THE APPLICATIONS OF ARTIFICIAL INTELLIGENCE IN SUPPLY CHAIN PROJECT MANAGEMENT: A SURVEY

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Abstract: This paper reviews the articles that address the use of artificial intelligence (AI) within the management of supply chain projects. The focus is on investigating AI's possible applications and benefits in project planning and execution. SCOPUS database is used to cover highly ranked scientific papers. The review concludes that AI connected supply chain projects were undertaken mainly in North America and Southeast Asia. AI offers excellent opportunities to increase the chance of achieving project targets. However, there is still a greater need for profound academic research on the use of AI in project management, emphasizing supply chain requirements within the serial production industry.

Keywords: artificial intelligence, supply chain management, project management, procurement, logistics

JEL Classification: M10

1. Introduction

Today in all sectors, businesses are operating in dynamic environments and observing rapid changes in the technologies that they have been using. Many companies have started transforming the processes by using new digital technologies. In this regard, Artificial intelligence (AI) offers great opportunities to support managerial decision-making and improve business operations' effectiveness and efficiency. Sharda et al. (2019) defines the principal goal of AI as developing machines that "can do reasoning, thinking, learning, and problem solving....". In academia, there is a high interest in AI research projects. The number of AI studies and published papers have been increasing rapidly. After a period of slow growth between 2010 and 2015, the number of articles increased by 150% between 2015 to 2021 (Zhang et al., 2022). The number of literature reviews published on AI use has also considerably increased along with that increase. Up to 2018, 1,544 systematic reviews have been published on either empirical studies or AI techniques (Cubric, 2020). Especially in Supply Chain Management (SCM), many papers have been published, especially on big data in SCM (Wang et al., 2016; Arunachalamet al., 2018; Roßmann et al., 2018; Oncioiu et al., 2019; Chakroun, et al., 2019). A tremendous amount of unstructured and structured data is generated by internal and external sources like suppliers, logistics service providers, or customers (Hamdani, 2022). The use of big data analytics supports to provide better supply chain visibility and higher product availability and minimizes costs, e.g., in transportation or inventory levels (Wang et al. 2016; Arunachalam, et al., 2018; Roßmann et al,. 2018; Oncioiu et al., 2019; Chakroun et al., 2019). Especially in the procurement area, an essential part of SCM, an enormous amount of data is available but not effectively used due to the lack of experience of the firms in data analytics (Mikalef et al., 2018).

Volatility, uncertainty, complexity, and ambiguity (VUCA) world strongly affects supply chains. Disruptions in the supply chain due to natural disasters, pandemics, and wars underline the need for more research,

especially on supply chain resilience (Naz et al., 2021). To manage uncertainties, project management (PM) plays a vital role in mitigating the risks in supply chains (Hartel, 2022). We study PM and SCM together in this research.

All the research papers that address the use of AI in SCM underline added value of implementing AI techniques to manage supply chain problems, but most of these do not address the use of AI in managing SC projects. The usual focus is on optimization of the processes. To the best of authors' knowledge, only a few researchers studied the use of AI in SC project management. Those authors focused on some specific aspects of project management. For instance, Hamdani et al. (2022) worked on agile management and developed an organizational framework to integrate big data into various Sprint loops.

This paper aims to analyze the current state of research, find the research gaps, and bring insights into future research work.

In the sequel, a review approach would be presented and an attempt to explain how the articles were selected. The authors define three main categories to cluster the contributions based on selected scientific works. These categories correspond to SCM area, PM problems, and AI methodology. After that, each article has been grouped based on specific subcriteria. Finally, the results of literature review are presented. Based on the findings, implications and research gaps are presented, including future research directions.

2. Review Approach and Material Collection

The authors implemented a systematic literature review process, as explained by Tranfield et al. (2003). First, the search keywords were identified. We used the following combinations of terms in the title, abstract, and keywords: ("Artificial intellig*" OR "Machine Learn* "OR "Deep Learn*" OR "Cognitive learn*" OR "Predictive analyt*" OR "Prescriptive analyt*" OR "Big data" OR "Data scien*" OR "Data manag*" OR "Blockchain" OR "Digiti*") AND ("Supply Chain" OR "Logistics" OR "Procurement" OR "Sourcing" OR "Supplier") AND ("Project Manag*" OR "Project Organi*"). By using these combinations, the authors limit the scope to only the articles that address Artificial Intelligence (AI), Supply Chain Management (SCM) and Project Management (PM) together. Using "*" allows searching all the possible words that contain the given sequence of letters. The search includes only articles published in English in peer-reviewed journals, which are indexed in SCOPUS, and does not include book chapters, technical reports, and conference proceedings.

The search returned 73 articles. Two researchers read the articles' abstract, introduction, and conclusion sections to finally decide the list to be examined in detail. This screening resulted in a list of 28 articles. The authors defined some analytical categories by considering the common features of the articles. These categories work to classify and analyze the literature and systematically present the results.

3. Results

The first article was published in 2002. In the following years, the number of papers increased gradually. Only six publications were accepted between 2002 and 2018. Nineteen articles published within the last two years (2020-2022) strongly indicate the current interest of researchers in the topic.

Types of Papers and Research Topics

Table 1 represents whether the article includes a literature review, theoretical or more practice-oriented work. Our article database, constructed from a systematic search, includes theoretical and practical approaches.

Table 1: Types of Papers (multiple answers possible)

Type of Paper	Number of Papers
Literature Review	6
Theoretical Framework and Models	15
Empirical Survey	6
Case Study	12

Theoretical studies focus on developing a theoretical framework, including models and algorithms. Twelve papers presented the AI implementation in SCM as case studies, often in the construction sector. In comparison to these two groups, empirical surveys ranked very low in number.
The research topics were identified inductively based on the review of the articles. Tab. 2 shows the eight main research topics for these 28 papers. The variety of topics emphasizes that clear mainstreams do not exist.

Tab. 2: Research Topics

Research Topic	**Number of Papers**
Construction Management	13
Data-Driven Decision Making	3
AI implementation	3
Agile and hybrid project management	2
Industry 4.0	2
Project Performance Management	3
Six Sigma and Process Mining	1
Software and Service Industry	1

Among the 28 studies, 13 addressed construction management domain. The construction sector works with many suppliers and undertakes complex projects worldwide (Akinosho et al. 2020). Especially construction projects in Asia have been using AI to enhance project performance (Kang et al., 2022; Karki and Hadikusumo, 2021).
Data-Driven Decision Making in SC, a promising research area, has been addressed only in three papers, e. g. in production and shipping (Baptiste et al., 2008) or in route planning for cash transports for a bank to avoid robberies (Tarantilis and Kiranoudis, 2004). Three papers can be grouped under the category "AI implementation“. García Rodriguez et al. (2019) worked on procurement in the Spanish public sector, investigating the relation between award prices and bidding prices using machine learning. Naz et al. (2021) addressed the supply chain problems faced during the COVID pandemic and examined the use of AI as enabler of SC resilience. The authors shortlisted 162 articles on AI in SCM but did not discuss the impact on project management.
Two studies focused on enhancing project performance using big data analytics and machine learning (Li et al., 2021; Taye and Feleke, 2022). The third article addressed multi-dimensional project performance management by designing a framework for complex projects (Lauras et al., 2010).
Two papers emphasized agile and hybrid project management. Hamdani et al. developed a framework to integrate agile-based sprints in big data projects for SCM (2022). On the other hand, Albrecht and Albrecht 2021 recommended adopting hybrid project management approaches rather than pure agile ones. Within the subcategory of “Industry 4.0“, Bag et al. (2021) discussed the critical resources for Industry 4.0 adaption and used factor analysis to consolidate them. Rane and Narvel focused on using blockchain technology in project resource management (2021).
Two out of 28 shortlisted articles did not belong to the other categories and were standing alone. Software used in procurement was investigated by Allal-Chérif et al. (2020). Based on interviews, the authors pointed out the potential of AI for procurement managers to address complexity. The use of AI for quality and project management was studied by Kregel et al. (2020). They integrated Process Mining as an AI method into the DMAIC cycle of Six Sigma projects.

Analysis from the AI perspective

The selected articles discuss AI in multiple ways, sometimes even without focusing on a specific AI technique. Allal-Chérif et al. (2020) found that AI does not merely support the decision process in procurement but also the collaboration with external members and other internal departments. The study of Cubic (2020) also underlined the importance of using AI in a broader sense without focusing on techniques. Especially, to cope with SC risks, AI techniques may contribute a lot. Naz et al. (2021) proposed a framework for AI in SC risk management without prioritizing specific AI techniques.

Apart from the general perspective of use, some articles focused on big data analytics. Process Mining, combining big data and process management, use of data analytics along the DMAIC cycle of Six Sigma projects and applied in a SCM project as early-stage research (Kregel et al., 2020). Hamdani et al. (2022) proposed data-based Sprint Meetings to manage SC projects within the SCRUM implementation. Bag et al. (2020) defined big data as one of the key resources for Industry 4.0 within the circular economy. You and Wu (2019) developed a framework for the construction SCM. Yang et al. (2020) worked on adapting big data implementation in construction to the automotive manufacturing sector.

From the perspective of AI techniques, most papers used or proposed to use deep or machine learning in SCM in different industries. Akinosho et al. (2020) presented an overview of the current research regarding the use of deep learning within the construction sector. Using expert opinions, Karki and Hadikusumo (2021) defined 15 competency factors for project management in Nepal. These factors are the basis of a prediction model to predict and analyze project managers' competencies by seven machine learning algorithms. Machine learning can also be used to predict failures in the software industry (Taye and Feleke, 2022). Also, Krechowicz and Krechowicz used a machine learning algorithm to assess risks in the field use of drilling machines (2021). Varouqa (2021) found that Artificial Neural Networks support construction project managers in proposing an optimum time and cost estimation model, which was validated.

Other techniques like "blockchain" and "cloud computing" are less emphasized than deep and machine learning. Just one article each could be filtered. Rane and Narvel (2022) used blockchain technology to develop an IoT architecture in EPC (Engineering, Procurement, and Construction) industry, to improve resource management with OEM, project managers, maintenance contractors, and spare parts vendors. Interestingly, Mohd Said and Mustaffa (2019) also analyzed the EPC industry but focused on contract management issues in the Malaysian oil and gas industry. According to the authors, cloud computing may contribute to establishing better cooperation among all parties concerned.

Analysis from the SCM perspective

Mainly due to the frequently faced disruptions in supply chains, the importance of SCM has increased in all industries. In the articles set selected by the authors, five articles studied SCM from a global perspective without distinguishing among the functional areas like procurement, production, logistics, or distribution (Bag et al., 2021; Hamdani et al., 2022; Li et al, 2021; Naz et al., 2021; Tah, 2005).

Among the other papers, eight addressed procurement and sourcing. Among these, four investigated how AI can contribute to the performance of procurement management (Allal-Chérif et al. 2021; Rane and Narvel, 2022; Choi et al., 2021; Wang and Chao, 2022). Two papers focused on the support of AI in decision making in the procurement departments (Wang and Chao, 2022; Kashiwagi and Byfield, 2002), while García Rodriguez et al. (2019) studied the bidding processes in Spanish public procurement. One article primarily discussed how artificial intelligence influences the contracts with suppliers, e.g., by presenting selected cloud solutions (Mohd Said et al., 2019).

Two articles addressed both production and distribution logistics. Baptiste et al. (2008) developed a decision support system (DSS) to integrate production and logistics optimization. You and Wu (2019) developed an integrated enterprise data platform framework as part of an ERP system in production planning and logistics). Tarantilis and Kiranoudis (2008) also developed a DSS to manage a bank's robbery and transportation risks in intra-city delivery routes. This paper is the only one exclusively focusing on distribution logistics.

Analysis from the "Project Phases" Perspective

In traditional PM, projects have a life cycle with "initiation," "planning," "execution," "monitoring," and "termination" phases. Most of the selected ten articles integrate the project management decisions from a global perspective and do not focus on a specific project phase. On the other hand, seven papers studied the use of AI in the planning phase (Bag et al, 2021; Choi et al; 2021; Karki and Hadikusumo, 2021; Rane and Narvel, 2022; Taye and Feleke; 2022; Tarantilis and Kiranoudis; 2004; Wang and Chao, 2022). Researchers' interest in integrating AI technologies in project planning can also be observed in recent publications increase. Other than Tarantilis and Kiranoudis (2004) article, others were published in 2021 and 2022.

Some papers examined the use of AI in the execution phase (Choi et al, 2021; Kamardee, 2008; Rane and Narvel, 2022; Varouqa, 2021; Wang and Chao, 2002). Three of the articles address "planning", at the same time. Note that there is a strong link between project phases. Similar to the observations the authors made for the "planning" phase, only one article was published earlier than 2021 (Kamardee, 2008). Only two papers analyze and apply AI in the monitoring phase of project management. Lauras et al. (2010) and Li et al. (2021) discussed the value of big data for performance management in complex projects.

4. Research Gaps and Future Research Needs

Although the number of articles about the use of AI in SC-Project management is very modest, the number of articles has been increasing in the last two years. The 28 papers the authors examined show a wide diversity of topics and methodologies. The focus on specific topics of SC project management or examine the use of AI in SCM. The results of the literature review establish a sound basis for future research. The following research gaps could be highlighted based on the authors' findings.

Industries:

Most of the articles address the construction industry's problems and model the supply chain complexity regarding participating project members, diverse organizations, and global supplies and deliveries. There is a lack of studies on manufacturing industries. The existing research articles do not focus on the automotive, mechanics, chemical, and pharmaceutical industries, although these are the leading sectors in many countries. In addition, those industries are strongly impacted by global SC disruptions and need good project management competencies.

Regions:

There is also a need for research on diverse regions. North America and South East Asia are relevant markets for AI research and practice, but not the only ones. Today it is observed that disruptions caused by the war in Ukraine on different sourcing, production, and sales markets prevail in many countries, especially in Europe, Asia, and Africa. Many of the papers the authors examined address Asian markets, probably correlating with the focus on the construction sector in emerging markets. So future research could contribute to the use of AI in SC project management of companies operating in different regions in Europe and Africa.

Project Phases:

None of the articles examined the project phases systematically. The papers either discuss project management from a more general perspective, apply a specific project management approach (Agile Management, Six Sigma), or only analyze one or two project phases. Consequently, the authors underline the importance of investigating the opportunities AI can bring to each phase of a project, from initiation to termination of SC projects. Naz et al. (2021) pointed out the importance, especially for SC risk management (SCR): "Future studies must integrate the role of project management in SCR post-pandemic because only a limited number of studies exists concerning project management and SCR" (Naz et al., 2021).

5. Conclusion

Currently technological possibilities of AI and SC bottlenecks have led to a rising number of publications within the last two years. The need to discover the main reasons for SC disruptions and find ways to mitigate these would boost the interest of scholars and practitioners on this research topic. AI-based project management supports SC resilience, availability, and costs. Hence, a literature review was conducted to verify the state-of-the-art research. After the selection process based on SCOPUS database, the authors clustered the shortlisted papers by the categories related to AI, SCM and PM. In all three main categories, the topic was often discussed on an overall level. Whereas examining the AI category, we can observe that most studies use deep or machine learning. In the SCM category, most papers use AI in procurement and sourcing. Finally, despite the relatively high number of papers analyzing project "planning" and/or "execution", most papers view project management from cross-phase perspective. In summary, a first scientific base has been conducted; nevertheless, the few articles and their thematic breadth underline the need for future research, namely “industries”, “regions", and "project phases”. The third need offers many opportunities for future research.

This study has some limitations. First, only scientific papers in English selected by SCOPUS database were examined; therefore, books, conference proceedings, or company case studies have not been examined. As an extension of this study, the authors will use additional databases to close the evaluated research gaps. Second, by nature, the content analysis is subjective. Using statistical methods may help to reduce authors’ bias. However, our article database contains few articles as we examine a focused topic. Consequently, we underline the need for future research on AI methods' opportunities, impacts, and implications within SC projects based on a phase-by-phase project management approach.

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