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A Review of AI in the Supply Chain Industry: Preliminary Findings

Conn Smyth[1[0000-0001-7072-6606]], Denis Dennehy[1[0000-0001-9931-762X]] and Samuel Fosso-Wamba[2[0000-0002-1073-058X]]

[1] NUI Galway, Galway, Ireland
[2] Toulouse Business School, Toulouse, France

Abstract. Artificial Intelligence (AI) has been claimed to provide transformational powers in developing efficient and sustainable supply chains. Despite this, the supply chain industry is grappling with a number of challenges related to the implementation of AI. Additionally, AI and supply chain research to date has largely focused on the technical elements or different functions of AI, rather than AI as a whole. In order to provide a consolidated view of AI in the context of supply chains, we synthesis this dispersed knowledge by conducting a systematic literature review of AI research in supply chains that have been published in 3* and 4* ranked journals between 2000 and 2020. The search strategy resulted in 468 studies, of which 56 were identified as primary papers relevant to this research. This research adds to aggregation of knowledge by providing a state-of-the-art of AI and supply chain research, synthesising the reported challenges of the supply chain industry and the claimed benefits of AI.

Keywords: Artificial Intelligence, Supply Chain, Systematic Literature Review.

1 Introduction

Supply chain firms are becoming increasingly aware of the potential of AI for coping with the unpredictable nature of supply chains and the world around them [1,2]. Supply chains have always been vulnerable to distributions [3,4], however, this vulnerability is further intensified due to customer demand continuously evolving [5], products becoming more complex [6], higher customer expectations [7], greater product variety [8,9], and greater emphasis on transparency and sustainability [10–13].

The concerns about the stability of modern supply chains were brought to light throughout the COVID-19 pandemic, with 86% of supply chain firms being negatively impacted [2]. Such events have raised awareness among both researchers and practitioners of the need to create a more resilient supply chain that can handle the complex problems faced by modern supply chains [14–17]. Previous SLRs (see Table 1) have demonstrated the many benefits of the different functions of AI (i.e. machine learning, expert systems), moreover, previous SLRs have also illustrated the various applications of AI such as, AI's potential for enhancing risk management [4]. However, these SLRs fail to provide a comprehensive overview of the collective functions and applications of AI in the supply chain industry, echoing the concerns of 'fragmented

adhocracy', which has proven costly to other research areas [19,20]. In order to avoid this scenario, this research will provide a state-of-the-art of AI and supply chain research, synthesise the claimed challenges of the supply chain industry and the reported benefits of AI.

Comparison Element	[18]	[21]	[4]	[22]	This study
Timeline	2002 - 2019	2007 - 2019	1978- June 2018	1994 - 2009	2000 - 2020
Focus	Machine learning application in the agricultural supply chain.	Analyse the application of Bayesian networks to supply chain risk, resilience, and the ripple effect.	Assess how effectively supply chain risk management research has exploited the potential of artificial intelligence.	Provides a comprehensive review of research conducted in textile and apparel supply chains using artificial intelligence and decision-support systems.	Illustrate the supply chain challenges that can be addressed by artificial intelligence.
Methodology	Systematic review	visualization-based scientometric analysis	State-of-art-review	State-of-art-review	Bibliometric analysis
Primary Studies	Scientific literature 93 papers	Scientific literature 63 papers	Scientific literature 276 papers	Scientific literature 35 papers	Scientific literature (IS basket, 3* & 4* CABS journals only) 56 papers

Table 1. Literature reviews of AI in supply chain management.

The paper is structured as follows. First, the approach taken to develop this SLR is outlined. Then, the analysis of AI research in a supply chain context is presented and followed by a discussion. The paper ends with a conclusion.

2 Research Methodology

The section outlines the systematic literature review (SLR) approach adopted in this study, which follows the established guidelines and procedures proposed by Kitchenham [23,24]. This approach (see Figure 1) consists of 9 steps across three phases: planning (3 steps), conducting (4 steps), and documenting (2 steps). The need for this review has been established throughout the introduction of this paper. The aforementioned objectives of this review are described in the form of three research questions:

RQ1: What is the current state of AI research in the supply chain industry?

RQ2: What are the reported challenges of the supply chain industry have been reported in A?

RQ3: What benefits of AI have been recorded in the context of supply chains?

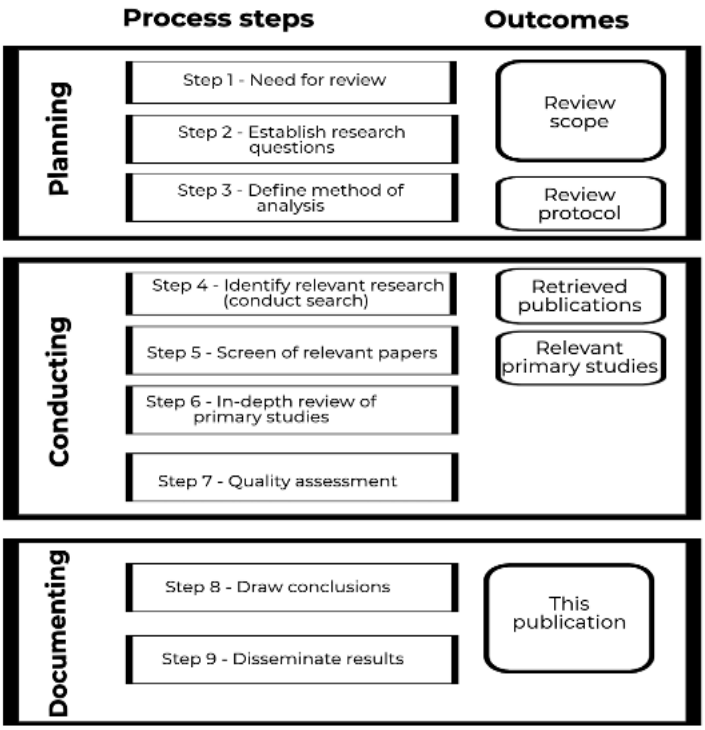

Fig. 1. SLR Steps followed in this study.

2.1 Search Strategy

The search was conducted within three electronic databases: AIS, Scopus, and Web of Science [25–27]. The search covered twenty years of research on AI and SC literature between January 2000 to December 2020. Papers were eligible for inclusion if it (i) directly answers one or more research questions of this study, (ii) clearly states its focus on AI in the IS domain and supply chains, and (iii) describes the application of AI and the approach used to study its use or implementation. The search initially retrieved a list of 5,059 papers, however, in order for studies to be eligible for inclusion in the SLR they must be published in 3* and 4* Chartered Association of Business Schools (CABS) ranked journals which resulted in 468 remaining papers. Our rationale for selecting from 3* and 4* journals was that these papers would be of higher quality having previously gone through a rigorous review, moreover, these journals place a larger focus on theorization, which collectively the authors believed would provide a better representation of AI and supply chain literature. The 468 papers were screened and excluded based on (i) duplicate papers, (ii) non-English, (iii) publication year, and (iv) title reading. This process resulted in 117 remaining papers, which were then subject to an in-depth review, which required two authors to read the papers in full. After the in-depth was conducted a total of 56 papers remained. Lastly, a quality

assessment was conducted on these using the criteria proposed by Dybå and Dingsøyr [28]. The quality of the papers was deemed appropriate as these papers have been published in 3* and 4* journals.

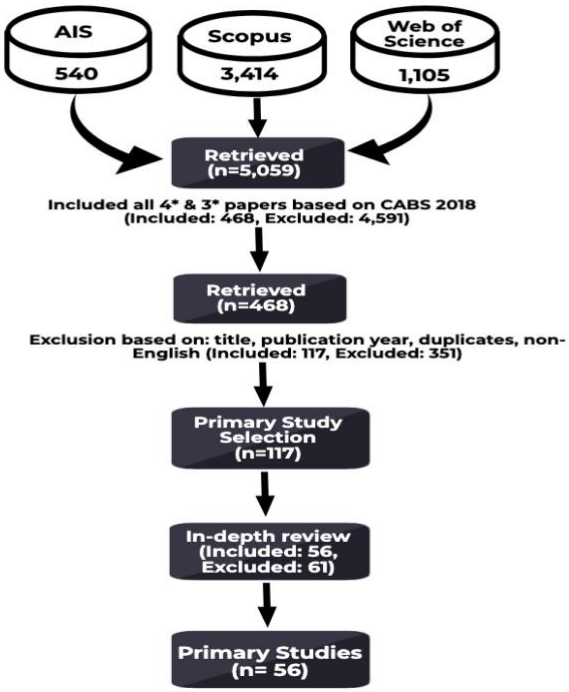

Fig. 2. Paper selection process

This study utilized bibliometric techniques to analysis the journal statistics of the primary papers, which has been widely applied in many research areas such as, supply chain management [29,30] and big data [31,32]. There are a number of statistics that can be used for bibliometric analysis, however, this study follows the guide of Gaviria-Marin [33] and utilizes h-index and its derivative m-index. The h-index is defined as "the number of papers with citation number ≥h" [34], while the m-index is the h-index divided by the "academic age" of the individual.

3 Analysis

This section presents the analysis of AI research in the context of supply chain management based on the following (i) publication by year, (ii) type of journals, (iii) reported challenges, and (iv) claimed benefits of AI. The primary papers were analyzed using Excel and presented using both Excel and Tableau.

3.1 Publication by year

RQ1: What is the current state of AI research in the supply chain industry?

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Between 2000 and 2001 no studies were reported, the first publications included in this study were received in 2002. Between 2002 and 2020 the number of publications that met the inclusion criteria grew from 2 to 56, this represents a 27-fold increase. A total of 15 articles were received in 2020, this is equivalent to the number of publications received from 2000 to 2010, and the number of papers published between 2014 and 2019. While a number of publication peaks and lulls can be observed across the 20-year period (see Figure 3), interest in AI research in the supply chain industry has been exponential.

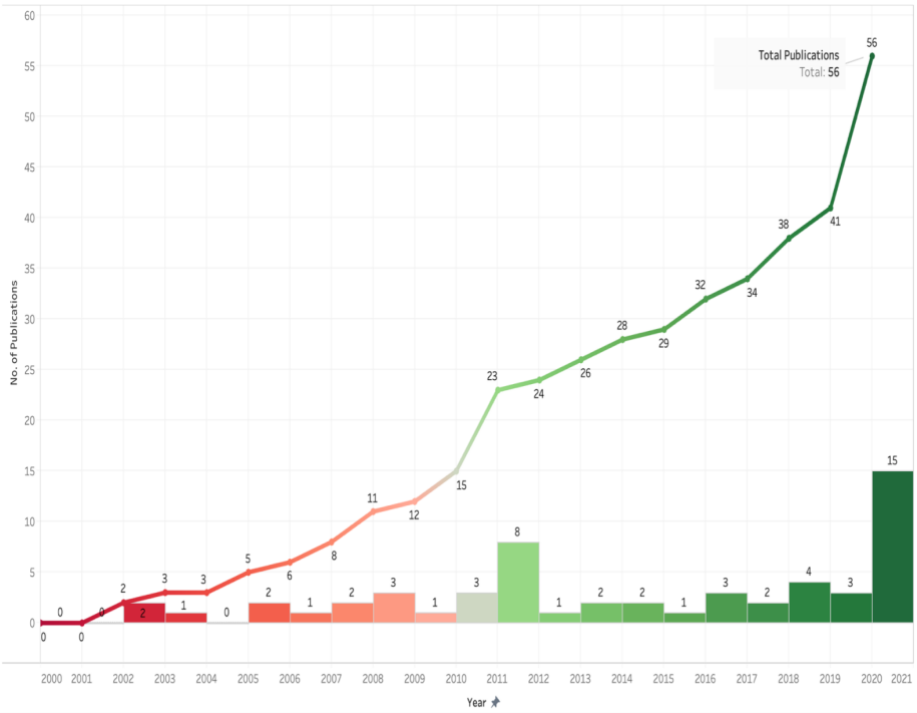

Fig. 3. Number of publications per year (2000 - 2020).

3.2 What 3* and 4* ranked journals are publishing AI research in the context of supply chains

AI research has been applied to a large number of areas [35,36], with AI and supply chain research accounting for a small portion. The articles included in this review were sourced form a total of 12 journals. International Journal of Production Research (IJPR) and Expert Systems with Applications (ESA) accounted for 17 and 16 of the articles

included, respectively. Figure 4 illustrates the 12 journals included in this study, ordered according to the h-index of the journal, which is calculated based on the citations and number of publications. The acronyms used in this table are described in Appendix 1.

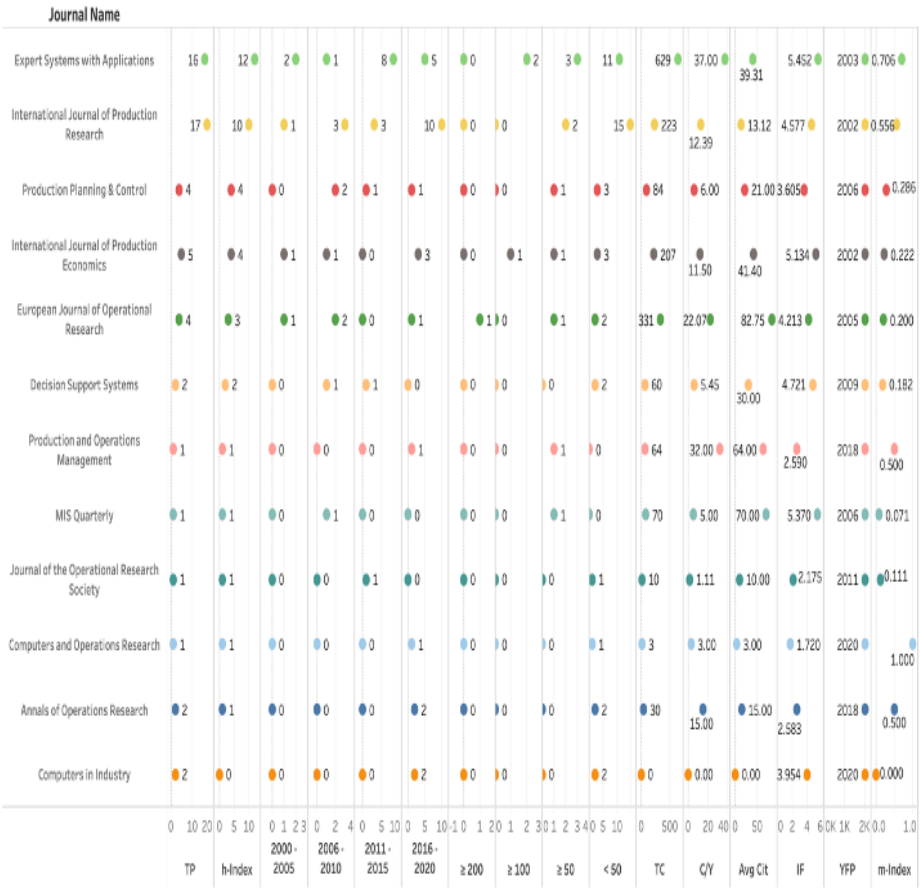

Fig. 4. Journal sources of AI and supply chain research.

Although ESA had one less publication than IJPR, it had the highest levels of influence (highest h-index, TC, C/Y). IJPR and ESA are the most dominate and influential journal sources for AI and SC research with h-indices of 10 and 12, respectively. However, the European journal of Operational Research was the only journal that recorded an article with over 200 citations and had the highest average citations per publication (C/Y). Four journals introduced their first AI and SC literature in the last two years, (1) Production and Operations Management, (2) Computers and Operations Research, (3) Annals of Operations Research, and (4) Computers in Industry, which reiterates the rapid growth AI and supply chain literature has experienced in recent years.

3.3 The reported challenges of the supply chain industry in AI literature

RQ2: What challenges of the supply chain industry have been reported in AI and supply chain literature?

Of the 56 primary papers analyzed 53 papers reported challenges faced by the supply chain industry, these papers subsequently examined how AI could potentially combat these challenges. The reported challenges are synthesized and categorized into seven categories (see Table 2). Each challenge is explained based on the analysis of the primary papers.

Challenges	**Explanation**	**#**
Problems resulting from using traditional forecasting techniques	Forecasting refers to either making predictions about internal operations and processes or customer demand forecasting. Traditional methods of forecasting are unable to handle the inherent complexity of modern supply chains [37–39], therefore difficult to make accurate and effective predictions, resulting in a number of subsequent issues.	16
Difficulties of selecting appropriate suppliers and managing supplier relationships	Supplier selection and management is becoming increasingly important for supply chains firms due to customers growing need for efficient delivery [40], and rising global competitiveness [41]. In order to select an appropriate supplier and to effectively manage this relationship, supply chain firms must consider and actively monitor a large array of tangible and intangible factors [42], which is very difficult through traditional methods.	4
Managing supply chain disruptions and risk mitigation	Supply chain disruptions and risk mitigation are grouped as they both have the same objective of minimising supply chain interruptions and delays. Supply chain disruptions can result in increased costs, loss of profits and damaged company reputation [43–45]. Therefore, the aversion of these risks is of the utmost importance to supply chain organisations.	10
Managing inventory and selecting appropriate replenishment strategies	Inventory is the cornerstone of every supply chain [46], therefore, as the supply chain evolves to align with customer needs and demand, so must the inventory and vendor management strategy. This paired with customer demand that is rapidly growing and changing [5] creates a continuous and daunting problem for supply chain firms.	5
Issues related to supply chain configuration, design, and planning (SCCDP)	SCCDP plays an essential role in creating a competitive advantage and ensuring supply chain responsiveness [47]. Effective SCCDP utilises all available resources to ensure that the supply chain is in a position to meet demand, while also being able to react to disruptions [48,49] and the fluctuating demand of customers [39,50].	7
Problems faced during the production process	Production processes have got the brunt of the increasing pressure on supply chain firms to increase transparency [10,13], and to provide higher quality products [51]. As a result, supply chains are left questioning how they can address the aforementioned problems while still creating a profitable product.	8
Difficulties in optimising supply chain processes and procedures	The increasing scale and number of entities involved in contemporary supply chains [52] has made supply chain optimisation a growing concern for firms, as traditional methods for solving optimisation problems typically lack the ability to handle the nonlinearity and complexity of modern supply chains [38,53,54].	6

Table 2. Reported challenges of the supply chain industry.

3.4 The claimed benefits of AI in the Supply Chain Industry

RQ3: What benefits of AI have been recorded in the context of supply chains?

The benefits of AI that are dispersed across the 56 primary papers have been synthesized and categorized into eight categories (see Figure 5). This review does recognize that some of these categories could be mapped into more than one category, however, to avoid complexity they are mapped into the most relevant category. It's evident that AI has the potential to impact a wide variety of supply chain elements, most notably, supply chain configuration, design and planning (SCCDP), with 12 papers reporting benefits to SCCP. This is due to AI's ability to simulate the configuration of supply chains and provide support across a wide variety of planning decisions. As expected, demand forecasting was also highly reported, due to machine learning's strong predicative powers. Collectively these benefits of AI have the potential to propel supply chains to a new level of efficiency and quality, in addition to strengthening supply chains resiliency to disruptions.

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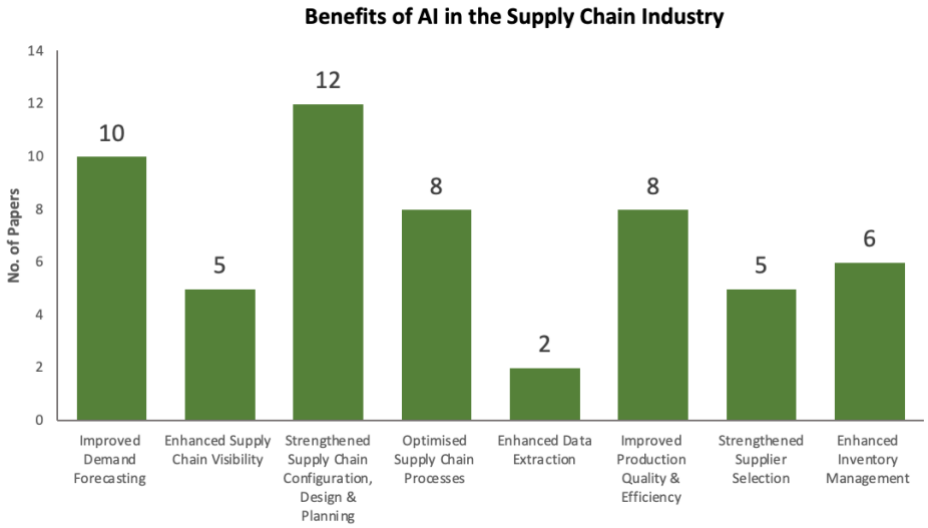

Fig. 5. Benefits of AI in the supply chain industry

4 Discussion

This study's objective was to synthesize the collective knowledge on AI and supply chain literature, with the ultimate goal of illustrating the potential of AI for addressing some of the most pressing concerns facing the supply chain industry. As previously highlighted, the supply chain industry is becoming increasingly susceptible to disruptions, in addition to report the challenges. Collectively, these issues will provide an opportunity for supply chain firms to shift their focus from traditional risk

management and efficiency techniques (i.e., lean, just-in-time) to developing resilient supply chains [4,14,17,55–57]. Therefore, firms must seek out enablers that support the development of resilient supply chains. It's clear from the many benefits of AI (Figure 5) that AI can not only improve the resilience of supply chains but can also enhance the overall efficiency and operations of the supply chain. However, despite the recent influx in publications (Figure 3) and uptake by journals (Figure 4) of AI and supply chain literature, the true potential of AI in the supply chain industry is yet to be achieved. It's evident that there is still a number of on-going issues in the supply chain industry, despite AI's potential for minimizing these concerns, this shortcoming instigates the need for more AI research in the context of the supply chain industry, particularly studies that focus on enabling supply chains firms to leverage the capabilities of AI. Despite this, we can conclusively say that this research has achieved its original target of synthesizing and adding to the accumulative knowledge of AI in the supply chain industry.

5 Conclusion

There has been a sharp influx in the applications of AI in the supply chain industry thanks to recent advances in computational power, big data, and cloud computing, to name a few. This paired with the growing digitation of supply chains provides an ideal platform for AI to address some of the most alarming concerns facing the industry. This review examined 56 articles synthesizing the claimed benefits of AI and the reported challenges faced by the supply chain industry, with the goal of making researchers and practitioners aware of the issues that can be addressed by AI. However, combating these issues only scraps the surface of the applications of AI in the supply chain industry. More research is required in order to truly gauge the full potential of AI.

Appendix 1: Acronyms used

Acronym	Description
TP	Total publications included in the study
≥ 200, ≥ 100, ≥ 50	Articles with more than 200, 100, and 50 citations
< 50	Articles with less than 50 citations
TC	Total citations
C/Y	Citations per year
Avg Cit	Average citations
IF	Impact factor
YFP	Year of first publication
YP	Year published

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