**Journal of Global Information Management**
Volume 32 • Issue 1

# Exploring the Potential of Large Language Models in Supply Chain Management:
## A Study Using Big Data

Santosh Kumar Srivastava, Institute of Management Technology, Ghaziabad, India

Susmi Routray, Institute of Management Technology, Ghaziabad, India

Surajit Bag, Research Center, Léonard de Vinci Pôle Universitaire, France

Shivam Gupta, Department of Information Systems, Supply Chain Management and Decision Support, NEOMA Business School, France

https://orcid.org/0000-0002-2714-4958

Justin Zuopeng Zhang, University of North Florida, USA*

https://orcid.org/0000-0002-4074-9505

## ABSTRACT

This study aims to identify emerging topics, themes, and potential areas for applying large language models (LLMs) in supply chain management through data triangulation. This study involved the synthesis of 33 published articles and a total of 3421 social media documents, including tweets, posts, expert opinions, and industry reports on utilizing LLMs in supply chain management. By employing BERT models, four core themes were derived: Supply chain optimization, supply chain risk and security management, supply chain knowledge management, and automated contract intelligence, which provides the present status of LLM in the supply chain. The results of this study will empower managers to identify prospective applications and areas for improvement, affording them a comprehensive understanding of the antecedents, decisions, and outcomes detailed in the framework. The insights garnered from this study are highly valuable to both researchers and managers, equipping them to harness the latest advancements in LLM technology and its role within supply chain management.

## KEYWORDS

BERT, Large language model, Social Media, Supply chain management

## INTRODUCTION

A supply chain, integral to modern businesses, facilitates the exchange of materials, information, and resources among interconnected organizations, ensuring the delivery of valuable products and services to consumers (Stadler, 2008). It operates within a complex web of suppliers, customers, and service providers, which demands intricate decision-making (Bag et al., 2023). While technological

DOI: 10.4018/JGIM.335125 *Corresponding Author

advancements have automated and optimized supply chain operations, the challenge of conveying optimization outcomes to stakeholders persists.[1]

Furthermore, the exponential growth of Internet data presents both opportunities and challenges for organizations. Modern supply chain professionals must leverage big data analytics, including data science and big data, to enhance the supply chain's processes and performance (Chatterjee et al., 2023; Waller & Fawcett, 2013). However, data quality remains paramount for effective decision-making in supply chain management (SCM), which emphasizes the significance of functional capabilities, information sharing, and data proficiency (Hazen et al., 2014). The successful management of operations and the supply chain hinges on a data-centric approach, which has evolved from traditional reporting to advanced analytics that encompasses statistical analysis, forecasting, and real-time optimization (Jacobs et al., 2014). Nonetheless, integrating big data analytics into supply chains remains a huge scope for research (Kache and Seuring, 2017).

Supply chain operations entail complex decision-making despite the automation and optimization achieved through advancements in computing (Oliveira & Pereira, 2023). Although optimization tools have enhanced the efficiency of supply chain decision-making, they frequently necessitate input from individuals lacking expertise, resulting in prolonged interactions with program managers and data experts (Lambert & Cooper, 2000). The emergence of large language models (LLMs) such as ChatGPT has spurred interest in the application of artificial intelligence (AI) within supply chains. These LLMs, including various deep generative models (DGM), play a pivotal role in deciphering intricate probability distributions (Li et al., 2023a). Within the retail sector, ChatGPT is used to enhance inventory management and detect trends in customer inquiries, seamlessly integrating with supply chain software and warehouse management systems (Kumar et al., 2023). Meanwhile, in the military domain, AI is revolutionizing equipment acquisition and sustainment, predicting demand, optimizing transport routes, and automating inventory management to trim expenses and enhance supply chain efficiency (Mikhailov, 2023).

Another critical aspect of the supply chain involves security breaches. Relying on software systems leads to increased vulnerability to supply chain breaches, resulting in significant financial and data losses. Prioritizing cybersecurity is crucial, yet traditional methods for analyzing past failures involve manual report reading and summarization. Automated support through natural language processing (NLP), including LLMs, can reduce costs and enhance the analysis of such incidents (Trappey et al., 2022; Singla et al., 2023).

There are numerous examples of industries that have started to use NLP and AI to enhance supply chain efficiency. For example, IBM Watson offers SCM solutions that incorporate NLP and AI capabilities. It can analyze unstructured data, such as news articles and social media, to provide insights into supply chain risks and opportunities (Ganesh & Kalpana, 2022). Another firm named SAP Ariba leverages AI and NLP to improve procurement and supplier management. It can assist in supplier discovery, risk assessment, and contract analysis, thereby enhancing supply chain efficiency.[2] Furthermore, Llamasoft's supply chain design software uses AI and machine learning, including NLP, to assist companies in optimizing their supply chain networks. It can process textual data to improve decision-making in its supply chain design.[3] Moreover, GEP SMART is a unified procurement platform that uses AI and NLP to conduct spend analysis, sourcing, and contract management. They can help companies to obtain an enhanced understanding of their supplier contracts and procurement data.[4] Some companies develop in-house or third-party text analysis tools that integrate LLMs, such as GPT-3, to process unstructured textual data from various sources, including news, social media, and email, to extract insights relevant to SCM (Yenduri et al., 2023).

However, the application of LLMs in SCM is still in its infancy, with limited academic literature available on the topic. However, discussions on social media, articles, and blogs have touched upon its potential benefits, particularly in enhancing the effectiveness of SCM (Shrivastav, 2023). For example, effective supply chain talent management is crucial amid disruptions and turnover, with standardization proving challenging due to context-specific operations (Li et al., 2023b). LLMs, trained

on internal data, such as emails, bridge knowledge gaps. LLMs enhance processes, data interpretation, historical context, and decision understanding. Furthermore, combining in-house LLMs with process mining streamlines data analysis, thereby boosting productivity.[5] LLMs also provide functions such as event triggering and task automation, which are valuable for tasks like product code management and dynamic planning in SCM (Li et al., 2023a).

Generative AI has the potential to rapidly respond to fluctuating demand, thus accelerating procurement and boosting revenue (Gill et al., 2022). It enhances real-time decision-making in purchasing and markdowns while fostering team collaboration for actionable strategies. LLMs, including generative AI, excel in handling unstructured text data. Unlike rule-based methods and NLP, which struggle with contract variability, LLMs automate tasks like contract clause extraction and data structuring, thereby reducing the reliance on costly legal expertise and facilitating specialized knowledge expansion.[6] LLMs also offer versatile applications in SCM, including inventory, procurement, route optimization, delivery, document management, and contingency planning.[7] Noteworthily, ChatGPT is revolutionizing SCM, offering automation, data insights, and process optimization. Manufacturers can leverage it to monitor their inventory, understand supply-demand dynamics, and enhance communication with suppliers and logistics partners for efficient raw material and product deliveries.[8]

The motivation for conducting this study was twofold. First, the rapid advancement of LLMs, exemplified by ChatGPT, has revolutionized AI (Kumar et al., 2023; Tsai et al., 2023). These models exhibit exceptional capabilities in the processing and generation of human-like text, which can potentially transform supply chain operations (Just, 2024). Second, the COVID-19 pandemic and other disruptive factors have underscored the need for agile and data-driven SCM. LLMs can enhance real-time decision-making, automate tasks, and optimize various aspects of the supply chain (Liu et al., 2023; Li et al., 2023b). This research study aimed to bridge the gap between the evolving potential of LLMs and their scarce utilization in addressing the challenges and complexities of modern SCM (Raiaan et al., 2023). The study sought to fill this critical void, offering valuable insights into the practical applications of LLMs in the supply chain and fostering efficiency, accuracy, and innovation in this crucial domain of business operations. It did so by systematically examining themes related to LLM utilization in SCM. A diverse range of sources were analyzed, including academic literature and social media discussions, to uncover trends, usage patterns, and insights into present and future developments. By employing multiple data sources, this study aimed to enhance the reliability and validity of its findings. The following research questions guided the study:

**RQ1.** What are the prevalent applications of LLM in the supply chain domain, and what are the key thematic areas of utilization?

**RQ2.** What are the antecedents, decisions, and outcomes linked to each application theme of LLM in the supply chain? Additionally, what are the prospective research trajectories in this domain?

This paper is divided into seven sections, the remainder of which are organized as follows. The second section presents the research methodology that was employed to conduct this study. Then, the third section presents a review of the relevant literature, while the fourth section discusses the proposed framework. Next, the fifth section summarizes the theoretical contributions to the literature and the implications for management, while the sixth section presents the conclusions of the study. Lastly, the seventh section describes the study's limitations and provides directions for future research.

## RESEARCH METHODOLOGY

The researcher and industry practitioner uses academic databases such as SCOPUS and WoS to conduct systematic literature reviews and keyword analysis to synthesis the current and past status of a particular topic (Williamson and Johanson, 2017). These databases contain peer-reviewed literature to covering

a wide range of disciplines. In this study, we have used multiple data sources (data triangulation) including social media such as Twitter, LinkedIn, blogs, forums and peer-reviewed articles published in various academic databases to examine and explore the current status, topic and themes of use of LLM in SCM. Since the social media information include the opinion and observation of both, academic researcher and industry practitioners (Wang et al., 2021), it provides a more authentic and wider facet of a LLM and its use in SCM.

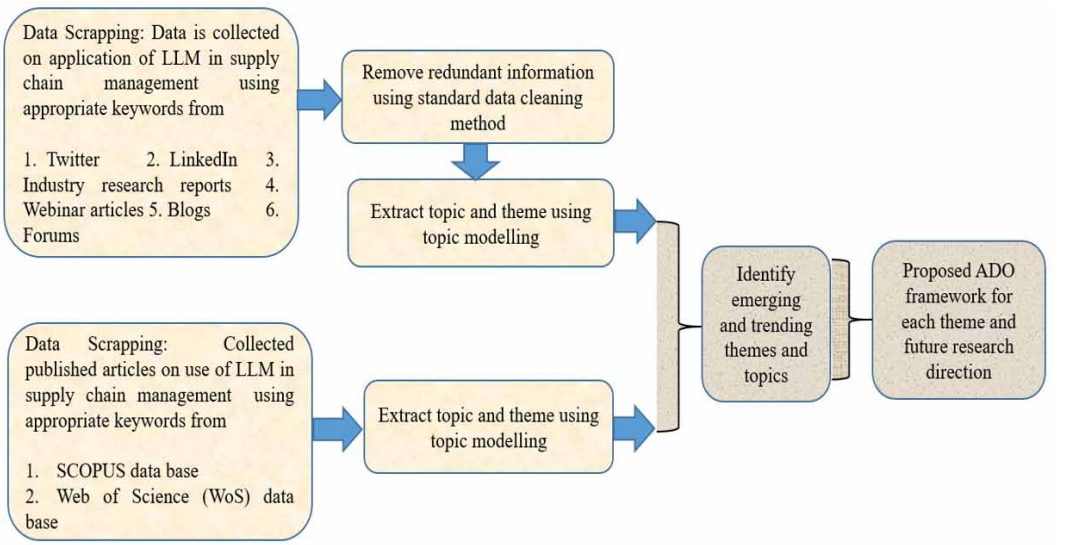
This study is overall divided into two phases. During the first phase of the study, we used published literature in peer-reviewed journals to derive the topic and theme using the python package "BERTopic" which combines BERT embedding with non-negative matrix factorization (NMF). During the second phase of the study, we used the "BERTopic" package to extract topic and themes from social media data. The final list of distinct themes is derived by combining the themes derived from social media and published literature on the use of LLM in SCM. In the end, the Antecedent, decision, and outcome (ADO) framework (Paul & Cariado, 2020) is proposed for each theme. Figure 1 depicts the flow of the study as below:

## Topic Modelling: BERT Embedding With Non-Negative Matrix Factorization (NMF) and Class-Based TF-IDF Topic Modelling

BERT embeddings with NMF and Class-Based TF-IDF is a popular machine learning unsupervised technique for topic modelling (Grootendorst, 2022). This method handles complex and large-sized data efficiently. Researchers prefer to use this technique often on social media data where the amount of redundancy and complexity is always high (Sayed et al., 2023). We have used the BERTopic python package to implement BERT embeddings with NMF and the steps are explained below:

The python package "BERTopic" process multiple steps in data processing including BERT embeddings, NMF and topic modelling (Grootendorst, 2022). In first step of data processing, BERT embeddings are used to map the context of each word of a sentence in a document through pre-trained language model. Next, NMF method is used on these documents to reduce the dimension of each document derived from the first step. After reducing the dimension of each document, we have used BERTopic, which implement the class-based TF-IDF procedure to derive the optimal number

**Figure 1. Flowchart of the study**
*(Source: Authors' own work)*



of topics. In essence, BERTopic generates document embedding with pre-trained transformer-based language models, clusters these embeddings, and finally, generates topic representations with the class-based TF-IDF procedure. Based on the distribution of keywords in a topic, a suitable theme is proposed (Grootendorst, 2022).

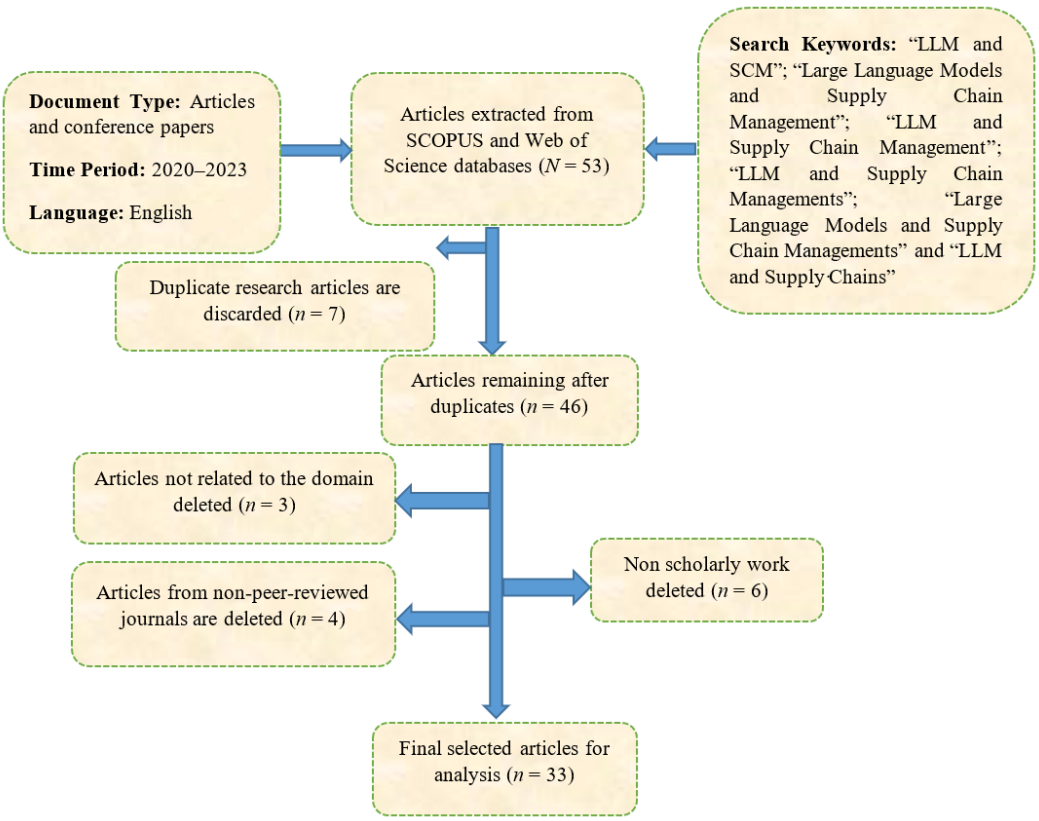
## LITERATURE ANALYSIS

### Topics and Themes from Published Literature in Peer-Reviewed Journals

In this section, we have used "BERTopic" to extract topics from published literature on the application of LLM in SCM. We have followed the systematic process proposed by Mohamed et al. (2021) to collect articles on the use of LLM for SCM. We have selected the peer-reviewed articles from two popular academic databases (SCOPUS and WoS), using appropriate keywords (refer to Figure 2) on the topic. Since the LLM is a new technology, we have found the published article on this topic ranging from 2020-23. Through manual check, we have discarded those articles which were redundant, published in non-peer reviewed journals and duplicated to ensure the reliability and accuracy of the results (Mohamed et al., 2021). Finally, we have found 33 published articles appropriate for topic modelling and data collection process are described in Figure 2.

The title, abstract, and author keywords of the selected articles were used for topic modeling as they contained valuable information about the articles (Hu et al., 2020). The title briefly summarizes

**Figure 2. Data collection process**
*(Source: Authors' own work)*



the main topic addressed in the article, while the abstract provides more detailed information about the research methods, results, and conclusions. Author keywords were also used for topic modeling, as they are a set of terms chosen by the authors to describe the main topics and themes covered in their article. Figure 3 presents a word cloud of published literature on the use of LLM in SCM. It helped to identify the topics discussed in the articles. The words that appear most frequently in the word cloud indicate the dominance of topics within the text. LLMs, SCM, inventory optimization, AI, NLP, automation, robotics, and predictive modeling were among the dominant keywords in the published literature.

Table 1 provides the frequency of keywords in all collected documents, which helped us to identify the main topics and themes (refer to Figure 4) as well as the most important terms and phrases used.

**Table 1. Top 15 keywords with their term frequency-inverse document frequency (TF-IDF)**

| Keywords | Frequency | % Shown | TF-IDF |
|---|---|---|---|
| Chatbot | 12 | 3.31% | 0.14 |
| Risk | 8 | 2.20% | 0.14 |
| Cost | 3 | 0.83% | 0.12 |
| Automation | 15 | 4.13% | 0.11 |
| Artificial intelligence | 23 | 6.34% | 0.07 |
| Planning | 11 | 3.03% | 0.06 |
| Forecasting | 21 | 5.79% | 0.05 |
| Last-mile | 7 | 1.93% | 0.042 |
| Inventory | 31 | 8.54% | 0.03 |
| Data analysis | 12 | 3.31% | 0.012 |
| NLP | 43 | 11.85% | 0.01 |
| Predictive analytics | 28 | 7.71% | 0.01 |
| Supply chain | 65 | 17.91% | 0.003 |
| LLM | 84 | 23.14% | 0.001 |

(Source: Authors' own work)
The top five keywords "chatbots"; "risk"; "cost"; "automation" and "artificial intelligence" represent areas of focus on the topic.

**Figure 3. Word cloud of published literature**
*(Source: Authors' own work)*

Keyword "chatbots" indicates the use of LLM for conversational AI in SCM, which helps to enhance customer support, provide real-time information, and streamline communication within the supply chain (Shrivastav, 2021; Kar et al., 2023). The presence of "risk" as a keyword suggests that managing and mitigating risks within the supply chain is a key concern (Hendriksen, 2023). This could encompass various types of risks, such as financial, operational, or logistical risks. Another important keyword, found in this analysis is "cost" that emphasizes about the cost of infrastructure to develop LLM for supply chain operations. Making investment in hardware and software for LLM infrastructure within SCM require prior research, weighing the profits against the associated cost (De Bock et al., 2023). "Automation" is another keyword that appears during analysis. Published literature on the topic data provides insights how LLM can be used for automation purpose within SCM to make the supply chain efficient, risk free and minimizing the human intervention. The last keyword is "artificial intelligence" which is somehow connected with previous one. This keyword suggests that AI jointly with LLM can be used for various purposes such as forecasting, optimization and automation. Overall these keywords provide initial insights and benefits of using Chabot, AI particularly LLM for automation, minimize risk and increasing efficiency of supply chain process. Table 2 presents some of the popular studies on the use of LLM in SCM.

## Topics and Themes (Published Literature)

The selected articles on the application of LLMs in SCM were used to gain insights into the prevalent subjects and discussions. Recognizing that abstracts, titles, and keywords typically encapsulate the most valuable information within articles, this study leveraged these components from each article to extract overarching topics and themes. Using perplexity and coherence scores (Wahid et al., 2022), we distilled four optimal topics from the collective body of published literature. These identified topics are visually presented in Figure 4.

Based on the keywords in each topic, a theme was proposed for each topic. They are presented in Figure 5.

Four themes were identified from the published literature – namely "LLM and supply chain forecasting," "LLMs for supplier relationship management," "supply chain risk aversion using LLMs," and "LLMs and supply chain modeling." The four identified themes from the published literature represent specific areas of focus and application of LLMs in SCM.

The first theme, "LLM and supply chain forecasting," concerns the use of LLMs for enhancing the accuracy and effectiveness of supply chain forecasting. LLMs are used to improve demand forecasting, sales predictions, and inventory management through NLP and text analysis of various data sources. The primary focus is on harnessing LLMs to enhance precision and data-driven predictions in supply chain operations.

The second theme, "LLMs for supplier relationship management," delves into the application of LLMs for managing and enhancing relationships with suppliers within the supply chain. This includes employing LLMs for sentiment analysis, contract assessment, and communication optimization. The objective is to improve communication, collaboration, and overall efficiency in supplier relationships through language models.

The third theme, "supply chain risk mitigation using LLMs," revolves around using LLMs to mitigate the risks inherent in the supply chain. It involves using NLP and text analysis to evaluate and manage risks associated with disruptions, geopolitical events, and other uncertainties. LLMs play a pivotal role in identifying potential risks and formulating strategies for preventing or reducing their impact on the supply chain. The fourth theme, "LLMs and supply chain modeling," focuses on the integration of LLMs into supply chain modeling and optimization. This entails the application of LLMs in mathematical modeling, simulation, and decision support systems for enhancing the overall efficiency and performance of supply chains. LLMs contribute to the creation of more accurate models, the optimization of network designs, and the facilitation of data-driven decision-making.

**Table 2. Past published literature on the use of LLM in SCM**

| Article | Keywords | Findings |
|---|---|---|
| Hendriksen (2023) | Robust systems for monitoring AI performance, establishing measures for disruption mitigation, and developing contingency plans. Coordination and collaboration with other supply chain actors—aligning AI strategies and developing shared best practices for AI integration and management as well as responsible management practices | The study delves into the theoretical and practical implications of AI, notably LLMs, in supply chain management. It introduces the AI Integration (AII) framework, which accounts for AI's role and integration across the supply chain while acknowledging human influence. The article highlights that diverse AI integration strategies yield distinct disruptions, underscoring the need for interdisciplinary collaboration and sociotechnical insights in SCM. |
| Wang et al. (2023b) | Intelligent manufacturing systems, Industrial-GPT, Data security and privacy protection, and Model as a Service | Manufacturers aim to harness industrial knowledge and unlabeled data for improved human–cyber-physical collaboration and autonomous intelligence. This article presents Industrial-GPT, which leverages industrial data for pertaining, scenario-specific fine-tuning, and domain knowledge reinforcement. It also introduces a cloud-based model as a service approach for enhancing Industrial-GPT's applicability, focusing on efficiency and customization. The article details the operation of an Industrial-GPT-powered intelligent manufacturing system and discusses the challenges and prospects in applying Industrial-GPT to manufacturing. |
| Wamba et al. (2023) | Organizational learning, increased supply chain performance, and organizational learning capacity | The rapid ascent of ChatGPT has sparked considerable societal debate, particularly concerning its potential to reshape the business landscape, including operations and supply chain management (OSCM). This study, while acknowledging limited empirical evidence, investigated the effects, challenges, and trends associated with generative AI/ChatGPT in OSCM based on data from 154 UK and 161 U.S. OSCM practitioners. The results highlight increased efficiency as a key benefit for both adopters and nonadopters in both regions, alongside concerns regarding security, risks, and ethics. Generative AI/ChatGPT integration enhances overall supply chain performance, facilitated by organizational learning. |
| Frederico (2023) | Route optimization, predictive maintenance, order shipment, customer and supplier relationships, data analysis, ordering process, invoice automation, waste reduction, and workforce training and guidance, among others | The study offers an introductory perspective on ChatGPT's applications and challenges in supply chains, drawing from initial evidence found in specialized magazines, blogs, and company websites. Due to a lack of research papers on this topic in databases, a systematic literature review was not feasible. This viewpoint provides practitioners in supply chain activities with foundational insights into ChatGPT's impacts and applications, aiming to inspire further research in this field. |
| Chowdhury et al. (2023) | Conversational AI systems and SCM security | The application NLP has seen exponential growth specially in conversational AI systems like ChatGPT. However, the ChatGPT can be misused in many ways due to its interactive power such as spreading information, automated spam and phishing and ignoring the security measures. It also investigated the misuse of ChatGPT in various stages of the supply chain. |
| Rathore (2023) | Optimization of the production process, generation of meaningful and automated customer support, efficiency enhancement, customer experience, sustainability, industry quality, and waste management | The study explored how ChatGPT can be integrated in the textile industry for Customer Support and Interaction; Order Processing and Tracking; Internal Communication and Documentation; supply chain tracking and tracing and, Training and Knowledge Transfer. |
| Li et al. (2023a) | Streamlining of operations, improvement of efficiency, and support for innovation in medical device production | Explored the role of ChatGPT in the manufacturing industry precise in medical devices. Further they explored how the ChatGPT can be used for device design while ensuring security and safety, quality, and compliance. |
| Widder & Wong (2023) | Automated decision systems and policy interventions | The study argued that the policy interventions for AI Ethics must consider AI as a supply chain problem, given how the political economy and intra-firm relations structure AI production. |
| Wang et al. (2023c) | Engineering design, product development, smart manufacturing, human-machine collaboration, knowledge management, design innovation, and engineering skill education | Performed a systematic testing of ChatGPT to uncover its advantages and limitations from a manufacturing perspective. The study also offered a technology development roadmap to effectively integrate ChatGPT into the manufacturing firms. |
| Mikhailov (2023) | Demand prediction, optimization of transportation routes, reduction of logistics risks and costs, assessment of frontline unit needs, scheduling of resupply missions, automation of inventory management, improvement of supply chain efficiency | AI plays a crucial role in optimizing the complex and resource-intensive acquisition and maintenance of military assets. The U.S. Air Force Material Command utilizes AI algorithms to predict demand, optimize transportation routes, and reduce logistics risks and costs. AI's capabilities include the assessment of frontline unit needs, scheduling of resupply missions, and automation of inventory management to improve supply chain efficiency and enhance military readiness against evolving threats. |

(Source: Authors' own work)

**Figure 4. Topics and themes**
*(Source: Authors' own work)*

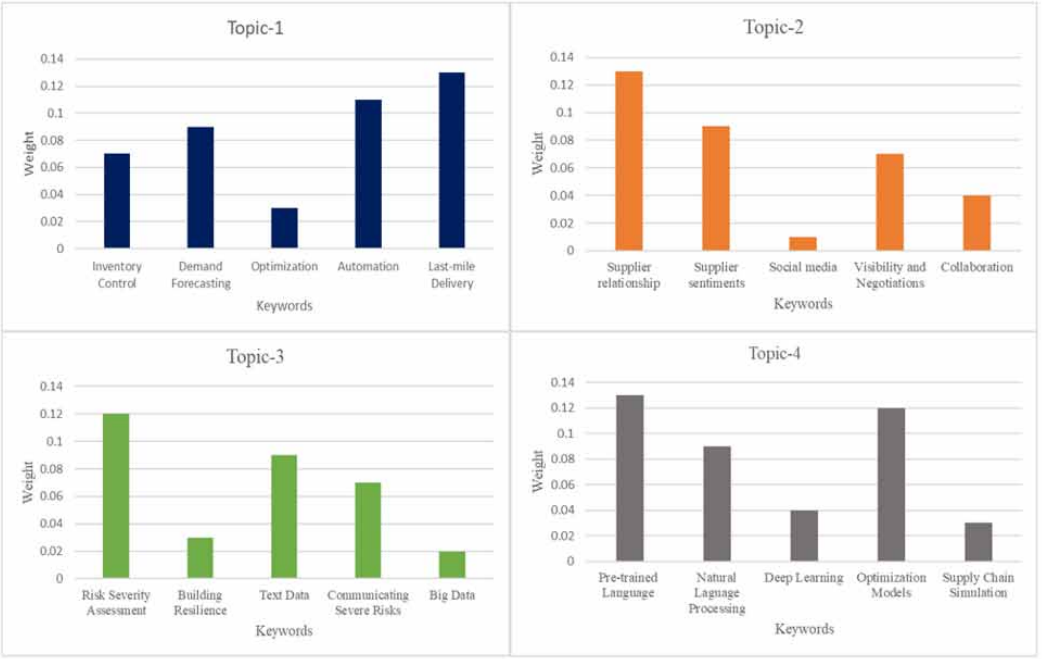



**Figure 5. Themes derived from Figure 4**
*(Source: Authors' own work)*


These four themes exemplify the diverse applications of LLMs across various facets of SCM, encompassing forecasting, supplier relationship management, risk mitigation, and modeling. They underscore the versatile ways in which language models are employed to elevate efficiency, accuracy, and decision-making within supply chain operations.

## Topics and Themes (Blogs, Forums, Twitter, LinkedIn, Industry Reports, and Webinars)

Individuals across the globe employ diverse social media platforms to articulate their viewpoints and interests, irrespective of their geographical location (Wang et al., 2021). These platforms have witnessed a significant upswing in recent years, allowing people to disseminate their opinions and evaluations concerning products, services, and businesses. Numerous websites, blogs, and social media platforms serve as sources for industry news, research, and valuable insights regarding the utilization of LLM in SCM trends and best practices. Noteworthy examples encompass platforms such as Supply Chain 24/7, Supply Chain Digital, Supply Chain Management Review, Kinaxis Blog, ToolsGroup Blog, the Supply Chain Forum, APICS Community, the Supply Chain Management

Association (SCMA) Forum, discussions on supply chain optimization, and interactions within the Supply Chain Today community. In addition, social media platforms such as Twitter and LinkedIn provide a networking forum for professionals to connect, disseminate information, and stay up to date on the latest developments (Muninger et al., 2022).

We compiled data from a diverse range of online outlets, encompassing platforms such as LinkedIn, Twitter, blogs, and forums dedicated to the application of LLM in supply chains. This data collection process spanned 6 months and was driven by the specific keywords illustrated in Figure 6.

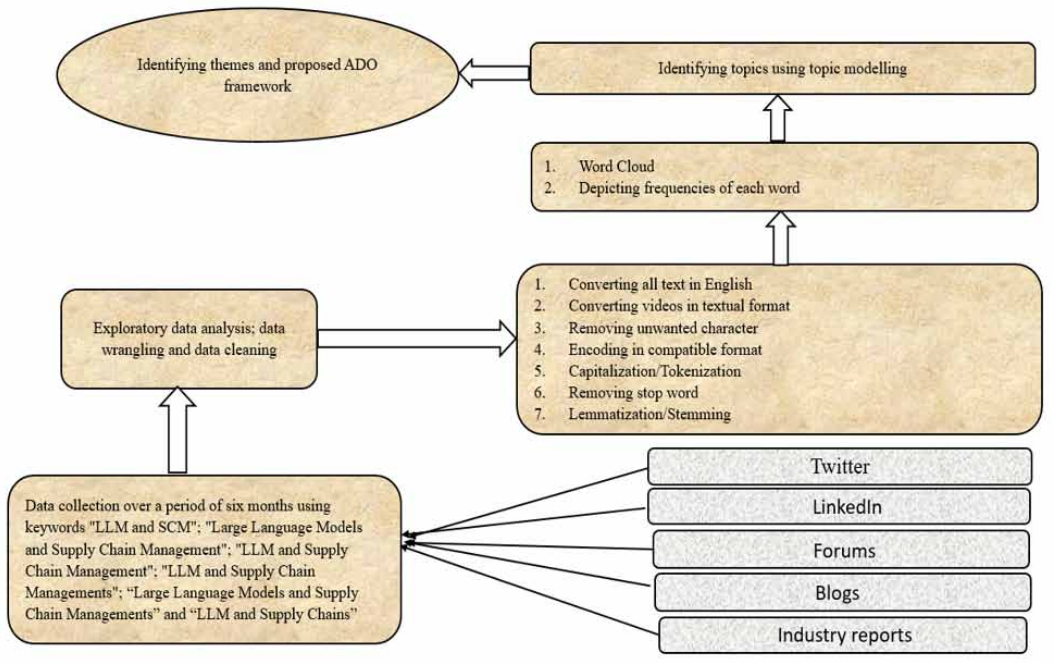
### *Data From Twitter*

Among social media platforms, Twitter is highly favored among researchers and industry professionals. For data collection, we used the following keywords to extract tweets through the Twitter API: "LLM and SCM," "Large Language Models and Supply Chain Management," "LLM and Supply Chain Management," "LLM and Supply Chain Management," "Large Language Models and Supply Chain Management," and "LLM and Supply Chains." Due to Twitter's limitation in providing a set number of daily tweets (Russell, 2011), we engaged in continuous data collection over 6 months. Our analysis involved 3,241 tweets, facilitated by the Twitter API and the Python package Twipy.

### *Data From LinkedIn*

Web scraping is a widely employed technique for retrieving data from web pages, and one of the go-to tools for this purpose is the highly popular Python library "BeautifulSoup" (Russel, 2011; Cortez et al., 2023). Using the keywords depicted in Figure 6, we embarked on a quest to compile posts and discussions regarding the use of LLMs in SCM. Notably, information on LinkedIn pages tends to be static in nature. Through our efforts, we successfully extracted approximately 21 posts and discussions from LinkedIn.

**Figure 6. Data collection processes**
*(Source: Authors' own work)*



### *Data From Blogs, Forums, and Industry Research Reports*

Blogs and forums that focus on supply chains offer excellent avenues for engaging in discussions. Prominent platforms, such as Supply Chain 24/7, Supply Chain Digital, Supply Chain Management Review, Kinaxis Blog, ToolsGroup Blog, the Supply Chain Forum, APICS Community, and the SCMA Forum, as well as the discussions around supply chain optimization and the interactions within the Supply Chain Today community, have garnered substantial popularity (Swain & Cao, 2019). To source relevant information, we employed the keywords displayed in Figure 6 to gather posts and discussions from these SCM blogs and forums (refer to Table 3). A total of 76 documents were scraped from blogs, forums, and industry research reports on the use of LLMs in SCM.

### *Data Cleaning*

The information collected in this research was sourced from a diverse range of origins, thus generating a blend of textual data, some of which may be repetitive. Our dataset comprised 3,518 documents, each of which corresponded to an individual instance. To facilitate the analysis of the social media data, we initially transformed all of the data into text format using the relevant Python tool. Subsequently, we refined the gathered data using the Natural Language Toolkit (NLTK) Python library (Hardeniya et al., 2016).

**Table 3. Frequency of tweets, posts, and discussions from social media**

| Forums/Blogs | Descriptions | Webpages | Number of documents |
|---|---|---|---|
| Twitter | Social media platform | https://twitter.com/ | 3,421 |
| LinkedIn | Social media platform | https://www.linkedin.com/feed/ | 21 |
| Supply Chain 24/7 | Covers various aspects of supply chain management, including technology and tools | https://www.supplychain247.com/ | 7 |
| Supply Chain Digital | Offers insights into supply chain technology, software, and best practices | https://supplychaindigital.com/ | 12 |
| Supply Chain Management Review | Provides articles and blogs on supply chain technology, innovations, and strategies | https://www.scmr.com/ | 5 |
| Kinaxis Blog | Focuses on supply chain software and techniques, including AI and machine learning | https://blog.kinaxis.com/ | 7 |
| ToolsGroup Blog | Discusses supply chain planning and demand forecasting tools and technologies | https://www.toolsgroup.com/blog/ | 3 |
| Supply Chain Forum | An online community for supply chain professionals to discuss tools, techniques, and industry trends | https://www.supplychainforum.com/ | 11 |
| APICS Community | A forum for members of the Association for Supply Chain Management to share knowledge and insights | https://www.apics.org/community | 3 |
| Supply Chain Management Association (SCMA) Forum | A community for supply chain professionals in Canada to exchange ideas and information about supply chain tools and techniques | https://forum.scma.com/ | 7 |
| Supply Chain Optimization | A LinkedIn group dedicated to discussions on supply chain optimization techniques and tools | https://www.linkedin.com/groups/2978138/ | 9 |
| Supply Chain Today | A LinkedIn group where supply chain professionals discuss the latest tools and technologies in the field | https://www.linkedin.com/groups/1825193/ | 12 |

(Source: Authors' own work)

Prominent keywords that were found to frequently emerge across social media platforms, blogs, forums, and industry reports about the use of LLM in supply chain operations encompass terms such as knowledge sharing, security, contract intelligence, customer feedback, vendor and supplier management, and risk. This noteworthy finding, exemplified in Figure 7 and expounded on in Table 4, reflects a discernible trend in the ongoing dialogues and discussions on the application of LLMs

**Figure 7. Word cloud of social media data**
*(Source: Authors' own work)*


**Table 4. Keywords and their term frequency-inverse document frequency (TF-IDF) from social media data**

| Keywords | Frequency | % Shown | TF-IDF |
|---|---|---|---|
| Knowledge sharing | 35 | 1.35% | 0.17 |
| Security | 87 | 3.35% | 0.16 |
| Contract intelligence | 13 | 0.50% | 0.14 |
| Customer feedback | 71 | 2.74% | 0.13 |
| Vendor and supplier management | 43 | 1.66% | 0.11 |
| Risk | 76 | 2.93% | 0.09 |
| E-commerce | 41 | 1.58% | 0.08 |
| Route | 98 | 3.78% | 0.07 |
| Regulatory compliance | 29 | 1.12% | 0.07 |
| Automation | 149 | 5.74% | 0.05 |
| Big data | 327 | 12.61% | 0.04 |
| Optimization | 431 | 16.62% | 0.03 |
| Knowledge capture | 21 | 0.81% | 0.01 |
| Data-driven decisions | 412 | 15.88% | 0.01 |
| Supply chain | 761 | 29.34% | 0.001 |

(Source: Authors' own work)

in SCM. This pattern underscores the areas of prime focus and interest within this particular domain, thus shedding light on the pivotal aspects that drive conversations and shape perspectives on the role of LLMs in optimizing supply chain processes.

## Topics and Themes (Social Media, Blogs, and Forums)

We derived five optimal topics using the BERTopic Python library (Mustak et al., 2021). They are depicted in Figure 8, and their graphical representation follows in Figure 9.

### *Final Themes From Both Databases*

We found three themes from the published literature, while five themes were derived from social media data, as shown in Figure 10. Finally, we found four different themes based on these two databases (see Figure 10).

The role of LLMs, such as GPT-3 or similar AI-powered systems, has become increasingly significant in various domains, including SCM (AlZu'bi et al., 2022).

The automation of contract intelligence using language models significantly improves contract management efficiency and provides the first theme of "LLM-driven automated contract intelligence." LLMs can extract, categorize, and analyze contract clauses, terms, and conditions. They identify potential risks, opportunities, and obligations. Furthermore, they facilitate contract creation, revision, and compliance monitoring. This automation streamlines the contract lifecycle, reducing errors and enhancing legal and financial security. LLMs are invaluable for knowledge management in supply chains and represent the second theme of "LLM-driven supply chain knowledge management." They help to catalog and extract insights from extensive documentation, such as regulations, contracts, and historical reports. This knowledge can be used to enhance decision-making, compliance, and process optimization. Additionally, language models enable supply chain professionals to quickly find and share expertise, fostering collaboration and efficient problem-solving (Belhadi et al., 2022). Managing risk and ensuring the security of supply chains is critical. Language models help to deal with the

**Figure 8. Topics and themes**
*(Source: Authors' own work)*

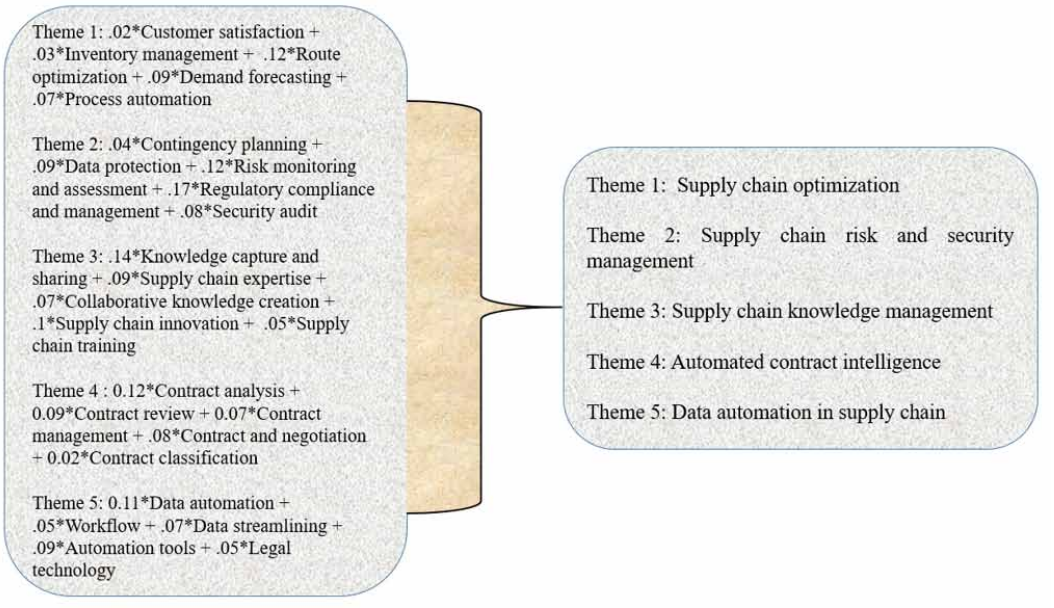
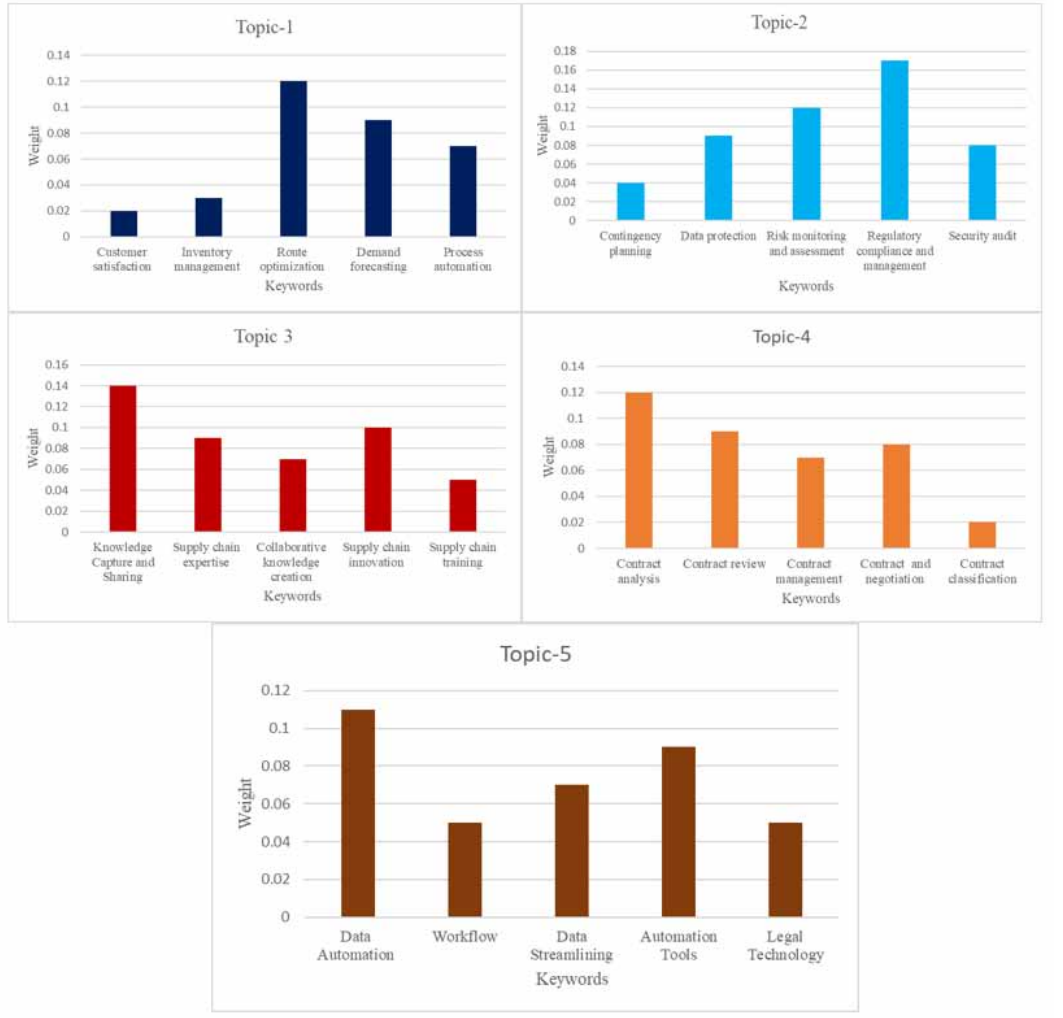


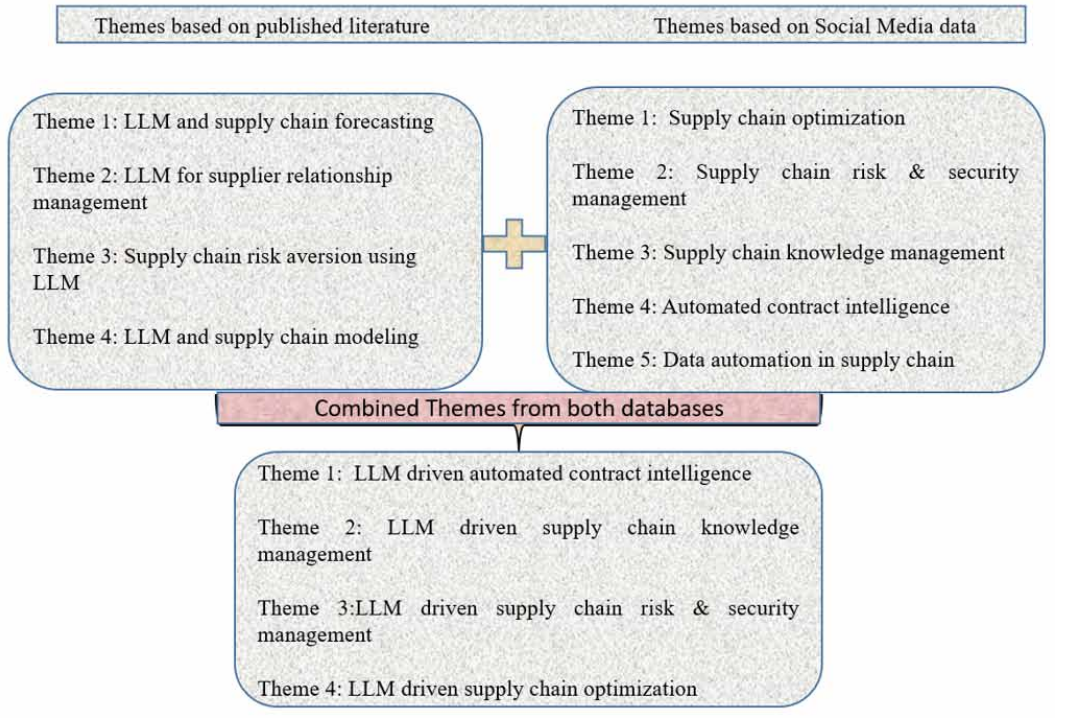
**Figure 9. Graphical representation of topics and themes**
*(Source: Authors' own work)*




third theme, namely "LLM-driven supply chain risk and security management," by continuously monitoring information sources for potential risks. They can assess geopolitical developments, weather patterns, and market shifts, providing early warnings for possible disruptions (Singla et al., 2023). Through analyzing legal documents and contracts, these models also enhance compliance and security by identifying potential issues in agreements or tracking cybersecurity threats (Singla et al., 2023). Moreover, LLMs play a pivotal role in the fourth theme, namely "LLM-driven supply chain optimization," by analyzing vast amounts of textual and numerical data. They assist in demand forecasting, inventory management, route optimization, and supplier selection. These models can process historical data, market trends, and even unstructured information from sources such as social media to refine decision-making (Yang et al., 2023b). Additionally, they provide real-time insights into potential disruptions, helping supply chains to adapt swiftly.

LLMs are instrumental in supply chain optimization, risk and security management, knowledge management, and automated contract intelligence (Kar et al., 2023). Their ability to process

**Figure 10. Final emergent themes from the two databases**
*(Source: Authors' own work)*




and understand vast volumes of data, both structured and unstructured, empowers supply chain professionals to make more informed decisions, mitigate risks, and optimize operations (Xu et al., 2023). As these models continue to evolve, they will play an increasingly critical role in reshaping SCM practices and strategies.

## PROPOSED ADO FRAMEWORK FOR EACH THEMES

The Antecedent, Decision, Outcome (ADO) framework as given by Paul & Benito (2018) defines the relationship between antecedents, decisions and the outcomes in a particular business situation. This is an analytical framework which is useful in explaining the cause and effect relationships and its impact on outcomes. Antecedents are the factors that precedes the specific decisions. These factors may be internal or external environmental conditions that may trigger a certain decision. In any given situation decisions are made on the basis of the factors or the antecedent identified. Decision leads to outcome. The outcome may be positive or negative in a given situation thereby impacting the business (Paul & Benito, 2018). Understanding the relationship between the antecedents that leads to the decision is highly significant. Because, based on the decisions strategies are formulated which leads to a specific outcome. By understanding the cause and effect relationship between the antecedents and the decisions leads to formulate appropriate strategy to deal with challenges and make the most of the situation.

This framework finds its application in various domains. The ADO framework provides researchers and practitioners with useful insights into the relationship between the antecedents and how they trigger the decision making process reaching to a particular outcome (Paul & Benito, 2018). This framework allows the organizations to gauge the cause and effect aspect in order to make a

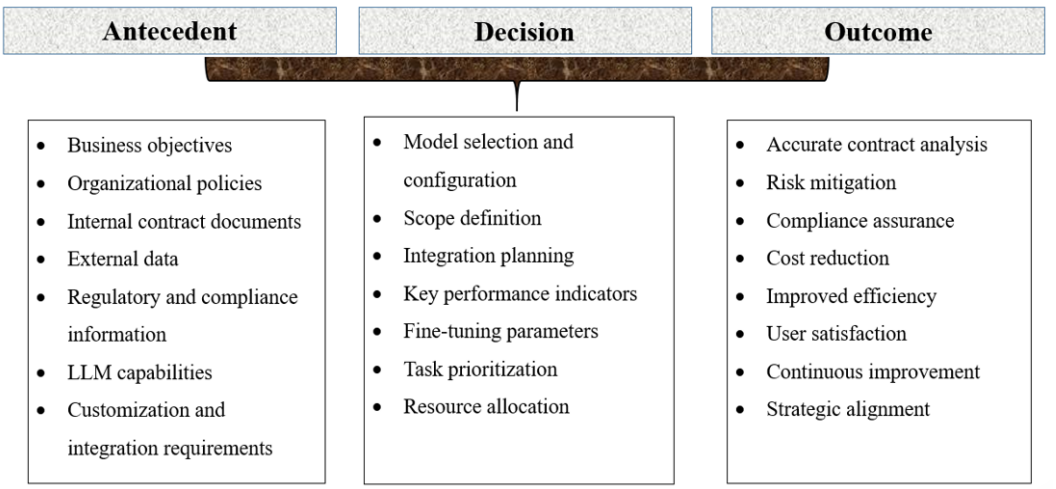
more informed decision. Further, it allows them to analyze and assess the outcomes and the strategies adopted and take necessary corrective actions wherever required. Thus, this analytical approach equips the organizations to make the most of the opportunities available and to handle the challenges.

## Theme One: LLM-Driven Automated Contract Intelligence

The traditional supply chain contract management system deals with various issues pertaining to manual handling of contracts, lack of centralized repositories, ensuring compliance with changing regulations and industry standards, scaling up, lacks proper communication and collaboration (Dubey et al. 2018). The first theme in the context of SCM signifies the incorporation of advanced AI-powered LLMs, such as GPT-3, for automating and enhancing contract-related procedures within supply chain operations. Within this theme, the primary focus revolves around the use of LLMs to streamline the administration of contracts in supply chain processes. The theme encompasses various vital aspects, including contract extraction and analysis, compliance and risk management, contract creation and revision, contract monitoring, security and cybersecurity, efficiency improvement, and error reduction. This theme highlights the vast opportunity LLM driven automated contract intelligence system possesses in automating and optimizing supply chain contract process. This will lead to reimagining the supply chain contract management system using AI's LLM capabilities. It empowers organizations to more efficiently handle contracts, reduce risks, ensure compliance, and ultimately elevate the management of their supply chain operations.

The ADO framework for this theme is depicted in Figure 11. Top of FormThe ADO framework's antecedents for theme 1 encompasses the relevant components that will lead to a successful automated contract intelligence system (Hadi et al., 2023). On the basis of analysis, the antecedents identified includes organization policies, internal contract documents, external data, regulatory and compliance information among others. To build an efficient automated contract intelligence system these antecedents provide the required building blocks. The factors or the antecedents identified through analysis includes internal contract documents. This will require inputs from various data sources including the past and current contract papers and legal databases. These may be collated and stored in a central repository. These datasets will provide information on legal requirements, compliance requirements particular to the sector, and contractual duties (Hadi et al., 2023; Mökander et al., 2023).

**Figure 11. ADO framework for theme one**
*(Source(s): Authors' own work)*



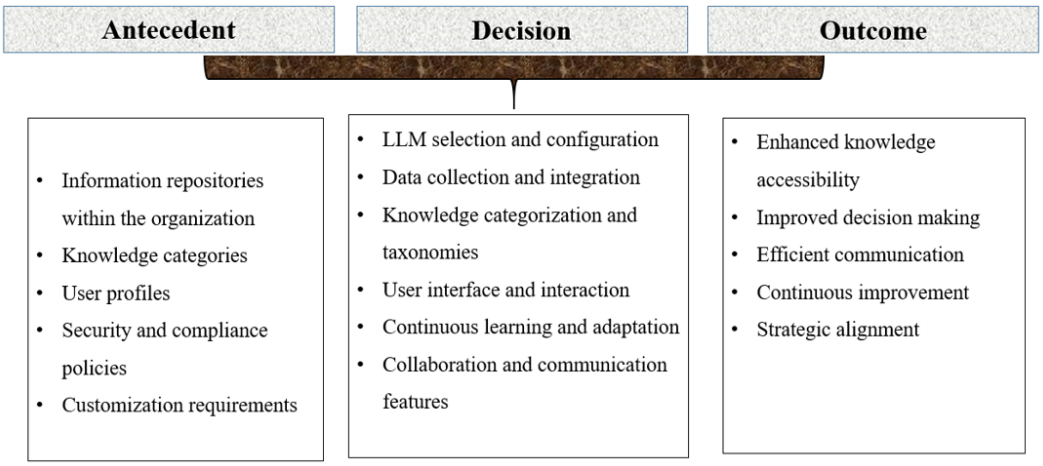
Another important factor or antecedent captured in the framework is the external market data along with the regulatory and compliance information which gives the understanding of the market trends, economic conditions and the industry dynamics this is crucial aspect in decision making (Mökander et al., 2023; Eloundou et al., 2023). Therefore, to develop an automated contract intelligence system, these antecedents play a critical role which has also to be consistent with organization objective and technical capabilities (Mökander et al., 2023; Eloundou et al., 2023; Wong et al., 2023). Additionally, financial reductions in the area of legal and contract management procedures are achieved; improved turnaround times indicate increased contract management efficiency; strong user training and intuitive user interfaces promote user happiness; and user input and performance evaluations drive the iterative process of continual improvement, which keeps the system honed and optimized. The final step in achieving strategy alignment is to ensure that contract intelligence activities are aligned with organizational priorities. The ADO framework, in its entirety, provides a methodical approach to the installation and assessment of automated contract intelligence systems that contain LLMs, assuring the achievement of expected outcomes while fitting with organizational goals (Tian et al., 2023).

## Theme Two: LLM-Driven Supply Chain Knowledge Management

The second theme embodies the application of advanced LLMs, such as GPT-3, in the realm of knowledge management specific to supply chain and logistics. This theme predominantly centers on harnessing the potential of LLMs to facilitate the acquisition, organization, and application of knowledge within the context of supply chain operations. Key facets of this theme encompass knowledge extraction, cataloguing, and storage; decision support and insights; collaboration and expertise sharing; and data-driven optimization. The ADO framework for this theme is depicted in Figure 12.

This themes focuses on the significance of capturing data and knowledge from various sources including internal and external knowledge repositories. By collating the data and integrating the LLMs into the supply chain knowledge management system and building effective knowledge retrieval systems will result in organizations making informed decisions. This will also initiate efficient collaboration among various stakeholders which was earlier not feasible due to a lack of data and information sharing. By capitalizing on the capabilities of LLMs, organizations can enhance their management of supply chain knowledge, retain competitiveness, and navigate the ever-evolving landscape of SCM more adeptly.[9]

**Figure 12. ADO framework for theme two**
*(Source: Authors' own work)*



The ADO paradigm offers a guide for LLM-driven supply chain knowledge management. It involves thinking about things such as data sources, which include both internal and external data streams, as well as market reports and communication channels, in the antecedent phase. To simplify information organization and satisfy various user demands, it is necessary to employ user profiles and organized knowledge categories. To protect sensitive supply chain data, it is also essential to have strong security and compliance rules. The system must be customized to fit the organization's particular supply chain scenario. The path to a complete LLM-enabled supply chain knowledge management system is paved by these fundamental components. Several important decisions are made during the framework's decision-making phase. The LLM's selection and configuration are crucial; they entail selecting the best LLM for understanding supply chain data and configuring it to meet certain organizational requirements (Mökander et al., 2023). Additionally, choices are made about data collection and integration, such as the choice of data sources to be combined and the frequency of data collection. How supply chain insights are categorized, tagged, and organized inside the system is guided by the structure of knowledge categorization and taxonomies. An intuitive and user-friendly interaction experience is what user interface design and the implementation of natural language search capabilities strive to provide. Real-time information on crucial supply chain events is made possible by the installation of an alerting and notification system (Ivanov & Dolgui, 2022).

Decisions on customization and tailoring determine how the system will change to satisfy the particular supply chain requirements of the organization. Decisions address security issues and specify how confidential information will be handled to guarantee data security and compliance. Additionally, methods for ongoing learning and adaptation are developed, allowing the system to change in response to user interactions and shifting supply chain conditions. There also needs to be seamless collaboration and communication between the various stakeholders in the supply chain for efficient teamwork and sharing of information. These are the important drivers in implementing an LLM-driven supply chain knowledge management system in an organization which is in tandem with the organizational objectives (Mikhailov, 2023).

LLM-enabled supply chain knowledge management has the potential to improve decision-making and provide useful insights as it captures and stores the relevant supply chain data thereby improving supply chain knowledge accessibility (Ganesh & Kalpana, 2022). The insights drawn can aid in developing effective strategies which will help produce significant outcomes for the organization[10]. The data captured will also aid in preempting any possible hazard or risk thereby, taking proactive measures to mitigate the risk. This will result in a risk minimization outcome.

Another important result is compliance assurance, which guarantees constant adherence to supply chain-related laws and compliance standards while reducing operational and legal risks. Additionally, it results in cost savings through efficiency improvements and well-informed decision-making. Additionally, user-friendly interfaces and automatic report summaries foster effective cooperation and improve communication among supply chain workers. Based on feedback and performance assessments, the system continually develops and improves itself to maintain relevance and effectiveness. Ultimately, it will advance the organization's mission by coordinating supply chain activities with organizational aims and objectives. The ADO framework provides the necessary structure and guidance to ensure that LLM-enabled supply chain knowledge management is not only well-implemented but also capable of delivering the desired outcomes, serving as a valuable roadmap for organizations that aim to harness the potential of LLMs for improved decision-making, efficient risk mitigation, and significant cost reductions in SCM.

### Theme Three: LLM-Driven Supply Chain Risk and Security Management

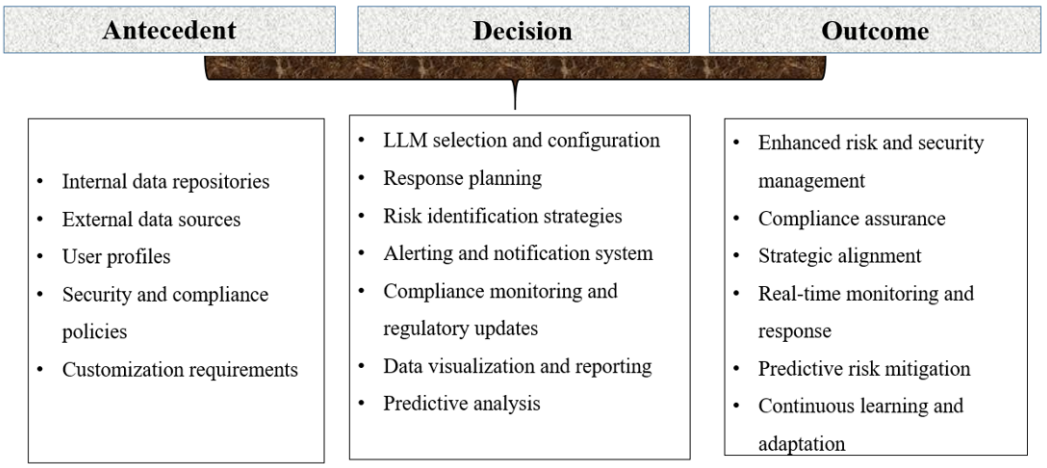
The third theme signifies the use of advanced LLMs, such as GPT-3, to enhance and fortify risk assessment and security measures within the realm of SCM. The antecedents in the supply chain risk and security management's ADO framework will be the internal and external data sources comprising historical contract data, supplier performance records, past risk incidents, identified vulnerabilities,

industry-specific risk assessments, and global market shifts among others. By integrating LLM into the supply chain risk and security management system will help identify the potential risks and take necessary corrective measures. Thus, LLM capabilities empower organizations to draw insights from the input data and handle supply chain risks, enhancing security policies adeptly. This will facilitate effective decision-making and avert crises (Richey et al., 2023). This will revitalize the SCM resilience in the face of potential challenges and threats. The ADO framework for this theme is depicted in Figure 13.

The ADO framework provides a structured way to conduct and evaluate LLM-driven supply chain risk and security management. The antecedent phase, includes a wide range of internal and external data sources that allow the system to access historical data, market reports, news sources, and real-time data streams. The user profiles of the employees working with the LLM system will include the compliance officials, security teams and supply chain managers (Barrett et al., 2023). This will lead to the implementation of a robust security and compliance policy which will ensure the effective handling of the sensitive data (Mikhailov, 2023). Further, customization may be provided in the supply chain and security environment as per the requirement of the organization enabling a customized solution (Mikhailov, 2023).

Decision phase includes the availability of various informed choices based on the antecedents. The decisions will center around risk mitigation and strategy formulation. The first and foremost decision is to select and implement the right LLM solution for catering to the organizational needs (Bi et al., 2013). This phase also defines the policy for data collection frequency, identifying the relevant data sources and the integration techniques. The defined risk identification methodologies, which use criteria to identify possible supply chain hazards and security threats using keywords, patterns, and contextual clues, are equally crucial. An alert and notification process is appended to the system to provide real time alerts and notifications to take effective decisions to avert risks. Predictive analytics based on the historical data will be able to proactively anticipate the risks thereby, allowing necessary actions to be taken to handle the situation. It also trains the system on response planning which generates plans in case of any eventuality. Data visualization and reporting tools aid in effective decision-making about active monitoring and regulatory adaptation which are driven by compliance and regulatory concerns. Therefore, the LLM-driven supply chain risk and security management system develops effective risk mitigation strategies along with appropriate security measures to guard against any possible supply chain threats.

**Figure 13. ADO framework for theme three**
*(Source: Authors' own work)*

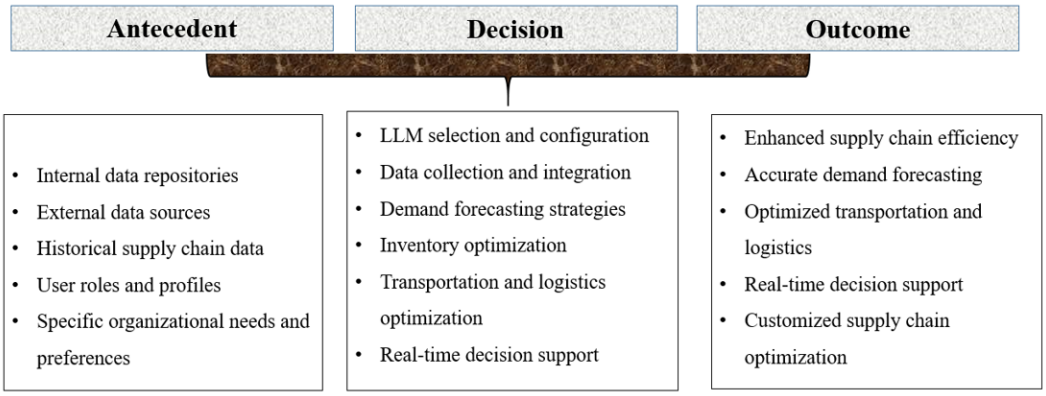


Implementing LLM-integrated supply chain risk and security management will lead to significant and positive results (Singla et al., 2023). Implementing an appropriate risk mitigation strategy results in improved supply chain risk and threat detection. Also, adherence to regulatory standards reduces legal and operational risks (Singla et al., 2023). Through predictive analysis, predictive risk mitigation assists in foreseeing and managing hazards before they reach critical levels (Singla et al., 2023; Mikhailov, 2023). In the outcome phase, the assessment of the risk mitigation strategy is performed. This phase will give an insight into the strategies that worked and if there were any gaps in the strategy that need to be addressed. Further, the results of the real-time monitoring and response system will be analyzed to check the efficiency of the system. The ongoing learning and adaptation will lead to the system's improvement over time. The ADO framework will help strengthen the organization's supply chain security and resilience by implementing a risk management strategy leading to compliance assurance, and cost reduction. It provides the necessary structure and guidance to ensure the successful implementation of LLM-enabled supply chain risk and security management.

## Theme Four: LLM-Driven Supply Chain Optimization

The ADO paradigm offers a formal framework for LLM-enabled supply chain optimization including antecedents like data sources, which include internal repositories that contain inventory data, order records, and supplier information, as well as outside sources such as market reports, weather predictions, and traffic data (Wang et al., 2023a). Historical supply chain data aid in developing benchmarks and promoting trends. The organization's objective generally includes cost reduction, speedy delivery and enhanced inventory management all of which aim to optimize the supply chain. As discussed in the previous themes, people who will be assigned to interact with the system will be the supply chain managers, logistics professionals, and procurement officers who will be included in the user profiles. LLM-enabled supply chain optimization system can increase the supply chain efficiency leading to cost reduction and enhancement of the overall performance. The system leads to accurate demand forecasting, inventory levels are optimized, carrying costs are decreased, and cost-effectiveness is increased (Wang et al., 2023a). The system allows customization to include specific organizational needs and preferences. The LLM enables streamlining of operations by optimizing the transportation and logistics processes thereby, leading to faster delivery and decreased transportation cost. The system also facilitates preparation to deal with emergencies due to the availability of data resulting in efficient risk mitigation. Real-time decision support helps organizations to become more resilient by enabling them to act quickly and wisely in the face of supply chain difficulties and interruptions. The ADO framework for this theme is depicted in Figure 14.

**Figure 14. ADO framework for theme four**
*(Source: Authors' own work)*



In the decision-making phase of the ADO framework for LLM enabled supply chain optimization, choosing the right LLM, its configuration and implementation plays a crucial role. This leads to efficient analysis of supply chain data pertaining to specific optimization goal. Further selecting the appropriate data sources, frequency of collection and consolidation are included in the decision-making process. The system provides efficient demand forecasting, optimized inventory management, and transportation and logistics optimization which leads to improved cost effectiveness and delivery dates. The external variables play a significant role in minimizing supply chain risks, the LLM-enabled system aids in the process by collating both internal and external data. The adoption of real-time decision support systems leads to efficient decision making offering prompt solutions for handling supply chain difficulties. The integration of process automation improves overall efficiency by streamlining regular operations and workflows. Thus the above decision choices lead to an effective LLM-enabled supply chain optimization system aligned to organizational goals and objectives.

The output phase of the ADO framework assesses the impact of the supply chain optimization system. This phase evaluates the efficiency of the various optimization processes such as the accuracy of the demand forecasting system, optimized transportation and logistics process, and real-time decision support system. The assessment will lead to identifying the gaps and improving the overall system. Therefore, implementing an LLM-enabled supply chain optimization system prepares organizations to flourish in a dynamic and highly competitive market.

## DISCUSSION

### Theoretical Implications

The introductory section poses two research questions that seek to address potential input variables, explain how these inputs contribute, and offer theoretical background for model formulations.

The research question RQ1: "What are the prevalent applications of LLM in the supply chain domain, and what are the key thematic areas of utilization?" is intended to reveal the current status of LLM in the context of the supply chain domain. RQ1 extensively investigate the application of LLM within the supply chain from various perspective including users, developers and managers. Understanding the significance of various input factors such as LLM capabilities, financial concerns for developing technical infrastructure to implement LLM within the supply chain and aligning the LLM capabilities within the supply chain is explored in this analysis. Making ethical judgments about input components in the establishment of theoretical frameworks for the use of LLM within the supply chain requires an understanding of the features of LLM and related advantages and how these can be mapped with various stages of the supply chain. Through an extensive synopsis of users' viewpoints, exploring the current status of LLM within the supply chain and the state of the field's research, RQ1 offers a theoretical basis. The second research question RQ2: "What are the antecedents, decisions, and outcomes linked to each application theme of LLM in the supply chain? Additionally, what are the prospective research trajectories in this domain?" investigates the emergence and role of LLM within supply chain processes, explores the important factors, and possible solutions connected to each themes found in the implementation of LLM within supply chain. The ADO framework that we have derived helps to explore the factors that precede the implementation of LLM within supply chain processes and some of the factors identified by the analysis are technological readiness, organizational culture, and data availability. The decision component of the ADO framework helps in selecting the features of LLM and mapping them within the supply chain for specific tasks. The outcome factor helps to measure the impact of LLM within the supply chain and improves the overall supply chain performance.

Our approach to reviewing the literature on the use of LLMs in SCM served two crucial purposes. First, we used NLP tools to analyze the discussion on the use of LLMs in the SCM literature, extracting valuable themes and insights (Srivastava & Bag, 2023). These themes significantly enhanced our understanding of current research and the complexities of the topic. Second, unlike most

reviews, which have relied heavily on scholarly research, our study took a more inclusive approach by integrating data from social media platforms such as Twitter, LinkedIn, blogs, and forums. By including social media data, this study accessed the latest challenges, benefits, and perspectives in the use of LLMs in the SCM domain, particularly those from industry experts. These findings not only built on existing literature reviews but also provided frameworks essential for each theme. They offer possible opportunities and help to understand constraints in the integration of LLMs into supply chain processes. Additionally, our study advances the theoretical foundations of the literature review process by introducing an innovative approach to the use of data triangulation.

## Managerial Implications

This study used data triangulation methodology and based on the analysis provides useful insights on LLMs integration in the SCM. The study identified four themes which are presented in Figure 10. The themes have been presented using the ADO framework which gives a detailed understanding of the various themes. These themes can be used by managers to understand the opportunities and challenges of implementing LLM in various supply chain activities.

The "LLM-driven automated contract intelligence" theme provides insights into the contract management process in supply chain operations. This can be used by managers to optimize the process of contract management. The insights drawn from the study can aid the managers in the following ways. Firstly, LLMs can automate and optimize contract-related processes in supply chain activities. They aid in data mining, classification, and analysis of contract clauses and the associated guidelines. This helps the managers to automate the contract creation process. It also facilitates the updating of the existing contracts. This results in accurate contracts that meet the required compliances. Secondly, an LLM-based system enables managers to access real-time data and gain insights into contract-related information facilitating effective decisions about supply chain trends. This will enhance the contract management activity thereby, optimizing supply chain operations. Finally, collaboration with legal experts and contract management specialists is important for the optimized working of the contract management system. This can be seamlessly integrated into LLM's contract management system making the system more effective. This integration will streamline contract management activity. This in turn improves the efficiency of the process and reduces the scope of errors. Thus, LLM integration in the contract management process allows managers to draw insights from the data and identify potential risks and opportunities in real-time (Wong et al., 2023).

"LLM-driven supply chain knowledge management," theme provides insights into knowledge management aspects related to supply chain operations. This theme highlights the identification and capture of knowledge from various sources including contracts and regulations along with historical reports by integrating LLMs. Supply chain managers can draw insights from this knowledge extracted. This theme can help the managers in the following ways. Firstly, LLMs can mine a vast amount of data including structured and unstructured data and provide useful actionable insights to the managers aiding informed decision-making (Fernandez et al., 2023). This will also support managers to develop effective strategies related to supply chain activities. Secondly, LLMs allow easy knowledge dissemination thereby, promoting knowledge sharing among various stakeholders in the supply chain domain and leading to strategic collaboration. LLM integration can further foster a culture of knowledge sharing within the organization promoting the exchange of expertise and knowledge. The LLM-based supply chain knowledge management system enhances productivity by providing fast and real-time access to the required information, thus streamlining workflows. Finally, integrating LLMs promotes a culture of continuous learning and sharing, which results in optimizing the supply chain leading to organizational growth.

Supply chain operations are exposed to various risks and security threats that can bring about supply chain disruption. The "LLM-driven supply chain risk and security management," theme provides managers with an opportunity to identify and mitigate the risk in real-time. LLM

integration will help the managers in the following ways. Firstly, the vast amount of data allows LLM systems to predict and monitor potential risks and the insights drawn from the analysis of data facilitate risk mitigation. Diverse data sources including internal and external data sources, environmental factors, and market trends can be analyzed by LLM based system. This allows the system to preempt and notify possible disruptions allowing managers to take swift action. Secondly, LLM can do real-time tracking and monitoring of security threats thereby, providing mechanisms to mitigate the threats, protect the sensitive data and safeguard the supply chain operations. Real-time insights enable timely and informed decisions to be made, challenges to be effectively addressed, and their impact to be minimized. The integration of LLMs into risk and security management provides supply chains resilience. Finally, These models offer valuable insights into risk factors and vulnerabilities, thereby enabling organizations to establish more robust and flexible supply chain networks. LLMs also facilitate the monitoring and enforcement of regulatory compliance, which is a pivotal aspect of risk and security management. Achieving the effective implementation of LLMs necessitates close collaboration with data scientists and cybersecurity experts.

The "LLM-driven supply chain optimization," theme enables managers to optimize supply chain operations. Firstly, LLMs can analyse the vast amount of structured and unstructured data along with the past historical data to provide insights leading to effective demand forecasting (Yang et al., 2023b). Secondly, by enabling real time data LLM helps in accurate predictions thereby, leading to optimized inventory management. Finally, LLMs facilitate the real-time optimization of delivery routes. This helps in minimizing transportation costs factoring various constraints such as traffic conditions and weather forecasts. Also, by evaluating supplier performance, costs, and reliability (Yang et al., 2023a) LLMs empower managers in supplier selection and contract negotiations.

Early Integration of LLMs into supply chain activities of any organization will provide a competitive advantage. The benefits in capturing and processing of vast amount of real time data will enable responsive supply chain management system. This will make the organization agile and effective in supply chain operations. Further, investment in AI technology and hiring or collaborating with data scientist is critical for the success of such an initiative.

## CONCLUSION

This comprehensive study conducted an extensive literature analysis to investigate previous research on LLM usage in SCM and to identify relevant topics and themes. The study employed a triangulation approach, incorporating data from diverse sources such as peer-reviewed articles as well as social media platforms, including Twitter, LinkedIn, blogs, forums, and industry reports. The dataset comprised 33 peer-reviewed articles and over 3,400 discussions, expert opinions, and articles shared by SCM specialists across various social media platforms. Figure 10 visually presents the final themes derived from this amalgamated dataset.

Furthermore, this study systematically addressed two research questions. RQ1 was as follows: "What are the prevalent applications of LLM in the supply chain domain, and what are the key thematic areas of utilization?". This question was addressed by identifying themes using both published literature and data from social media platforms, such as Twitter, LinkedIn, blogs, industry reports, and forums. RQ2 was as follows: "What are the antecedents, decisions, and outcomes linked to each application theme of LLM in the supply chain? Additionally, what are the prospective research trajectories in this domain?". To address this question, this study formulated an ADO framework for each theme in the fourth section and highlighted future research directions in the seventh section. A noteworthy observation is the prevalent focus of social media discussions on LLMs' role in creating a more ethical, transparent, and trustworthy supply chain, while published literature has predominantly delved into tools and algorithm-related issues.

## LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

The themes of "LLM-driven automated contract intelligence," "LLM-driven supply chain knowledge management," "LLM-driven supply chain risk and security management," and "LLM-driven supply chain optimization" are closely interconnected, representing various aspects of SCM. These themes work like a orchestra to enhance the overall efficiency and effectiveness of supply chains.

For instance, LLM-driven automated contract intelligence (Theme 1) simplifies contract management and contributes to improved supply chain optimization (Theme 4). Moreover, LLM-driven supply chain knowledge management (Theme 3) complements risk and security management (Theme 3) by offering crucial insights and data for well-informed decision-making, particularly in the demesne of risk management. Furthermore, all of these themes pivot on data and information. LLM-driven supply chain knowledge management (Theme 2) concentrates on effective data and knowledge management, which is critical for risk assessment and mitigation (Theme 3) and the optimization of supply chain processes (Theme 4). These interrelated themes explore the potential, threats, challenges, and technical requirements for the successful implementation of LLMs in SCM. They can serve as input or output factors for future research, enabling the exploration of linear or nonlinear relationships. Empirical validation through case studies is an avenue for future research. More explicitly, the future research directions based on each theme are provided in Table 5.

As the use of LLM in business are increasing specially from Gen-AI side, it offers both opportunity and challenges to supply chain managers (Buthelezi et al., 2021). Since this study has dealt with secondary data only, to explore the issues of implementation, future research can collect primary data also from various stakeholders to deepen their comprehension and opinion. Primary data would provide a clearer perspective of stakeholders and may help in enhancing the generalizability of the outcome of this study.

**Table 5. Future research directions for each theme**

| Themes | Future Research Directions |
|---|---|
| LLM-driven automated contract intelligence | This theme paves the way for future research aimed at enhancing and broadening LLM potential in contract analysis and automation. Subsequent studies may delve into methods for improving the precision and effectiveness of contract review, the identification of potential risks, and the automation of everyday contract-related tasks. Moreover, research within this domain can explore the legal and practical consequences associated with the growing reliance on automated contract intelligence. |
| LLM-driven supply chain knowledge management | The future researcher may investigate and develop adoption models for LLM in knowledge management within the supply chain. Also, the researcher may work on tools and techniques which can effectively extend the essential knowledge of the supply chain process to each actor of the supply chain using LLM. |
| LLM-driven supply chain risk and security management | The future researcher may develop a model which can measure and mitigate supply chain risks using LLM. Also using these models, research may also like to investigate significances of AI-informed decision-making on supply chain security. Another important area where future researchers can delve into the legal and ethical considerations for LLM-driven risk management in supply chain processes. |
| LLM-driven supply chain optimization | Future researchers could focus on leveraging the features of LLM to optimize supply chain operations. Also, researchers may investigate how business can use LLM with AI to enhance demand forecasting, inventory management, and logistics optimization. Another important area is about managing the legal and compliance related issues in use of LLM within supply chain. |

(Source: Authors' own compilation)

## CONFLICT OF INTEREST

The authors declare that they have no known financial or personal interests which can impact the work presented in this study.

## FUNDING

This study did not receive any grant from a funding agency in the public, commercial, or not-for-profit sectors.

## REFERENCES

AlZu'bi, S., Mughaid, A., Quiam, F., & Hendawi, S. (2022). Exploring the Capabilities and Limitations of ChatGPT and Alternative Big Language Models Artificial Intelligence and Applications. *OJS*. 10.47852/bonviewAIA3202820

Bag, S., Rahman, M. S., Rogers, H., Srivastava, G., & Pretorius, J. H. C. (2023). Climate change adaptation and disaster risk reduction in the garment industry supply chain network. *Transportation Research Part E, Logistics and Transportation Review*, *171*, 103031. doi:10.1016/j.tre.2023.103031

Belhadi, A., Kamble, S. S., Venkatesh, M., Jabbour, C. J. C., & Benkhati, I. (2022). Building supply chain resilience and efficiency through additive manufacturing: An ambidextrous perspective on the dynamic capability view. *International Journal of Production Economics*, *249*, 108516. doi:10.1016/j.ijpe.2022.108516

Bi, R., Davidson, R., Kam, B., & Smyrnios, K. (2013). Developing organizational agility through IT and supply chain capability. [JGIM]. *Journal of Global Information Management*, *21*(4), 38–55. doi:10.4018/jgim.2013100103

Buthelezi, B. E., Ndayizigamiye, P., Twinomurinzi, H., & Dube, S. M. (2021). A systematic review of the adoption of blockchain for supply chain processes. [JGIM]. *Journal of Global Information Management*, *30*(8), 1–32. doi:10.4018/JGIM.297625

Chatterjee, S., Chaudhuri, R., Gupta, S., Sivarajah, U., & Bag, S. (2023). Assessing the impact of big data analytics on decision-making processes, forecasting, and performance of a firm. *Technological Forecasting and Social Change*, *196*, 122824. doi:10.1016/j.techfore.2023.122824

Chowdhury, M., Rifat, N., Latif, S., Ahsan, M., Rahman, M. S., & Gomes, R. (2023, May). ChatGPT: The Curious Case of Attack Vectors' Supply Chain Management Improvement. *2023 IEEE International Conference on Electro Information Technology (eIT)* (pp. 499-504). IEEE. doi:10.1109/eIT57321.2023.10187385

Cortez, R. M., Johnston, W. J., & Dastidar, A. G. (2023). Managing the content of LinkedIn posts: Influence on B2B customer engagement and sales? *Journal of Business Research*, *155*, 113388. doi:10.1016/j.jbusres.2022.113388

De Bock, K. W., Coussement, K., De Caigny, A., Slowiński, R., Baesens, B., Boute, R. N., & Weber, R. (2023). Explainable AI for Operational Research: A Defining Framework, Methods, Applications, and a Research Agenda. *European Journal of Operational Research*. doi:10.1016/j.ejor.2023.09.026

Dubey, V. K., Chavas, J. P., & Veeramani, D. (2018). Analytical framework for sustainable supply-chain contract management. *International Journal of Production Economics*, *200*, 240–261. doi:10.1016/j.ijpe.2018.03.003

Fernandez, R. C., Elmore, A. J., Franklin, M. J., Krishnan, S., & Tan, C. (2023). How Large Language Models Will Disrupt Data Management. *Proceedings of the VLDB Endowment International Conference on Very Large Data Bases*, *16*(11), 3302–3309. doi:10.14778/3611479.3611527

Frederico, G. F. (2023). ChatGPT in Supply Chains: Initial Evidence of Applications and Potential Research Agenda. *Logistics*, *7*(2), 26. doi:10.3390/logistics7020026

Ganesh, A. D., & Kalpana, P. (2022). Future of artificial intelligence and its influence on supply chain risk management–A systematic review. *Computers & Industrial Engineering*, *169*, 108206. doi:10.1016/j.cie.2022.108206

Gill, S. S., Xu, M., Ottaviani, C., Patros, P., Bahsoon, R., Shaghaghi, A., & Uhlig, S. (2022). AI for Next-Generation generation computing: Emerging trends and future Directions. *Internet of Things : Engineering Cyber Physical Human Systems*, *19*, 100514. doi:10.1016/j.iot.2022.100514

Hardeniya, N., Perkins, J., Chopra, D., Joshi, N., & Mathur, I. (2016). *Natural Language Processing: python and NLTK*. Packt Publishing.

Hazen, B. T., Boone, C. A., Ezell, J. D., & Jones-Farmer, L. A. (2014). Data quality for data science, predictive analytics, and big data in supply chain management: An introduction to the problem and suggestions for research and applications. *International Journal of Production Economics*, *154*, 72–80. doi:10.1016/j.ijpe.2014.04.018

Hendriksen, C. (2023). AI for Supply Chain Management: Disruptive Innovation or Innovative Disruption? *The Journal of Supply Chain Management*. doi:10.1111/jscm.12304

Hu, Y. H., Tai, C. T., Liu, K. E., & Cai, C. F. (2020). Identification of highly-cited papers using topic-model-based and bibliometric features: Consideration of keyword popularity. *Journal of Informetrics*, *14*(1), 101004. doi:10.1016/j.joi.2019.101004

Ivanov, D., & Dolgui, A. (2022). Stress testing supply chains and creating viable ecosystems. *Operations Management Research : Advancing Practice Through Research*, *15*(1-2), 475–486. doi:10.1007/s12063-021-00194-z

Jacobs, F. R., Chase, R. B., & Lummus, R. R. (2014). *Operations and supply chain management*. McGraw-Hill/Irwin.

Just, J. (2024). Natural language processing for innovation search–Reviewing an emerging non-human innovation intermediary. *Technovation*, *129*, 102883. doi:10.1016/j.technovation.2023.102883

Kache, F., & Seuring, S. (2017). Challenges and opportunities of digital information at the intersection of Big Data Analytics and supply chain management. *International Journal of Operations & Production Management*, *37*(1), 10–36. doi:10.1108/IJOPM-02-2015-0078

Kar, A. K., Varsha, P. S., & Rajan, S. (2023). Unravelling the Impact of Generative Artificial Intelligence (GAI) in Industrial Applications: A Review of Scientific and Grey Literature. *Global Journal of Flexible Systems Management,* 1-31. 10.1007/s40171-023-00356-x

Kumar, A., Gupta, N., & Bapat, G. (2023). Who is making the decisions? How retail managers can use the power of ChatGPT. *The Journal of Business Strategy*. doi:10.1108/JBS-04-2023-0067

Lambert, D. M., & Cooper, M. C. (2000). Issues in supply chain management. *Industrial Marketing Management*, *29*(1), 65–83. doi:10.1016/S0019-8501(99)00113-3

Mohamed Shaffril, H. A., Samsuddin, S. F., & Abu Samah, A. (2021). The ABC of systematic literature review: The basic methodological guidance for beginners. *Quality & Quantity*, *55*(4), 1319–1346. doi:10.1007/s11135-020-01059-6

Mökander, J., Schuett, J., Kirk, H. R., & Floridi, L. (2023). Auditing large language models: A three-layered approach. *AI and Ethics*, 1–31. doi:10.1007/s43681-023-00289-2

Muninger, M. I., Mahr, D., & Hammedi, W. (2022). Social media use: A review of innovation management practices. *Journal of Business Research*, *143*, 140–156. doi:10.1016/j.jbusres.2022.01.039

Mustak, M., Salminen, J., Ple, L., & Wirtz, J. (2021). Artificial intelligence in marketing: Topic modeling, scientometric analysis, and research agenda. *Journal of Business Research*, *124*, 389–404. doi:10.1016/j.jbusres.2020.10.044

Oliveira, E. E., & Pereira, T. (2023, September). A New Generation? A Discussion on Deep Generative Models in Supply Chains. In *IFIP International Conference on Advances in Production Management Systems* (pp. 444-457). Cham: Springer Nature Switzerland. doi:10.1007/978-3-031-43662-8_32

Paul, J., & Benito, G. R. (2018). A review of research on outward foreign direct investment from emerging countries, including China: What do we know, how do we know and where should we be heading? *Asia Pacific Business Review*, *24*(1), 90–115. doi:10.1080/13602381.2017.1357316

Paul, J., & Criado, A. R. (2020). The art of writing literature review: What do we know and what do we need to know? *International Business Review*, *29*(4), 101717. doi:10.1016/j.ibusrev.2020.101717

Richey, R. G. Jr, Chowdhury, S., Davis-Sramek, B., Giannakis, M., & Dwivedi, Y. K. (2023). Artificial intelligence in logistics and supply chain management: A primer and roadmap for research. *Journal of Business Logistics*, *44*(4), 532–549. Advance online publication. doi:10.1111/jbl.12364

Russell, M. A. (2011). *Mining the social web: analyzing data from Facebook, Twitter, LinkedIn, and other social media sites*. O'Reilly Media.

Sayed, M. A., Braşoveanu, A. M., Nixon, L. J., & Scharl, A. (2023, June). Unsupervised Topic Modeling with BERTopic for Coarse and Fine-Grained News Classification. In *International Work-Conference on Artificial Neural Networks* (pp. 162–174). Springer Nature Switzerland. doi:10.1007/978-3-031-43085-5_13

Shrivastav, M. (2021). Barriers related to AI implementation in supply chain management. [JGIM]. *Journal of Global Information Management*, *30*(8), 1–19. doi:10.4018/JGIM.296725

Shrivastava, S. (2023). Recent trends in supply chain management of business-to-business firms: A review and future research directions. *Journal of Business and Industrial Marketing*, *38*(12), 2673–2693. doi:10.1108/JBIM-02-2023-0122

Srivastava, S. K., & Bag, S. (2023). Recent Developments on Flexible Manufacturing in the Digital Era: A Review and Future Research Directions. *Global Journal of Flexible Systems Management*, 1-34. 10.1007/s40171-023-00351-2

Stadler, H. (2008). *Supply chain management—an overview in Supply Chain Management and Advanced Planning* (H. Stadler & C. Kilger, Eds.). Springer-Verlag. doi:10.1007/978-3-540-74512-9

Swain, A. K., & Cao, R. Q. (2019). Using sentiment analysis to improve supply chain intelligence. *Information Systems Frontiers*, *21*(2), 469–484. doi:10.1007/s10796-017-9762-2

Tian, Y., Li, X., Zhang, H., Zhao, C., Li, B., Wang, X., Wang, F. Y., & Wang, F.-Y. (2023). VistaGPT: Generative Parallel Transformers for Vehicles with Intelligent Systems for Transport Automation. *IEEE Transactions on Intelligent Vehicles*, *8*(9), 4198–4207. doi:10.1109/TIV.2023.3307012

Trappey, A. J., Chang, A. C., Trappey, C. V., & Chien, J. Y. C. (2022). Intelligent RFQ summarization uses natural language processing, text mining, and machine learning techniques. [JGIM]. *Journal of Global Information Management*, *30*(1), 1–26. doi:10.4018/JGIM.309082

Tsai, S. B., Wu, C. H., & Mou, J. (2023). Theme issue on emerging advances in ubiquitous artificial intelligence: Trends, challenges, and future research directions. *Personal and Ubiquitous Computing*, *1-2*(4), 1453–1454. doi:10.1007/s00779-023-01715-2 PMID:36778528

Wahid, J. A., Shi, L., Gao, Y., Yang, B., Wei, L., Tao, Y., & Yagoub, I. (2022). Topic2Labels: A framework to annotate and classify social media data through LDA topics and deep learning models for crisis response. *Expert Systems with Applications*, *195*, 116562. doi:10.1016/j.eswa.2022.116562

Waller, M. A., & Fawcett, S. E. (2013). Data science, predictive analytics, and big data: A revolution that will transform supply chain design and management. *Journal of Business Logistics*, *34*(2), 77–84. doi:10.1111/jbl.12010

Wamba, S. F., Queiroz, M. M., Jabbour, C. J. C., & Shi, C. V. (2023). Are both generative AI and ChatGPT game changers for 21st-Century operations and supply chain excellence? *International Journal of Production Economics*, *265*, 109015. doi:10.1016/j.ijpe.2023.109015

Wang, H., Liu, M., & Shen, W. (2023b). Industrial-generative pre-trained transformer for intelligent manufacturing systems. *IET Collaborative Intelligent Manufacturing*, *5*(2), e12078. doi:10.1049/cim2.12078

Wang, X., Anwer, N., Dai, Y., & Liu, A. (2023c). ChatGPT for design, manufacturing, and education. *Procedia CIRP*, *119*, 7–14. doi:10.1016/j.procir.2023.04.001

Wang, Y., Rod, M., Deng, Q., & Ji, S. (2021). Exploiting business networks in the age of social media: The use and integration of social media analytics in B2B marketing. *Journal of Business and Industrial Marketing*, *36*(12), 2139–2149. doi:10.1108/JBIM-05-2019-0173

Williamson, K., & Johanson, G. (Eds.). (2017). *Research Methods: Information, Systems, and Contexts*. Chandos Publishing.

Xu, J., Pero, M., & Fabbri, M. (2023). Unfolding the link between big data analytics and supply chain planning. *Technological Forecasting and Social Change*, *196*, 122805. doi:10.1016/j.techfore.2023.122805

## ENDNOTES

1 https://huggingface.co/papers/2307.03875
2 https://www.sap.com/india/products/spend-management/supplier-risk.html
3 https://www.coupa.com/blog/coupa-news-culture/coupa-acquires-llamasoft-connect-ai-powered-supply-chain-spend-management
4 https://www.gep.com/software/gep-smart
5 How will Large Language Models impact supply chains? by Ralf W. Seifert, Richard Markoff, 17 May 2023, https://www.imd.org/ibyimd/supply-chain/large-language-model-impacts-on-supply-chain/
6 https://blog.dataiku.com/generative-ai-use-cases-in-supply-chain
7 https://indatalabs.com/blog/chatgpt-in-retail-supply-chain
8 https://www.scmdojo.com/chatgpt-supply-chain/
9 https://www.imd.org/ibyimd/supply-chain/large-language-model-impacts-on-supply-chain/
10 https://www.course5i.com/blogs/democratization-of-supply-chain-insights-using-llm/