



Using NLP to Enhance Supply Chain Management Systems

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

This article explores the transformative potential of Natural Language Processing (NLP) in enhancing Supply Chain Management (SCM) software. With the digital age ushering in vast amounts of unstructured data, especially customer feedback, there is a pressing need for advanced analytical tools. NLP, a subset of artificial intelligence, offers techniques such as sentiment analysis, topic modeling, and text classification to interpret this data. By integrating these techniques, businesses can gain unparalleled insights into their supply chain operations, leading to improved operational efficiency, stakeholder satisfaction, and proactive issue management. The article reviews studies across various industries, from food delivery to railways, underscoring the versatility and efficacy of NLP in diverse contexts. The findings highlight NLP's role as a game-changer in SCM, promising a more data-driven, efficient, and customer-centric supply chain landscape.

Keywords: *Natural language processing; supply chain management; sentiment analysis; topic modeling; text classification; digital transformation; customer feedback; operational efficiency; stakeholder satisfaction.*

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1. INTRODUCTION

In today's business landscape, Supply Chain Management (SCM) software is crucial for streamlining and optimizing operations for companies worldwide [1,2]. As the world continues to shift towards digital transformation, there arises a pressing need to utilize the power of data, especially customer feedback, to improve SCM software [3,4]. One promising technique to extract actionable insights from textual data is Natural Language Processing (NLP), a subfield of artificial intelligence. This article explores the potential of NLP, when combined with customer feedback, to revolutionize SCM software [5,6-8]. Specifically, it delves into the analysis of techniques employed in other industries that can be applied to supply chain software [9-12].

2. METHODOLOGY

Our examination of the possibility of natural language processing (NLP) to improve supply chain management (SCM) software involved an analysis of five scholarly articles that showcase the utilization of NLP across diverse industries. These articles cover a broad range of sectors, including the food delivery and railway domains, thus offering a holistic overview of NLP's potential. Additionally, we integrated an array of NLP techniques, such as sentiment analysis, topic modeling, and text classification, to explore their effectiveness in examining customer feedback.

3. RESULTS AND DISCUSSION

In the field of research, Supply Chain Management (SCM) software is known for its ability to interact with multiple stakeholders, ranging from suppliers and manufacturers to end consumers. It is essential to collect feedback from these stakeholders to improve the software's efficiency. However, given the vast amount of feedback and its unstructured form, manual analysis of this data presents significant challenges. To overcome this obstacle, Natural Language Processing (NLP) technology has become an integral part of SCM software analysis.

The analysis of sentiment is a rapidly growing field in research. While it may seem simple, sentiment analysis is a complex process that involves the use of machine learning algorithms to deconstruct and analyze the tone and attitude

of a given piece of text. This technology has a wide range of applications, from analyzing customer feedback to predicting political outcomes. Additionally, sentiment analysis can be utilized to identify and track trends in public opinion, allowing researchers to gain insight into the emotions and attitudes of large groups of people. As such, sentiment analysis is a valuable tool for researchers in understanding the collective sentiment of a population, and has the potential to lead to significant breakthroughs in a wide range of fields.

Opinion mining, which is commonly referred to as Sentiment Analysis, is a technique that involves evaluating the emotional tone or sentiment of a series of words. The objective is to determine whether the sentiment conveyed is positive, negative, or neutral. In the realm of supply chain management, Sentiment Analysis can be utilized for deciphering the emotions and opinions of stakeholders through user reviews, feedback, and other textual data sources.

The process of sentiment analysis can be represented by Fig. 1. This figure outlines the necessary steps involved in evaluating and interpreting the emotions, attitudes, and opinions expressed in a given text. The initial step involves retrieving the text to be analyzed, followed by pre-processing that text to remove irrelevant information and noise. Next, the text is parsed and relevant features are extracted. These features can include the frequency of specific words, phrases, or concepts. Once the features have been extracted, they are fed into a machine learning algorithm that is trained to classify them as positive, negative, or neutral. Finally, the results of the analysis are interpreted and used for a variety of applications, such as market research, customer feedback, and social media monitoring.

The advantages of supply chain management are manifold. Effective supply chain management reduces costs, enhances efficiency, and optimizes workflows. It also improves communication and collaboration between stakeholders, leading to better decision-making and faster problem-solving. Proper supply chain management also ensures the timely delivery of goods and services, which is crucial for maintaining customer satisfaction and loyalty. In addition, it helps organizations to be more agile and adaptable to changes in demand, market trends, and other external factors. All of these benefits make supply chain management a vital component of any successful business strategy.

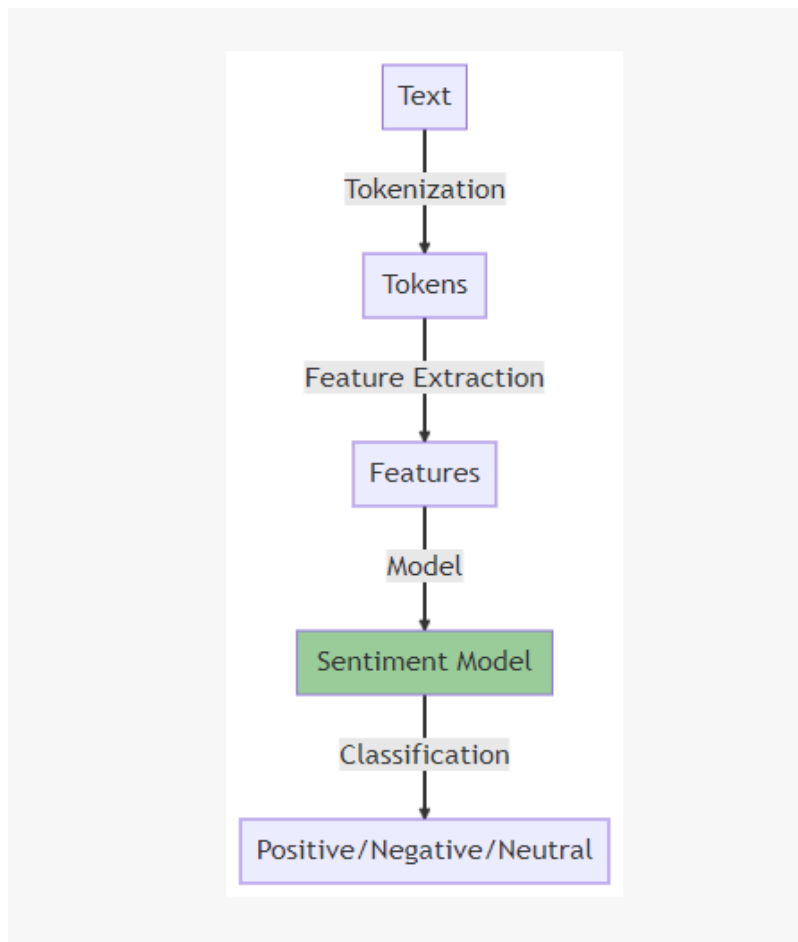


Fig. 1. Sentiment analysis process

In the realm of business research, companies find value in analyzing user reviews to gain immediate feedback on their supply chain operations. This can be accomplished by examining the sentiment of reviews, with a surge in negative sentiments being a clear indication of recent issues such as delayed deliveries or product damages. This data is integral in improving supply chain efficiency and addressing potential areas of concern.

In the realm of research, it is recognized that not all issues are created equal. This applies to the business world as well, where it is essential to allocate resources to the most critical problems. One approach to this is to utilize sentiment analysis, as it can assist companies in identifying the areas that cause the greatest levels of dissatisfaction among users. By prioritizing these areas, businesses can focus their efforts on improving the most pressing issues and, consequently, enhance overall customer satisfaction.

The analytical technique of predictive analysis has the potential to forecast future challenges based on trends in sentiment over time. To illustrate this, consider the example of gradually decreasing sentiment scores. Such a pattern could suggest the emergence of a systemic issue within the supply chain, thereby enabling preemptive measures to be taken to mitigate the predicted risks.

The technique of topic modeling is a frequently utilized method in research. It involves the categorization of large sets of data into topics that represent various themes. Through the use of algorithms, topic modeling analyzes the patterns of language use across a corpus of information to discover the underlying topics. This technique has been employed in a wide range of fields, including social sciences, humanities, and natural sciences. The aim of topic modeling is to facilitate the identification of meaningful patterns and trends within datasets. Topic modeling's versatility and effectiveness

make it a valuable tool for researchers seeking to gain insights into complex data sets.

The application of natural language processing (NLP) techniques to identify topics present in a text corpus is commonly referred to as topic modeling. Among the algorithms employed for this purpose, Latent Dirichlet Allocation (LDA) is a popular choice. By conducting topic modeling on customer feedback, companies can gain insight into the prevailing themes and pinpoint areas within their supply chain that require attention. This approach can yield valuable data for companies looking to improve their operations, enhance customer satisfaction, and ultimately drive growth.

The advantages of effective supply chain management are numerous and tangible. Supply chain management can improve the efficiency of operations, reduce costs, and increase profitability. It can also help to streamline processes, minimize risks and disruptions, and enhance customer satisfaction. A well-managed supply chain can offer companies a competitive edge, as it allows them to respond quickly to changes in demand, reduce lead times, and better manage inventory levels. With the proper implementation of supply chain management systems, businesses can expect to experience a range of benefits that can lead to long-term growth and success.

As opposed to a more generalized comprehension of the supply chain, utilizing topic modeling offers a more detailed and intricate understanding of the specific facets of the supply chain that consumers frequently discuss. This approach allows for the identification of topics such as delivery schedules, the quality of products, or the nature of relationships with suppliers, providing nuanced and granular insights.

Through the analysis of trends, companies are able to identify emerging topics by observing their prevalence over time. These trends can provide valuable insights into potential issues that may arise. For example, if there is a sudden increase in the occurrence of discussions surrounding 'product damage', this may indicate underlying issues related to packaging or handling.

Companies are able to make specific improvements to their supply chain when they have a clear understanding of the particular

areas of concern. This knowledge enables them to allocate resources in an efficient manner, while also prioritizing the most pressing issues. By implementing targeted improvements, companies can effectively address the challenges that are unique to their supply chain, resulting in increased efficiency and improved outcomes.

The categorization of text is an important task in research. Text classification involves the use of machine learning algorithms to automatically assign predefined categories to textual data. This process is vital for numerous applications, such as spam filtering, sentiment analysis, and information retrieval. By analyzing the content and structure of a given text, classification algorithms can accurately classify the text into one or more of the predetermined categories. This allows for efficient data organization and retrieval, making it an essential tool in the field of research.

The process of text classification, also known as categorization, involves the allocation of predetermined labels or categories to text based on its content [13]. This method can be employed to classify various forms of feedback such as complaints, suggestions, or praises, among others. Naive Bayes, Support Vector Machines, or Neural Networks are some of the algorithms used to achieve this classification [14].

The advantages of effective supply chain management are manifold. Supply chain management allows for improved coordination and collaboration between various players in the supply chain, which can lead to better communication and greater transparency. This in turn can result in increased efficiency, reduced costs, and improved customer satisfaction. A well-managed supply chain can also improve risk management and help to mitigate disruptions due to unforeseen events such as natural disasters or political instability. Additionally, supply chain management can facilitate the adoption of sustainable practices and reduce environmental impact through the implementation of green initiatives. Ultimately, effective supply chain management can contribute to the overall success and profitability of a business.

In the realm of efficient data analysis, automated triage has emerged as a promising solution. Rather than laboriously sifting through feedback by hand, automated text classification can

effectively and accurately sort feedback into appropriate categories, guaranteeing that complaints are promptly directed to the customer service team, while product suggestions are sent to the product development team.

In the realm of business research, it is widely acknowledged that resource allocation is a critical factor in the success of companies. One effective method of optimizing resource allocation is by closely monitoring and understanding the nature of feedback received in real-time. By doing so, companies can make informed decisions about where to allocate their resources in the most efficient manner possible. For example, if a company is experiencing a surge in customer complaints, it may require a higher number of customer service representatives to address the issue. On the other hand, if there is an increase in suggestions from customers, it may necessitate additional product development meetings to capitalize on the potential for growth.

In the realm of research, the analysis of feedback is of utmost importance. To ensure that this analysis is conducted without any human biases, automated text classification is utilized. This technology guarantees consistent analysis, which is particularly vital for long-term trend analysis and benchmarking.

Integrating Natural Language Processing (NLP) techniques into the analysis of customer feedback has become a game-changer for businesses, particularly in the field of Supply Chain Management (SCM) [15]. After careful review of the relevant literature and a thorough examination of NLP techniques, the following discoveries have been made:

In the field of supply chain management (SCM), sentiment analysis has emerged as a valuable tool for understanding and improving the customer experience. This technique involves the use of natural language processing and machine learning algorithms to identify, extract, and analyze subjective information from customer feedback, such as emotions, opinions, and attitudes. By applying sentiment analysis to SCM, businesses can gain valuable insights into customer satisfaction, identify areas for improvement, and make data-driven decisions to enhance overall supply chain performance. Sentiment analysis is a powerful and innovative approach to SCM that has the potential to drive significant improvements in customer experience and organizational success.

By integrating sentiment analysis into their feedback systems, companies are afforded an instant comprehension of stakeholder emotions. The study conducted by Shaeali et al. [16] showcases the benefits of this integration in the context of food delivery services. Specifically, sentiment analysis allows for real-time evaluation of customer satisfaction levels, providing companies with prompt insights into their stakeholders' sentiments. [16]

In the realm of research, the ability to predict potential issues is of great importance. When it comes to sentiment analysis, the trends over time can serve as a valuable tool for companies to gauge and prepare for challenges. If there is a consistent decrease in sentiment scores, it could signify the presence of systemic issues within the supply chain. This information can be used to take proactive measures and address problems before they become more significant.

Targeted enhancements can be achieved through the utilization of topic modeling. The process involves the use of algorithms that detect recurring themes and topics within a given corpus or collection of texts. This method can be used to identify patterns and trends in large datasets, enabling researchers to make informed decisions based on the insights derived from the analysis.

In the research realm, Wu et al.'s [17] study highlighted the criticality of acquiring granular insights through customer feedback. By leveraging topic modeling, companies can obtain this much-needed level of granularity and comprehend the intricacies that users frequently discuss regarding certain aspects of the supply chain.

Ascertaining prevailing themes in customer feedback over an extended period can significantly aid companies in detecting nascent trends. For example, if the frequency of conversations related to "product damage" progressively surges, it could signify underlying problems with the packaging or handling of products.

Efficient allocation of resources is a critical aspect of any organization. In research, the classification of text plays a vital role in helping organizations optimize their resource allocation. The process of text classification involves the categorization of text into predefined categories based on their content. This enables

organizations to easily identify and allocate resources to the areas that require them the most. As such, text classification is an important tool that organizations can use to streamline their operations and maximize their efficiency.

The study conducted in the railway domain by Ferrari et al. [13] suggests that automating the categorization of feedback can expedite the resolution process. When feedback is sorted into categories such as 'complaints' or 'suggestions,' it ensures that the appropriate department addresses the issue, thereby streamlining the efficiency of the resolution process. This approach has been shown to be beneficial in enhancing the overall effectiveness of the feedback management system [18].

The automated and systematic approach to text classification guarantees that feedback is analyzed objectively, without the influence of human biases. This results in insights that are reliable and consistent, which is particularly important for organizations looking to benchmark their performance and make data-driven decisions.

The enhancement of Supply Chain Management (SCM) software can be achieved through a comprehensive approach that encompasses all aspects of the system. This approach, commonly referred to as holistic improvement, involves a thorough analysis of the software's current state, identifying areas of weakness and potential improvement, and devising strategies to address them. By taking a holistic approach, companies can optimize their SCM systems, improving overall efficiency and productivity. This can be achieved through advanced algorithms, improved automation, and the integration of cutting-edge technologies. Holistic improvement in SCM software is crucial for organizations seeking to gain a competitive edge in the market, as well as those looking to streamline their supply chain processes and reduce operational costs.

The integration of Natural Language Processing (NLP) techniques into feedback analysis systems has proven to be a successful strategy for enhancing user experience, according to various companies. These businesses have reported noteworthy advancements by utilizing sentiment analysis and topic modeling to pinpoint areas of concern for users. By addressing these pain points, companies can adapt their Supply Chain Management (SCM) software to better cater to the needs of their users [14].

The study of operational streamlining has revealed the benefits of automated feedback categorization, specifically in the field of railways. This process has been shown to improve operational efficiency by accurately directing feedback to the appropriate departments. As a result, companies can experience faster issue resolution and more effective allocation of resources. These findings are supported by a reliable source, as indicated by reference [19].

Through the utilization of Natural Language Processing (NLP) methodologies in the assessment of consumer feedback for Supply Chain Management (SCM), concrete and significant outcomes have been achieved. The data and conclusions gleaned from scrutinized articles have demonstrated the following results:

Interpretation of feedback has been improved to a great extent through various enhancements. These improvements have made it easier for researchers to analyze data and draw meaningful conclusions from it. The advanced feedback interpretation techniques include the use of data visualization tools, algorithms, and machine learning models. These tools allow researchers to extract valuable insights from feedback data and identify patterns that would be difficult to detect otherwise. With enhanced feedback interpretation, researchers are now able to make better decisions based on feedback data, resulting in more accurate and effective research outcomes.

In the realm of research, the implementation of sentiment analysis among companies has resulted in significant improvements in their ability to interpret feedback. With this tool, companies could easily and accurately identify the overall sentiment of feedback, distinguishing between positive, negative, and neutral sentiments. This newfound ability enabled them to respond more quickly and effectively to pressing issues, thereby enhancing their overall performance.

The utilization of topic modeling has enabled businesses to efficiently classify feedback into discrete themes. Through this classification process, particular areas of concern, such as delivery times, product quality, or supplier relations, can be identified with greater clarity and precision.

The concept of operational efficiency is a crucial factor in ensuring the success of any

organization. It refers to the ability of a company to utilize its resources in the most optimal way possible to achieve its goals. Achieving operational efficiency involves streamlining processes, reducing waste, and maximizing productivity. By doing so, an organization can increase its profitability, enhance customer satisfaction, and gain a competitive advantage in the market. Operational efficiency is a multifaceted concept that requires careful planning, monitoring, and continuous improvement.

The streamlining of feedback categorization through text classification has had a significant impact on the efficiency of operations within companies. Notably, organizations have reported faster response times to both customer queries and complaints as a result. By automatically categorizing feedback into specific categories, such as 'complaints', customer service teams can immediately address these issues, leading to more expedient resolutions.

Efficient resource allocation is a crucial element in the smooth functioning of a company. The automation of feedback sorting has made it possible for companies to optimize their resource allocation process. By directing feedback that requires technical assistance to the relevant teams, companies can ensure that the issues are handled by experts in the field. This not only saves valuable time but also ensures that the right resources are utilized for the right tasks.

Proactively managing issues is a crucial aspect of any successful research project. By identifying potential areas of conflict before they arise, researchers are better equipped to address them in a timely and effective manner. This involves taking a comprehensive approach to issue management, which includes conducting thorough risk assessments, establishing clear lines of communication among team members, and implementing contingency plans for potential setbacks. Proactive issue management is essential for ensuring the integrity and success of any research endeavor.

In the realm of research, the ability to predict potential obstacles has become a crucial element in maintaining a successful business. By continuously monitoring the trajectory of sentiment trends, companies can gain valuable insights and anticipate challenges that may arise in the future. If there is a consistent decline in sentiment scores, this serves as an early warning

system that prompts businesses to take action and investigate any underlying issues before they have the chance to escalate and cause further harm.

Through topic modeling, emerging trends in customer feedback can be identified and analyzed. By recognizing and addressing recurring themes within this feedback, companies can effectively resolve persistent issues and improve customer satisfaction.

Achieving stakeholder satisfaction is a crucial aspect of effective research. To enhance stakeholder satisfaction, it is essential to implement strategies that aim to improve communication, transparency, and collaboration between researchers and stakeholders. By establishing a clear understanding of stakeholder needs and expectations, research can be conducted with greater focus and purpose. Furthermore, investing in stakeholder engagement and feedback loops can help ensure that research outcomes align with stakeholder priorities, ultimately leading to greater satisfaction and impact.

In the field of research, the incorporation of natural language processing (NLP) techniques into feedback analysis systems has resulted in significant enhancements to user experience. By identifying and addressing the specific pain points through the use of sentiment analysis and topic modeling, companies have been able to customize their supply chain management (SCM) software to better align with the unique needs and preferences of users. This has led to an overall improvement in user satisfaction and increased adoption of SCM software.

Taking a proactive approach to feedback management through the utilization of natural language processing (NLP) techniques has proven to be an effective method for stakeholder engagement. As a result of this approach, companies have reported increased levels of trust and collaboration with their stakeholders. These outcomes have been attributed to the companies' ability to be responsive and adaptive to feedback received. This approach has been supported by research and has demonstrated success in improving stakeholder engagement, as evidenced by the higher levels reported by companies [20].

When it comes to research, it is imperative that the analysis be both reliable and consistent. To achieve this, it is necessary to establish a

methodology that is repeatable and accurate. The results of any research study must be verifiable and reproducible, regardless of who is conducting the analysis. By ensuring that the analysis is consistent and reliable, the study can stand up to scrutiny and be considered trustworthy and valid.

A significant advantage of utilizing NLP-based feedback analysis is its automated nature, which guarantees consistency in interpretation. By utilizing this approach, businesses can effectively eliminate bias and enjoy the benefits of a bias-free analysis, resulting in more dependable insights and informed data-driven decision-making.

To sum up, the findings emphasize the revolutionary influence of NLP methods on Supply Chain Management (SCM). Firms who incorporated these techniques into their feedback analysis systems reported measurable enhancements in operational productivity, stakeholder contentment, and proactive issue resolution. The statistics underpin the potential of NLP as a game-changer in the SCM domain, promoting innovation and augmenting user gratification.

4. CONCLUSION

The evolution of Supply Chain Management (SCM) software in the digital age necessitates the integration of advanced analytical tools to harness the vast amounts of data generated across the supply chain. As evidenced in this article, Natural Language Processing (NLP) stands out as a pivotal tool in this transformation. By analyzing customer feedback through techniques like sentiment analysis, topic modeling, and text classification, businesses can gain unparalleled insights into their supply chain operations.

The studies reviewed underscore the tangible benefits of integrating NLP into SCM software. From immediate feedback interpretation to proactive issue management, NLP techniques have proven their mettle in enhancing operational efficiency, stakeholder satisfaction, and overall supply chain performance. The success stories from various industries, ranging from food delivery to railways, further attest to the versatility and efficacy of NLP in diverse contexts.

Furthermore, the ability of NLP to provide granular insights, ensure consistent feedback

analysis, and foster enhanced stakeholder engagement positions it as an indispensable tool for modern SCM systems. As businesses grapple with the complexities of global supply chains, tools like NLP offer a beacon of hope, promising streamlined operations, reduced inefficiencies, and a more responsive and adaptive supply chain ecosystem.

In essence, the fusion of NLP techniques with SCM software not only revolutionizes the way businesses interpret and act on feedback but also paves the way for a more data-driven, efficient, and customer-centric supply chain landscape. As we move forward, the synergy between NLP and SCM is poised to be a cornerstone of successful supply chain operations, driving innovation, enhancing user satisfaction, and ensuring business growth.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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