCM, environmental aspects were found to be considered more often than social aspects. This is possible because the measurement of social aspects is more tangible. The description of SSCM is very complex, starting from eco-design, sustainable production, environmental-based marketing, reverse logistics, and internal sustainable management such as technological orientation and company culture, as well as supplier selection (Debnath et al., 2023); (Asha et al., 2023). In short, SSCM is the application of environmentally friendly activities to conventional supply chain management processes (Panigrahi & Rao, 2018).

Environmental and social factors greatly influence the selection of suppliers because if the materials and production equipment provided by the supplier are safe, it will minimize the occurrence of production accidents (Wu et al., 2021). In chemical industry activities that have a high level of risk, if a production or shipping accident occurs, it will affect the company's image. The selection of suppliers for SSCM in the health sector prioritizes the factors of price stability, sustainable development, and management of quality, reputation, and performance (Debnath et al., 2023). In the same industry, agility, greenhouse gas emissions, durability, and waste management are other important criteria besides cost and quality (Nayeri et al., 2023).

2. Method

Data was collected from public discussions held on social media regarding SSCM on the Twitter platform. As a social media that focuses on text, Twitter is the right medium for open discussions. The limitation on the number of characters on Twitter is one of the reasons that discussions on Twitter are more intense. For this research, the Twitter data taken is on tweets that have relevance to the subject matter, namely SSCM. Collecting, processing, and analyzing data are performed with Python programming language.

Data was collected from 2000 to 2023, collecting 6526 tweets at data collection on May 31, 2023. In this research, crawling Twitter data was not carried out using the Twitter Application Programming Interface (API) due to limited access and the number of tweets that could be collected using the API with a free license.The focus of this research is analyzing frequency and correlation to determine discussions on Twitter regarding SSCM. After the tweet data is collected, the next stage is to clean the data by applying several pre-processing procedures using some package named: cleantext (text cleaning), Word Counter (counting words, hashtags, location, entity), Natural Language Toolkit (NLTK) to doing tokenization, lemmatization, and n-gram analysis. Word or data is visualized using a visualization technique for text data wherein each word is picturized with its importance in the context or its frequency using WordCloud (cloud of words). This procedure consists of several stages, namely changing all uppercase letters to lowercase, removing URL addresses, punctuation, tags, mentions, alphabets, stop words, lemmatization, and tokenization. Next, the tweet data was processed using natural language processing (NLP) to analyze the data quantitatively. In the final stage, visualizations are produced to facilitate understanding of the findings produced. In this research, the NLP model used is to find keywords that can represent all tweets. The frequency of appearance of a discussion topic on Twitter shows the relevance between discussion topics, this can be determined by conducting frequency analysis. Through the word cloud feature, a graph of the frequency of word occurrences will be presented to be used as a basis for qualitative analysis (Mastroeni et al., 2023).

Data processing is not only limited to presenting data for each word based on the frequency of occurrence through a word cloud but also combining two words and three words.

Proximity of words is calculated from the number of words that often appear, from this grouping can then be analyzed. Proximity of words that often appear can indicate relevance or a particular character. The results can be used to arrange or classify categories consisting of n-grams per character (unigrams, bigrams, and trigrams).

Apart from taking into account the level of word occurrence, seeing the grouping of words in various topics is one of the interesting things discussed in this research. Topic modeling is applied to very large collections of words, which can be modeled in a probabilistic way from a corpus of texts (Blei, et al., 2003). From this collection of text it can be modeled so that latent topics are formed, each topic will represent an explicit group of topics. In this group of words, there is an invisible structure in the form of topics, distribution of topics, and determination of topics per word.

In this research, sentiment analysis was also carried out using a lexicon-based approach for all tweet results. The model used in this sentiment analysis is VADER (valence-aware dictionary for sentiment reasoning). The approach of this model is similar to human thinking which integrates qualitative analysis and qualitative and quantitative empirical validation. The Lexicon model converts lexical characteristics into sentiment scores. The intensity applied to all words makes it possible to obtain a score for each word. The score value resulting from sentiment analysis is between -1 and 1, where 1 is a high positive, and vice versa. (Kastrati, et al., 2023).

3.   Result and Discussion

Through a search regarding sustainable supply chain management and word mapping using the word cloud, an overview of the dataset is obtained as shown in Figure 1. It was found that dominant words appeared frequently and those that appeared relatively less frequently, as illustrated by the size of the letters in Figure 1. As keywords, words containing parts of sustainable supply chain management are deleted. From the word cloud in Figure 1, you can see the discussion topics that most frequently arise regarding discussions about SSCM. The emergence of discussions about logistics, delivery time, operation, procurement, and efficient delivery is a discussion related to the implementation of supply chain operations (SCM). One of the competitive advantages from an SCM perspective is to shorten the time to market or the time from product development until the product is ready for consumer acceptance (Pujawan, 2017). Sustainability, green, and future are part of the aspects of sustainable development, especially in environmental discussions. The focus of management for the long term is one of the characteristics of SSCM Ahi & Searcy (2013) which in the word cloud is indicated by the frequency with which "future" appears.

In addition to the word cloud, to see topics that often arise in discussions about SSCM is to look at hashtags. Hashtags indicate topics or keywords that can be used en masse in a free discussion on social media. In the results of data processing with NLP on Twitter, it was found that the five most used hashtags were #sustainability #green #CSR #SCM #logistics. The hashtags are interconnected in discussions about SSCM, #sustainability and #green are the core ideas of a more environmentally friendly SSCM. Business lines that play a role in running #SCM and #logistics need to ensure that SSCM can be run by fulfilling the triple bottom line as a whole. This involves participating in #CSR in taking steps to reduce the negative environmental impact of business arising from SCM activities.

Figure 1 Word Cloud of Dataset

In the words count, the top five words are sustainability, business, logistics, supply chain, and green which tend to show economic and environmental aspects. Several business types/objects are also part of the public discussion such as aerospace, food, and blockchain. Blockchain has been discussed a lot in recent years and is developing its application in sustainable supply chains. From an economic aspect, blockchain can increase effectiveness in terms of traceability and transparent processes, but from social and environmental aspects it can play a role in resource efficiency and accountability (Munir et al., 2022). In companies engaged in the food industry, demands for quality and sustainability are the starting point for developing innovation (Cagliano et al., 2016). The discussion of food in the context of SSCM is growing due to increased awareness of environmental issues and the need to reduce cases of hunger, increased food risk, and awareness of the benefits of reducing food wastage, health management and welfare across all geographical areas (Palazzo & Vollero, 2021).

Figure 2 and Figure 3 show pairs of words that appear based on the frequency of occurrence of the word. The closeness of the frequency of occurrence of words can indicate the relevance of the pair of words. For example, the relevance of the words "ensuring" and "efficient" is widely discussed in the application of SSCM to the entire supply chain. Allenbacher & Berg (2023) discusses the application of SSCM to the entire supply chain, especially in applying social elements through the concept of knowledge transfer between supply chain partners. The relevance of "delivery" and "time" is very high, one of the factors that causes customer dissatisfaction, which is the unbalanced delivery time in the supply chain (Asha et al., 2023). However, another perspective says that some consumers' preferences for online purchases choose more environmentally friendly delivery options, rather than prioritizing fast delivery times (Thomas et al., 2022).

One of the combinations of three words that appear most often is "supplier" "selection" and "sustainability". The addition of constraints on the supplier selection problem makes the supplier selection problem more complex. Cost stability, continuous improvement, quality control, performance, and reputation are the things most considered in supplier selection (Debnath et al., 2023).
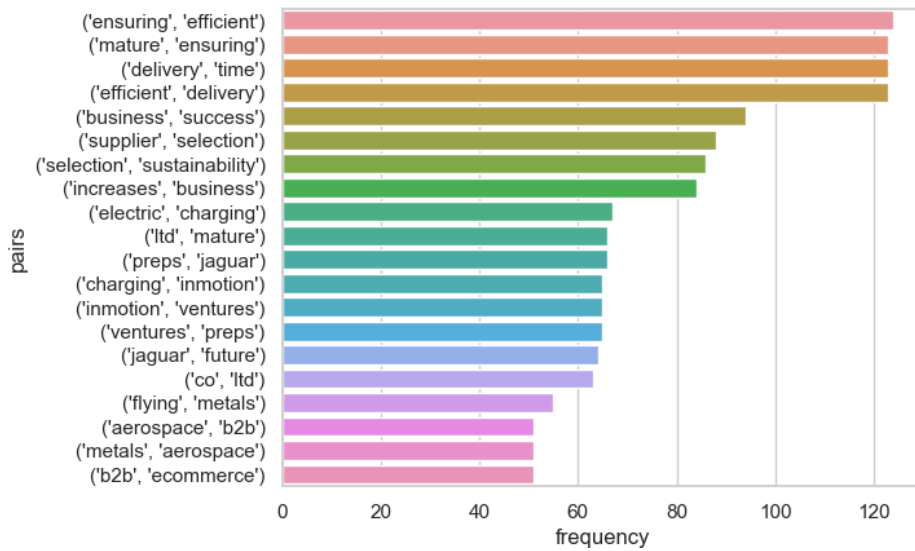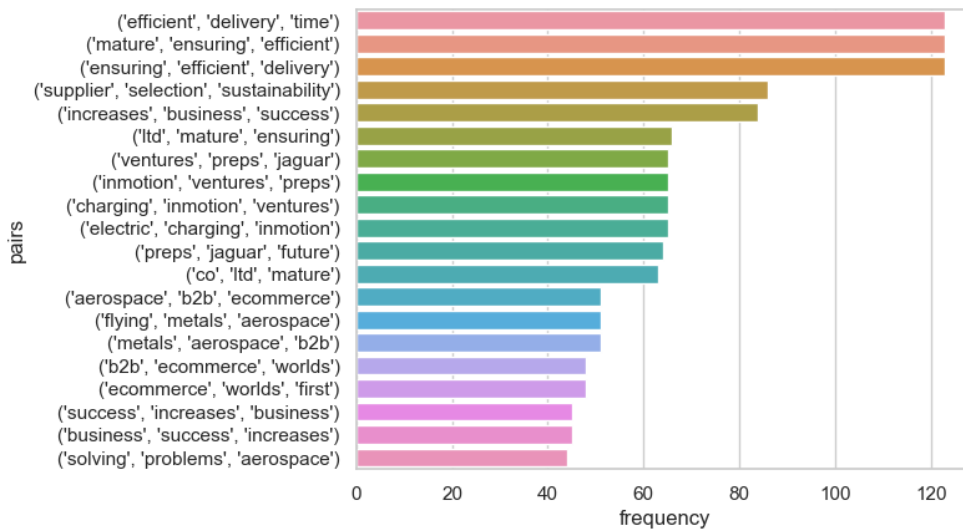
Figure 2 N-gram for Two Words

Figure 3 N-gram for Three Words

The coherence of each topic of discussion on social media can be mapped by creating discussion topic groups. The grouping of topics or topic modeling is done by LDA analysis(Latent Dirichlet Allocation). Decision-making regarding topic modeling is adjusted by looking at the details of the description formed, the coherence of words for each topic, and the withdrawal of topic labels. This topic modeling is done by conducting grouping tests of up to 16 topic grouping models. From the modeling test that has been carried out, a model with coherence and ease of labeling on each topic is obtained in a model with 8 topics. Each topic is given a label that describes the essence of the discussion on that topic. The Table 1 shows the labels and topics that are formed.

Table 1 Topic and Label of Topic

Topic	Topic Words	Label
1	Sustainability business supplier product web social selection development platform role	Sustainability on business
2	Green value logistics managing stepping creates intersects procurement information webinar	Green perspective
3	New read exploring post lean framework article blog great check	New framework
4	Approach eco focus key mcdonald study practice visibility towards practical	Practical approach
5	Navigating china manufacturing sourcing mean future step com getting wal	Roadmap SSCM in China
6	Beyond scm part report good analysis review major simple source	Review and report
7	Innovation risk term healthcare long might around mcdonald continuous rise	Innovation and continuity
8	Interesting seminar series group thanks three come implementing hour leadership	Study on implementing

Topic 1 discusses sustainability in business, which involves suppliers and products. Supplier selection is important in designing and implementing SSCM, Wu et al. (2021) because SSCM performance is assessed comprehensively, including all partners who collaborate and are involved in the supply chain business. Apart from suppliers, products are the main component in designing SSCM, products made or distributed need to be ensured that they meet the triple bottom line elements in the SSCM concept. Topic 2 contains a discussion regarding perspectives on managerial logistics, where the main activity in SCM is managing logistics. The green approach is one perspective in implementing SSCM, the value of this green approach is identical to the value of sustainability in the environmental aspect (Ahi & Searcy, 2013).

Topic 3 focuses the discussion on a new framework in the SCM business chain by considering lean manufacturing aspects. The combination of "green" and "lean" in business is a strategy for success, especially in relation to waste which is part of routine operational results (Awan et al., 2022). Topic 4 is labeled as a practical approach, in this topic the word "eco" appears as one of the keywords used as an approach to implementing SSCM. This topic is interesting because one brand emerged, namely "mcdonald" where McDonald had held a seminar on SSCM issues with an eco-innovation approach. Basically, various large companies are making moves to implement SSCM, one of which plays an important role in this regard is Corporate CSR (Herbst, 2009).

Topic 5 shows the implementation of SSCM in China with the emergence of "Navigating China manufacturing", where China already has a roadmap in implementing the SSCM, especially for European market. One of the implementations of SSCM in China is to target the European market with several regulations that have changed (ARC Group, 2023). Topic 6 discusses reports and reviews of the implementation of SSCM in various fields. The context of the word "beyond" in this topic is the scope of technology and the extent of the area that applies SSCM. Technology has an important role in implementing SSCM, especially in reducing waste as a by-product in operational activities (Awan et al., 2022). In addition, the implementation of SSCM is a process that continues to grow and always requires improvement, so reports and reviews are needed periodically to make improvements. Topic 7 is labeled innovation and continuity because this topic talks about implementing innovation in SSCM which can be carried out for the long term and continuously. One of the business segments that appears on this topic is healthcare, the application of SSCM innovations in the health sector, one of which is reverse innovation, so that it can implement value-based services in a more agile manner (Alamelu et al., 2022).

Topic 8 illustrates that SSCM learning and application is interesting to apply in various business fields. Learning through seminars and discussions consisting of several series by various resource persons in the implementation of SSCM is an interesting learning topic. Of

course, this discussion includes discussing the triple bottom line and an additional interesting discussion regarding leadership. There is a positive relationship between sustainable leadership and lean manufacturing, lean manufacturing, and sustainability performance, also the relationship between sustainable leadership and sustainability performance has a partial mediation effect (Burawat, 2019).

Looking at the sentiment in a collection of words posted on social media can extract information from the trend of the discussion that is taking place. The SSCM discussion on Twitter social media is dominated by positive sentiment. The more the compound value approaches 1, the more discussions will have a positive sentiment. Meanwhile, if the compound value is brought to zero, the discussion will have a negative sentiment. Thus, it can be seen that the public will be more optimistic and confident when talking about SSCM. Meanwhile, with a number that is not much different, the public is neutral towards SSCM where in this condition the number of positive opinions is almost the same as the number of negative opinions. Positive discussions on SSCM revolved around the topic of SSCM as a solution and applied innovation. Meanwhile, negative sentiment is a discussion about vulnerability and disruption.

4.   Conclusion

Free discussion in online discussions held on Twitter is dominated by discussions regarding the implementation of SSCM and business matters. Apart from discussing matters related to SCM, basically such as the topics of logistics, delivery, and efficiency, discussions on SSCM raised topics related to sustainability, green, and innovation. The discussion focuses more on increasing business success and discussions related to environmental impacts. Meanwhile, discussion of the social aspect did not develop much in open discussions on Twitter social media. This is possible because the topic of green supply chain has been widely discussed before, while the discussion of social aspects is still a new thing and does not attract too much attention. Public discussions about SSCM are dominated by discussions that have positive and neutral sentiments, meaning that the public considers SSCM to be a solution for dealing with environmental impacts without ignoring social aspects in the life cycle of products or services. Even though in practice there are still gaps that are vulnerable to interference, the public remains optimistic that SSCM is feasible to implement.

References

Ahi, P., & Searcy, C. (2013). A comparative literature analysis of definitions for green and sustainable supply chain management. Journal of Cleaner Production, 52, 329–341. https://doi.org/10.1016/j.jclepro.2013.02.018

Alamelu, R., Rengarajan, V., Dinesh, S., Nalini, R., Shobhana, N., & Amudha, R. (2022). Sustainable supply chain practices with reverse innovation in healthcare start-ups - A Structural Equation Model (SEM) approach. *Materials Today: Proceedings*, *52*, 882–887. https://doi.org/10.1016/j.matpr.2021.10.292

Allenbacher, J., & Berg, N. (2023). How assessment and cooperation practices influence suppliers' adoption of sustainable supply chain practices: An inter-organizational learning perspective. Journal of Cleaner Production, 403(October 2022). https://doi.org/10.1016/j.jclepro.2023.136852

ARC Group. (2023). *Sustainable Supply Chains In China: A Roadmap For European Companies*. https://arc-group.com/sustainable-supply-chain-china/

Asha, A. A., Dulal, M., & Habib, D. A. (2023). The influence of sustainable supply chain

management, technology orientation, and organizational culture on the delivery product quality-customer satisfaction nexus. Cleaner Logistics and Supply Chain, 7(November 2022). https://doi.org/10.1016/j.clscn.2023.100107

Ashby, A., Leat, M., & Hudson-Smith, M. (2012). Making connections: A review of supply chain management and sustainability literature. Supply Chain Management, 17(5), 497–516. https://doi.org/10.1108/13598541211258573

Awan, F. H., Dunnan, L., Jamil, K., Mustafa, S., Atif, M., Gul, R. F., & Guangyu, Q. (2022). Mediating Role of Green Supply Chain Management Between Lean Manufacturing Practices and Sustainable Performance. Frontiers in Psychology, 12(January), 1–11. https://doi.org/10.3389/fpsyg.2021.810504

Burawat, P. (2019). The relationships among transformational leadership, sustainable leadership, lean manufacturing and sustainability performance in Thai SMEs manufacturing industry. International Journal of Quality and Reliability Management, 36(6), 1014–1036. https://doi.org/10.1108/IJQRM-09-2017-0178

Cagliano, R., Caniato, F. F. A., & Worley, C. G. (2016). A pathway towards truly sustainable food supply chains: Balancing motivation, strategy, and impact. Organizing for Sustainable Effectiveness, 5, 287–318. https://doi.org/10.1108/S2045-060520160000005020

Carter, C. R., & Rogers, D. S. (2008). A framework of sustainable supply chain management: Moving toward new theory. International Journal of Physical Distribution and Logistics Management, 38(5), 360–387. https://doi.org/10.1108/09600030810882816

Debnath, B., Bari, A. B. M. M., Haq, M. M., de Jesus Pacheco, D. A., & Khan, M. A. (2023). An integrated stepwise weight assessment ratio analysis and weighted aggregated sum product assessment framework for sustainable supplier selection in the healthcare supply chains. Supply Chain Analytics, 1(December 2022), 100001. https://doi.org/10.1016/j.sca.2022.100001

Dwivedi, A., Johnson, L. W., Wilkie, D. C., & De Araujo-Gil, L. (2019). Consumer emotional brand attachment with social media brands and social media brand equity. European Journal of Marketing, 53(6), 1176–1204. https://doi.org/10.1108/EJM-09-2016-0511

Herbst, J. (2009). *Triple Bottom Line of Eco-Innovation*. https://informaconnect.com/free-web-seminar-mcdonalds-eco-innovation-approach-to-sustainable-supply-chain-management/

Karthik, B., Raut, R. D., Kamble, S. S., Kharat, M. G., & Kamble, S. J. (2015). Decision support system framework for performance based evaluation and ranking system of carry and forward agents. Strategic Outsourcing, 8(1), 23–52. https://doi.org/10.1108/SO-02-2015-0008

Massaroni, Enrico. Cozzolino, Alessandra. Wankowicz, E. (2020). Sustainability supply chain management - a literature review. Journal of Global Responsibility, 11(3), 233–255. https://doi.org/10.1108/JGR-11-2019-0108

Mastroeni, L., Naldi, M., & Vellucci, P. (2023). Twitter and the circular economy: examining the public discourse. Management Decision, 61(13), 192–221. https://doi.org/10.1108/MD-03-2022-0396

Munir, M. A., Habib, M. S., Hussain, A., Shahbaz, M. A., Qamar, A., Masood, T., Sultan, M., Mujtaba, M. A., Imran, S., Hasan, M., Akhtar, M. S., Uzair Ayub, H. M., & Salman, C. A. (2022). Blockchain Adoption for Sustainable Supply Chain Management: Economic, Environmental, and Social Perspectives. Frontiers in Energy Research, 10(May), 1–24. https://doi.org/10.3389/fenrg.2022.899632

Nayeri, S., Khoei, M. A., Rouhani-Tazangi, M. R., GhanavatiNejad, M., Rahmani, M., &

Tirkolaee, E. B. (2023). A data-driven model for sustainable and resilient supplier selection and order allocation problem in a responsive supply chain: A case study of healthcare system. Engineering Applications of Artificial Intelligence, 124(March), 106511. https://doi.org/10.1016/j.engappai.2023.106511

Palazzo, M., & Vollero, A. (2021). A systematic literature review of food sustainable supply chain management (FSSCM): building blocks and research trends. TQM Journal, 34(7), 54–72. https://doi.org/10.1108/TQM-10-2021-0300

Panigrahi, S. S., & Rao, N. S. (2018). A stakeholders' perspective on barriers to adopt sustainable practices in MSME supply chain: Issues and challenges in the textile sector. Research Journal of Textile and Apparel, 22(1), 59–76. https://doi.org/10.1108/RJTA-07-2017-0036

Pujawan, I. N. (2017). *Supply Chain Management* (3rd ed.). Andi.

S. Dixon. (2023). Most popular social networks worldwide as of January 2023, ranked by number of monthly active users. Statista.

Setiyawati, T., Nurlina, N., Ula, R., & Rahman, A. (2022). Model Natural Language Processing untuk Pemetaan Diskusi Publik di Media Sosial tentang Sustainable Supply Chain Management. 15(1), 75–82.

Seuring, S., & Müller, M. (2008). From a literature review to a conceptual framework for sustainable supply chain management. Journal of Cleaner Production, 16(15), 1699–1710. https://doi.org/10.1016/j.jclepro.2008.04.020

Thomas, R. W., Ueltschy Murfield, M. L., & Ellram, L. M. (2022). Leveraging sustainable supply chain information to alter last-mile delivery consumption: A social exchange perspective. Sustainable Production and Consumption, 34, 285–299. https://doi.org/10.1016/j.spc.2022.09.014

Wu, C., Lin, Y., & Barnes, D. (2021). An integrated decision-making approach for sustainable supplier selection in the chemical industry. Expert Systems with Applications, 184(December 2020), 115553. https://doi.org/10.1016/j.eswa.2021.115553