# A Literature Review on Smart Technologies and Logistics

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**Abstract.** The emergence of smart technologies has brought substantial changes in logistics. Hence, understanding smart technologies applied in logistics has become critical for practitioners and scholars to make smart technologies better empower logistics activities. Because research on this issue is new and largely fragmented, it will be theoretically essential to evaluate what has been studied and derive meaningful insights through a literature review. In this study, we conduct a mixed-method literature review of smart technologies in logistics. We classify these studies by topic modeling and identify important research domains and methods. More importantly, we draw upon the task-technology fit theory and logistics activities process to propose a multi-level theoretical framework in smart technologies in logistics for understanding the current status in research. We believe that this framework can provide a valuable basis for future logistics research.

**Keywords:** literature review, topic modelling, logistics, smart technologies, multi-level framework.

## 1 Introduction

With the rapid development of artificial intelligence (AI), AI application in logistics has become more and more extensive. There are three main reasons for the realization of the value of AI in logistics: first, the cost reduction of information technology (cloud computing, RFID, etc.) has made the cost of perception, processing, and learning of logistics data popular. Second, logistics operations often involve many links, complex relationships between entities, and a large number of physical objects, funds, information, complex network structure, and large data volume characteristics make logistics suitable for AI application scenarios. Third, the current AI application ratio in logistics enterprises is less than 10%, which has a great development prospect[1].

Taking predictive logistics as an example, the aviation industry uses machine learning algorithms to analyze 50-60 parameters, which can accurately predict the delay time of flights to arrange goods, personnel, consumables, and other elements more reasonably, and reduce the cost of air transportation. Ernst & Young has applied image recognition processing technology to the audit of import and export documents. Its recognition accuracy rate can reach 97%, which can significantly shorten the time for import and export customs clearance and make logistics operations smoother. To maintain

competitiveness, practitioners in the logistics industry have to keep up with the trend and explore how AI can empower the logistics industry and scholars.

AI research has a long history since the creation of the Turing Test in 1950. Early AI mainly only refers to expert systems or decision support systems. Until 2012, increasing computing power and advances in big data and machine learning research have led to renewed interest in AI. After carefully studying the existing literature in AI and logistics, we find some related literature reviews. The first category summarizes current research on the combination of supply chain and big data[2-3]or machine learning[4]. The second category is focused on combining AI technology with specific industry research, such as apparel[5] and agriculture[6]. The third category is a general analysis of the status quo and future trends in applying AI in the supply chain[7–11].Despite valuable contributions to the previous literature reviews, when observed, none of the reviews studied the overall status of AI in the logistics industry. Besides, it has raised the need to have a broader outlook of AI techniques employed for improving efficiency in different logistics stages. To address the concerns from both industry and academia, we propose two research questions for conducting this literature review:

1. Since the new generation of AI (i.e. Since 2012), what is the trend and application of AI in logistics?
2. How to understand and exploitation of AI techniques employed at various logistics stages?

To achieve the two objectives mentioned above, we collect the literature related to AI application in logistics. In particular, we use the topic modeling algorithm to classify the literature. After the systematic literature review of each topic, we synthesize the findings and propose a multi-level theoretical framework.

## 2 Literature identification and collection

Many studies focus on the respective fields of logistics and AI. Still, the study that combines the two is limited, presenting challenges for constructing good research and review strategy, as it can be difficult to distinguish between relevant and non-relevant research in the paper collection. On the one hand, in AI, where the number of keywords is high and ranges from specific technology to the strategic level. When including many keywords in a search, the search will likely return a large number of researches, many of which may not be relevant. On the other hand, some studies use words such as “smart” in logistics but do not involve specific AI concepts or technologies.

We employed a systematic approach to identifying relevant articles for our literature review. We selected the Scopus database as it encompasses a wide range of refereed journals belonging to major publishing houses such as Elsevier, Taylor and Francis, IEEE, Emerald, and Springer. The papers' search applied the "AND" operator between both AI and logistics areas and an "OR" operator within each area. This ensures that at least one keyword of each area is present. An overview of the search words is depicted in Table1. The search was conducted on Title and Keywords where applicable. The Subarea was limited to “decision sciences”, “social sciences”, “business, management and accounting”, “economics, Econometrics and finance”. After excluding the book

chapters, edited, conference review, note, and short survey, we collected 397 studies in total. Due to AI's rapid development in recent years and the rapid update and iteration, we did not exclude conference articles.

**Table 1.** Search words in AI and logistics

| Research domain | Search words |
|---|---|
| Logistics | logistics; shipping; reverse logistics; shipment; transport*; storing; warehous*; package*; inventory. |
| AI | machine learning; deep learning; artificial intelligen*; big data; smart; robot*. |

## 3 Topic modeling

Topic modeling refers to the generation probability model that automatically extracts its implicit semantic topics from discrete data. Topic modeling is used to grouped related papers into topics, enabling an overview of the main research topics. The advantage of topic modeling is that it allows replicability and transparency. Other researchers can run the same code to verify the results or run the analysis when more papers have been published, providing an updated overview of the research. Based on the outcome of topic modeling, relevant papers on the same topic can be selected for a systematic literature review.

We use the topic modeling algorithm - Latent Dirichlet Allocation (LDA) for an exploratory review and classification of relevant papers. The model regards documents as a collection of words and is not affected by the position and order of words. After the group features are learned, topics are generated in the form of the vocabulary probability distribution to describe the data set.

The topic modeling process begins with loading and cleaning the abstract of papers, where words are converted to lower case and stemmed. We use the stop words of the NLTK (natural language toolkit) corpus to remove the stop words. Besides, to ensure the readability of the LDA results, we expand the stop words which are common and highly appeared in most papers such as “use”, “paper”, “research”, “propose,” etc. After the papers are cleaned, we set the parameters and conduct the iterative experiment to select the correct number of topics.

Having grouped the study into five different topics, each topic must have its topic named. The naming of the topic is based on the most frequent words in each topic group, taking the title and abstract into account. The result is presented in Table 2. Topic 1 can be named “AI in logistics system design”. It studies how the logistics system could be configured physically and as far as the infrastructure is concerned. Topic 2 and 3 are about improving the efficiency or performance in inventory/warehouse management and transportation respectively by specific AI tools or models. Topic 4 is labeled as AI in logistics performances, whose literatures are about exploring the dimensions and indicators of logistics performance evaluation in the AI context. Topic 5 is named “Trends and framework of AI in logistics,” whose primary focus is to analyze

the current situation and future AI trends applied in the logistics field from a strategic level.

**Table 2.** Overview of topics

| Topic Label | Ten most frequent words |
|---|---|
| AI in logistics system design | Design; urban; system; city; model; management; improve; industry; interaction; adoption. |
| AI in warehouse and inventory management | Inventory; replenishment; pick; demand; model; decision; policy; time; control; forecasting. |
| AI in transportation | Transport; freight; time; route; optimization; delivery; vehicle; local; speed; decision. |
| AI in logistics performance | Performance; maturity; implementation; approach;level; process; dimension; facility; evaluation; combine. |
| Trends and frameworks of AI in logistics | Trend; present; technology; efficiency; outbound; framework; potential; enhance; organizational; review. |

## 4 A theoretical multi-level framework for AI in logistics

Through the results of topic modeling, we can identify several critical stages of studying AI in logistics. To provide a coherent picture of the steps in this context, we propose an integrated multi-level framework based on the LDA results and task-technology fit (TTF) theory.

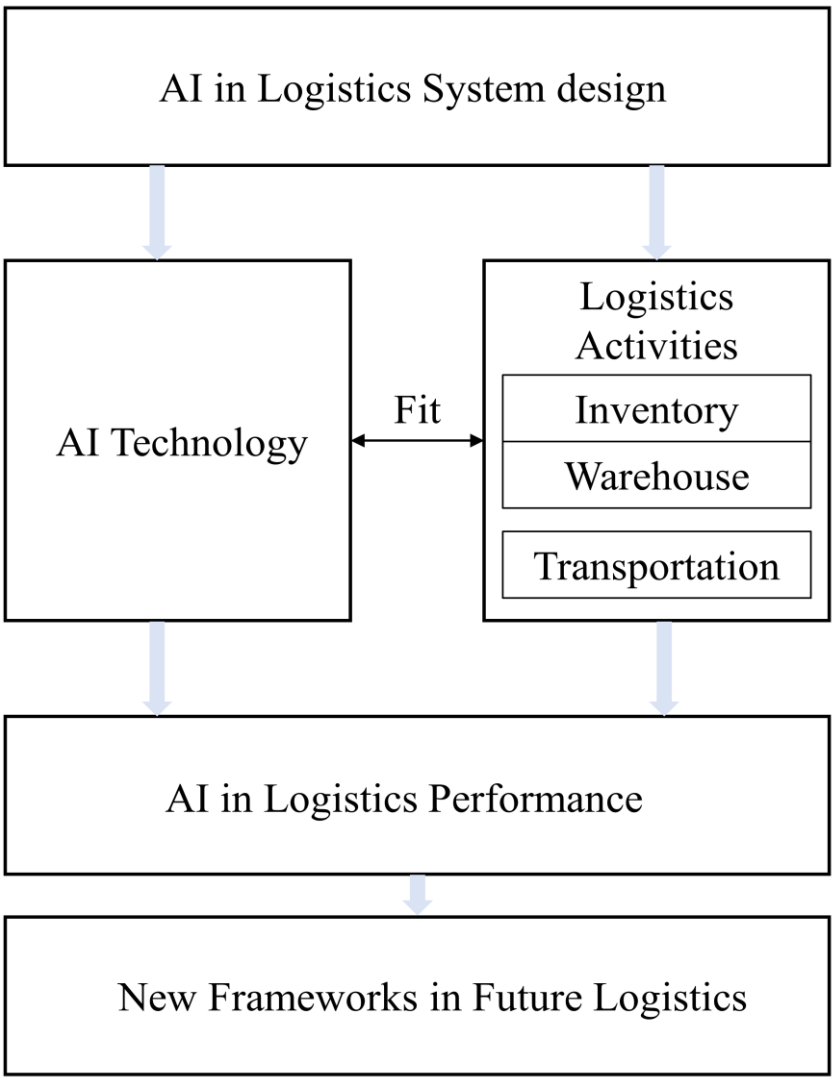


Fig. 1.Multi-level framework for AI in logistics.

The figure 1 depicts an overview of the framework. We divide the entire logistics activities into five stages: Topic 1 - AI in logistics system design. This stage's primary purpose is to design a logistics system and propose a specific implementation plan for logistics activities. Topic 2 - AI in warehouse and inventory management and Topic 3 - AI in transportation are based on TTF theory's perspective. We explore how AI technologies can empower specific logistics processes. Topic - 4 concerns how to evaluate the efficiency of the entire logistics activities. The final stage is topic 5 - the future

trends of AI in logistics. Details of its theoretical background and essential components and factors are discussed below.

### 4.1 AI in logistics system design

Logistics system design refers to completing the conception of the logistics system hardware and software structure, thus forming the logistics system design and technical roadmap. From a macro perspective, according to the scope of the logistics system, the logistics system design can be classified into regional logistics system design, industry, logistics system design, city logistics system design, and port logistics system design. From a micro perspective, logistics system design can be classified into node design and link design.

### 4.2 AI in warehouse and inventory management

AI and big data have disruptively changed the industry as the barriers to its implementation disappear. A subject profoundly discussed in logistics management is warehouse and inventory planning, which is the essential activity of many logistics enterprises.

### 4.3 AI in transportation

The innovation in transportation can be classified into five main categories: new vehicles, proximity stations or points, collaborative and cooperative urban logistics, optimization of transport management, and routing. All these innovations can be applied in both long and short-distance transportation. From our perspective, we divide the research on this topic into the application of AI in long-haul freight transportation and short-haul freight transportation.

### 4.4 AI in logistics performance

As we all know, it is bound to pursue the quality and efficiency of logistics performance when its development reaches a certain level. Especially in the modern logistics network, after the penetration of AI gets higher and higher, the previous logistics evaluation dimensions and indicators will change and iterate accordingly.

### 4.5 Trends and frameworks of AI in logistics

AI has received increasing attention because of its popular and prominent role in logistics in improving the overall supply chain performance. The academic literature within this topic has revealed the emergence of two sub-topics: the first one is identifying opportunities for logistics research by analyzing the current research status and trends from different perspectives. The second one is proposing definitions and a framework for new conceptions.

Finally, we summarize each logistics stage's details by providing a detailed framework for AI in logistics. Building upon figure 1, a holistic view of our complete theoretical frame is depicted in figure 2.

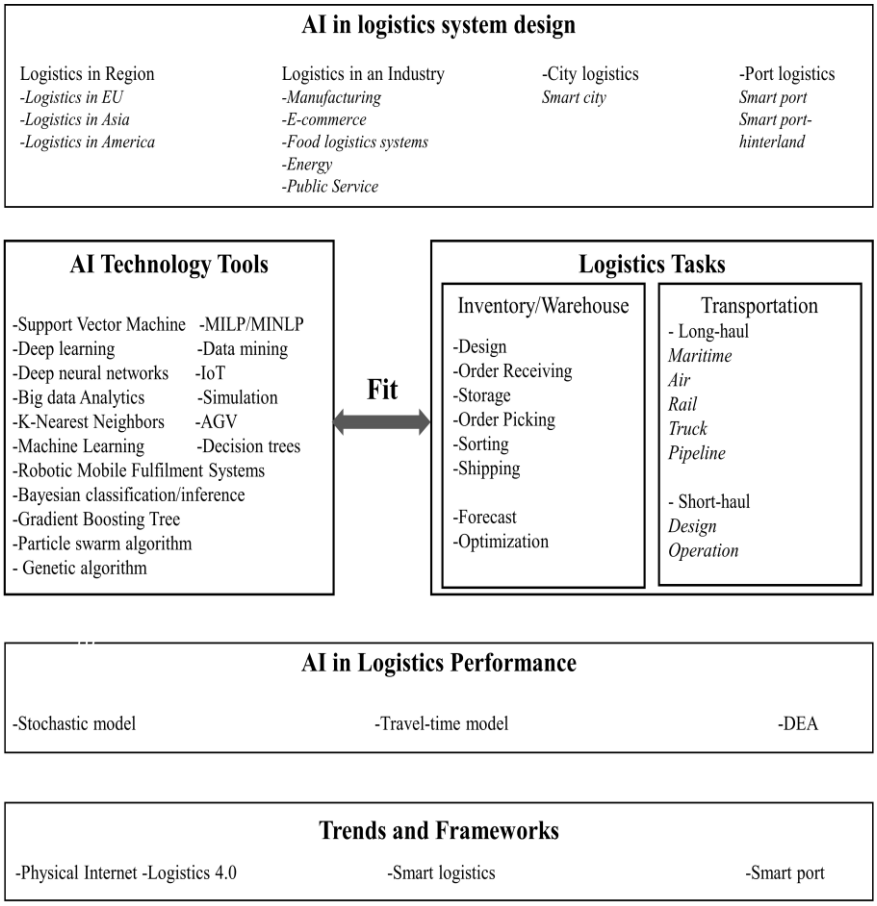


Fig. 2.Complete multi-level framework for AI in logistics.

## 5 Discussion

The purpose of this study is to conduct a systematic review of the literature on AI in logistics. AI has been shown to exercise a significant influence on modern logistics, while research on this issue is new and largely fragmented. We focus on reviewing the state-of-the-art research to propose a multi-level framework. The collected literature shows an increasing publication trend in the emerging area of AI in logistics. We also use the topic modeling algorithm (LDA) to classify the papers. In our review, we categorize the studies into five groups, summarized in three stages. Further, we discuss what important themes and technology have been studied combined with the TTF theory. Finally, we propose an integrative multi-level framework to understand the current status of AI in logistics, enabling us to achieve a holistic understanding in the setting of AI in logistics.

We believe that the findings of this study carry several important implications. First, to the best of our knowledge, this is the first study to conduct a thorough literature review on AI in logistics. While existing studies in this area are emerging, their findings are fragment and in their infancy. Thus, it isn't easy to obtain conclusive insights regarding how AI empowers logistics activities. In this respect, we provide an overview of the literature's current state and uncover the research contexts and methods. More importantly, we propose a multi-level theoretical framework to show and integrate the three stages of logistics activities. It can advance our knowledge of how AI is applied in logistics in different tasks and provide a notable theoretical foundation for future research.

Second, our research is one of the very few studies that conceptualize logistics activities with various stages. This broad view directs us to achieve a more comprehensive understanding of AI and to examine logistics activities occurring in different stages in this context. As shown in figure 13, our findings reveal that different research emphases are placed on different stages. For instance, in the topic 1,4 and 5, research focus on the overall design and implementation of AI in logistics, rather than the specific technologies in the topic 3 and 4.

## References


[1] M. M. Queiroz and R. Telles, “Big data analytics in supply chain and logistics: an empirical approach,” *Int. J. Logist. Manag.*, vol. 29, no. 2, pp. 767–783, 2018, doi: 10.1108/IJLM-05-2017-0116.

[2] Y. H. Kuo and A. Kusiak, “From data to big data in production research: the past and future trends,” *Int. J. Prod. Res.*, vol. 57, no. 15–16, pp. 4828–4853, 2019, doi: 10.1080/00207543.2018.1443230.

[3] G. Wang, A. Gunasekaran, E. W. T. Ngai, and T. Papadopoulos, “Big data analytics in logistics and supply chain management: Certain investigations for research and applications,” *Int. J. Prod. Econ.*, vol. 176, pp. 98–110, 2016, doi: 10.1016/j.ijpe.2016.03.014.

[4] C. B. Asmussen and C. Møller, “Enabling supply chain analytics for enterprise information systems: a topic modelling literature review and future research agenda,” *Enterp. Inf. Syst.*, vol. 14, no. 5, pp. 563–610, 2020, doi: 10.1080/17517575.2020.1734240.

[5] C. Giri, S. Jain, X. Zeng, and P. Bruniaux, “A Detailed Review of Artificial Intelligence Applied in the Fashion and Apparel Industry,” *IEEE Access*, vol. 7, pp. 95376–95396, 2019, doi: 10.1109/ACCESS.2019.2928979.

[6] R. Sharma, S. S. Kamble, A. Gunasekaran, V. Kumar, and A. Kumar, “A systematic literature review on machine learning applications for sustainable agriculture supply chain performance,” *Comput. Oper. Res.*, vol. 119, no. February, 2020, doi: 10.1016/j.cor.2020.104926.

[7] K. Lamba and S. P. Singh, “Big data in operations and supply chain management: current trends and future perspectives,” *Prod. Plan. Control*, vol. 28, no. 11–12, pp. 877–890, 2017, doi: 10.1080/09537287.2017.1336787.

[8] H. Min, “Artificial intelligence in supply chain management: Theory and applications,” *Int. J. Logist. Res. Appl.*, vol. 13, no. 1, pp. 13–39, 2010, doi: 10.1080/13675560902736537.

[9] L. Wu, X. Yue, A. Jin, and D. C. Yen, “Smart supply chain management: A review and implications for future research,” *Int. J. Logist. Manag.*, vol. 27, no. 2, pp. 395–417, 2016, doi: 10.1108/IJLM-02-2014-0035.

[10] W. I. Yudhistyra, E. M. Risal, I. S. Raungratanaamporn, and V. Ratanavaraha, “Exploring big data research: A review of published articles from 2010 to 2018 related to logistics and supply chains,” *Oper. Supply Chain Manag.*, vol. 13, no. 2, pp. 134–149, 2020, doi: 10.31387/OSCM0410258.

[11] R. Y. Zhong, S. T. Newman, G. Q. Huang, and S. Lan, “Big Data for supply chain management in the service and manufacturing sectors: Challenges, opportunities, and future perspectives,” *Comput. Ind. Eng.*, vol. 101, pp. 572–591, 2016, doi: 10.1016/j.cie.2016.07.013.