Application of Deep Learning Techniques in Managing Supply Chain: A Bibliometric Analysis

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Abstract

   Deep learning has become the driving force behind many contemporary technologies and has been successfully applied in many fields. The core objective of this study is to comprehend, investigate, and stipulate significant insights into the deep learning applications in various supply chain management functions through a bibliometric analysis. The literature for the study is gathered from the Scopus database. A bibliometric analysis is conducted using R Studio. It has been found that researchers from China are publishing the most research findings in this area. The study observed drift in concentrated areas of the field from 2007 to 2022. This analysis introduces a paradigm shift in trend techniques. Compared to using computer simulation, long- and short-term memory and reinforcement learning techniques are frequently used for the analysis. Also, the evolution of behavioral research in supply chain-related areas is given prominence compared to research related to agriculture and human interventions, which predominated.

Keywords: Supply Chain, Deep Learning, Bibliometric Analysis.

1. Introduction

   The supply chain (SC) is a well-organized network of individuals, equipment, supplies, actions, and technology employed in the manufacture and supply of a product to customers. It encompasses each stage, from transporting raw materials or semi-finished products from suppliers to the manufacturer to the transformation and delivery of the finished service or product to the client or clients, according to [1]. Managing the operations of the supply chain is crucial to ensuring the uninterrupted flow of materials and goods [2]. The decision-makers are expected to schedule a number of tasks linked to the purchase, transportation, and distribution of raw materials and finished goods at the proper location and at the appropriate time to avoid any insufficiencies.

   Companies should apply artificial intelligence approaches to boost corporate growth through useful insights derived from datasets, given the large amount of data that is now readily available [3]. One of these technology strategies to influence growth is deep learning, which automates knowledge labor [4]. The multi-layer neural network used in the new

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learning method known as "deep learning," a subset of machine learning, is used to find many stages of disseminated representations [5].

This study tries to analyze the recent trends in deep learning techniques and their applications in supply chain management. For this, the authors conducted a bibliometric analysis of relevant papers published in the domain. The following are the research questions formulated for conducting this study:

1.   Which authors, nations, and institutions have the most sway in the field of deep learning techniques' application in SCM?

2.   Which topics on deep learning applications in SCM have received the most attention in the literature?

3.   What patterns can be found in the literature in the SCM area that apply deep learning techniques?

The research paper is organized in the following manner: Section 2 presents the methodology of review embraced in this paper. Section 3 discusses a detailed bibliometric analysis. Section 4 summarizes the conclusions of the study.

2. Review Methodology

The authors conducted the bibliometric analysis and a detailed review of the selected papers. The bibliometric analysis will help the authors address the first three research questions. The methodology followed in the paper is divided into two parts: collection of material and bibliometric analysis. A bibliometric analysis is conducted to identify the influencing authors, journals, countries, and trends in the publication of literature.

Previous literature of high relevance from the Scopus data base was selected to address the insufficiencies of the existing research, thereby finding appropriate solutions for the research questions discussed in the introduction section, also with the help of combining the keywords given in Figure 1.

Keywords used for Deep Learning Techniques supply chain

"Recurrent Neural Networks" or RNN "Convolution Neural Networks" or CNN "Deep neural networks" "Long Short Term Memory" or LSTM "Auto encoders" "Deep Learning"	"Supply Chain"

Figure 1: Combining keywords used for deep learning techniques in the supply chain

2.1 Material Collection

The gathering of research papers is a crucial step in the bibliometric analysis process. We used the keywords from Figure 1 to complete this work, and we integrated published and accepted papers from English-language journals published up until September 18, 2022, that

are currently online. The stages of data collection and the methodology followed in this review process are explained in Figure 2. After collecting 183 documents as shown in Figure 2 (documents that are articles and reviews and in the English language), a detailed bibliometric analysis is conducted using software. In this study, software programs including RStudio, Biblioshiny, and MS Excel were employed. R's "RStudio" is an integrated development enterprise (IDE). The data was cleaned and organized using Excel workbooks. The unrefined BibTeX file adapted from the selected Scopus database was introduced into RStudio with the help of the package Biblioshiny for analysis and producing the findings. A detailed discussion of the bibliometric analysis is given in Section 4.

Formulation of Review questions
1. Who are the most influential authors, countries, institutions in the field of application of deep learning techniques in SCM?
2. What are the most explored areas in the literature on deep learning applications in SCM?
3. What are the trends in the literature published on SCM domain having the application of deep learning techniques?

Locating of research articles
• Database: Scopus
• Keyword search

Appropriate articles with combination keyword search. The search syntax is
TITLE-ABS-KEY (("supply chain" AND "deep learning") OR ("Supply Chain" AND "Recurrent Neural Networks") OR ("Supply Chain" AND "RNN") OR ("Supply Chain" AND "Convolution Neural Networks") OR ("Supply Chain" AND "CNN") OR ("Supply Chain" AND "Deep Neural Networks") OR ("Supply Chain" AND "Long Short Term Memory") OR ("Supply Chain" AND "LSTM") OR ("Supply Chain" AND "Auto encoders"))

440 document results

Literatures are limited to articles and review published in English language. The search syntax is
TITLE-ABS-KEY (("supply chain" AND "deep learning") OR ("Supply Chain" AND "Recurrent Neural Networks") OR ("Supply Chain" AND "RNN") OR ("Supply Chain" AND "Convolution Neural Networks") OR ("Supply Chain" AND "CNN") OR ("Supply Chain" AND "Deep Neural Networks") OR ("Supply Chain" AND "Long Short Term Memory") OR ("Supply Chain" AND "LSTM") OR ("Supply Chain" AND "Auto encoders")) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re")) AND (LIMIT-TO (LANGUAGE , "English"))

183 document results

Figure 2: Systematic literature review procedure with search syntax

3. Bibliometric Analysis

The research issues selected for this study were best addressed via bibliometric analysis. Bibliometrics is based on the potential structure, which may be precisely described using a single estimate based on the relationships between various authors and journal articles.

The following are the three crucial bibliometric analytic techniques applied in this case: (A) citation analysis; (B) co-citation analysis; and (C) coupling of bibliographies. Researchers can better grasp a topic's evolution, current trends, and area of future study by using bibliometric analysis. The use of bibliometric analysis has many benefits. To start, it adds a logical writing style to the literature review, giving a comprehensive viewpoint on a certain issue or field. Here, the results it provides can be fully replicated and are unaffected by the biases of the researcher. It also seeks to objectify the various indications by concentrating on them. The technique is based on the number of references or co-citations, as these are signs of the assumed investigative foundations on which the current analytical commitment is based [6, 16, 17]. The ability to find major hypotheses and research gaps is helpful for future

research as well as uncovering the analytical model of a particular theme or field [7]. It aids in identifying relevant sources and locating emerging and new areas of inquiry for the specified study discipline. Bibliometric analysis is an assessable method for summarizing and representing all significant writing in a body of literature. A combination of categorization and illustration methodologies is used to analyze the gathered bibliographic data provided by diverse academics working in a field.

By counting the citations to a work, which can be either an author citation or a journal citation helpful to gauge influence, citation analysis is carried out [8, 12, 13]. Any document or article that is heavily cited, whether by the author or when considering a journal, should be regarded as being of significant importance. Here, the assumption is that researchers consider articles important for the advancement of research and make appropriate references. Co-citation is when authors, journals, or other relevant papers are cited alongside another publication's list of references in order to promote similarities amongst them. So, to outline co-citation, it is the rate at which two documents are cited in conjunction with one another. When thoroughly examined over an extended period, co-citations can provide an extremely accurate indication of an analytical structure and its development [9–11, 14–15]. The initial stage in extracting pertinent literature on the topic was to find relevant keywords that might be used to search research papers in the databases. As the research problems spun around analyzing the literature on deep learning in supply chains, the researchers used a combination of keywords, as shown in Figure 1. Descriptive analyses of the published literature are discussed in Table 1.

Table 1: Description of the Literature Used for Bibliometric Analysis

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2007:2023
Sources (Journals, Books, etc)	126
Documents	183
Annual Growth Rate %	0
Document Average Age	1.36
Average citations per doc	16.04
References	9385
DOCUMENT CONTENTS	
Keywords Plus (ID)	1601
Author's Keywords (DE)	622
AUTHORS	
Authors	661
Authors of single-authored docs	7
AUTHORS COLLABORATION	
Single-authored docs	8
Co-Authors per Doc	4
International co-authorships %	30.6
DOCUMENT TYPES	
Article	171
Review	12

A general description of the papers published each year that are considered for bibliometric analysis is given in Figure 3.
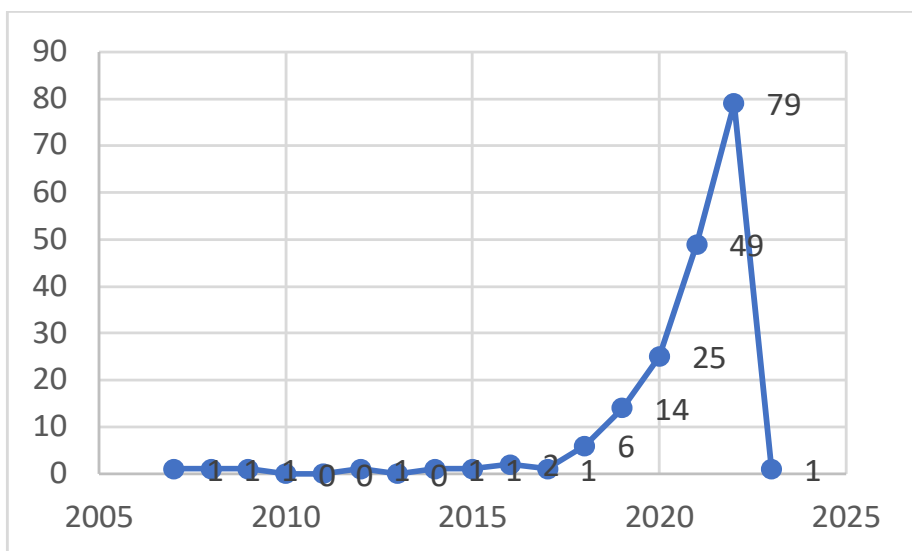
Figure 3: Number of Publications per Year

From the analysis, it is observed that the maximum number of papers will be published in 2022; the number equals 79.

Figure 4 depicts the analysis of publication based on the journals chosen by the authors.
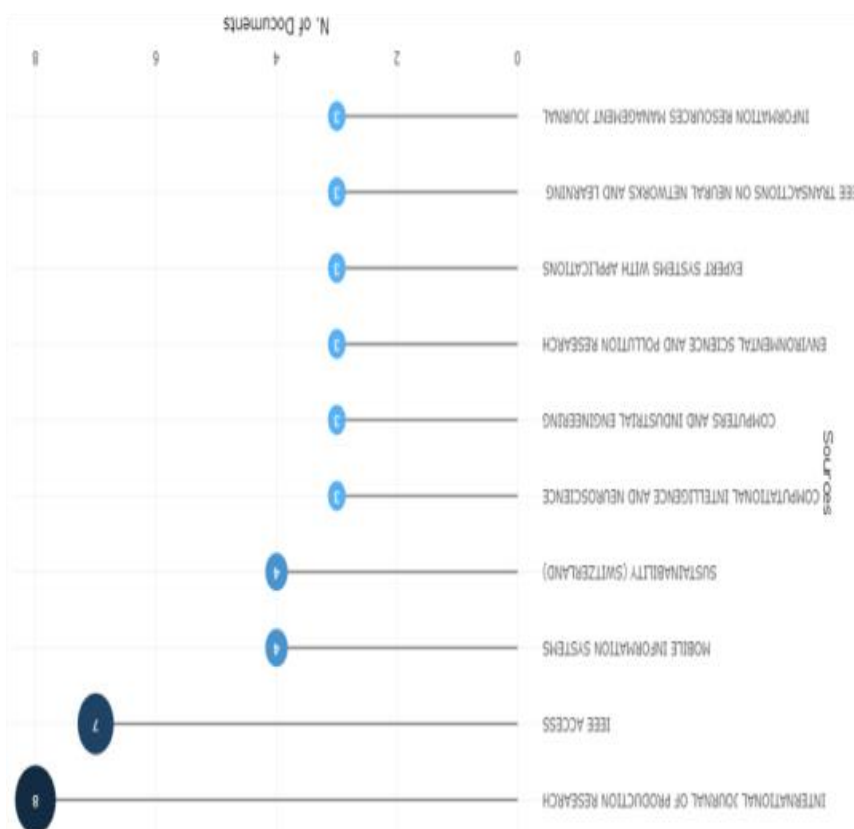

Figure 4: Journal-wise Publication

It is observed that eight papers are published in the International Journal of Production Research and seven papers in IEEE Access.

3.1 Most influential authors, countries, and institutions

In this section, the authors conducted an analysis to understand the most influential authors, countries, and institutions who published in supply chain management using deep learning techniques.

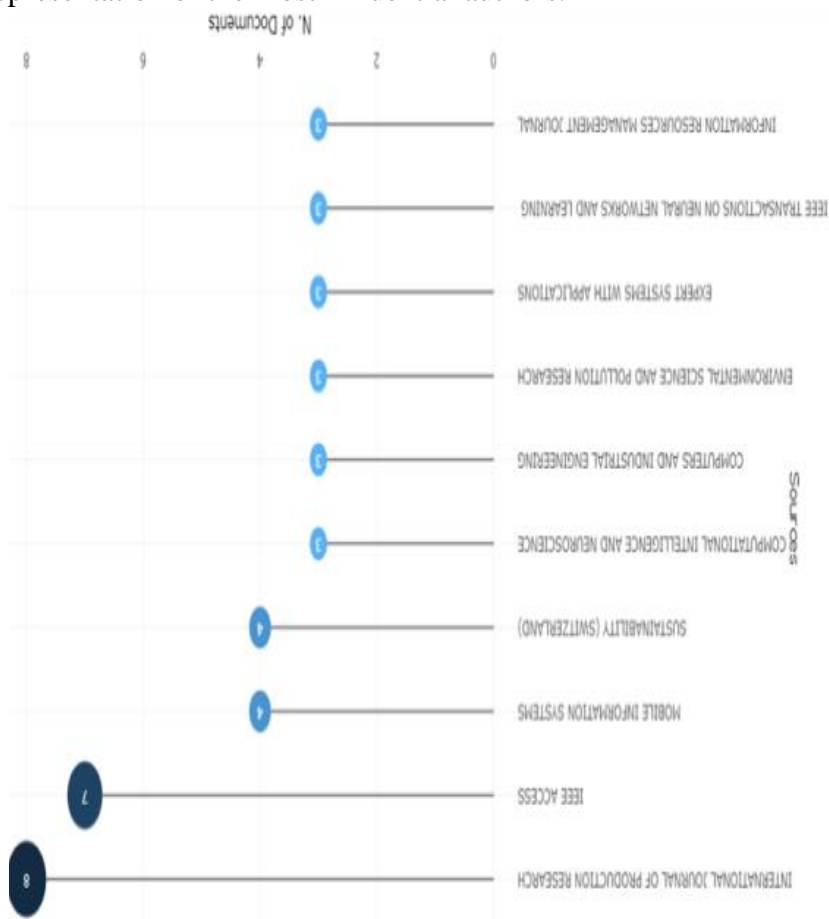Figure 5 is a representation of the most influential authors.

Figure 5: Influential Authors

There are six authors, Guo, L., Khan, S., Li, C., Li, Z., Liu, Y., and Wang, X., who published four papers in this area.

Figure 6 is the representation of the most influential countries.

Region	Freq
CHINA	117
INDIA	62
USA	40
UK	19
CANADA	16
SAUDI ARABIA	16
AUSTRALIA	14
MOROCCO	14
SOUTH KOREA	14
IRAN	13

Figure 6: Country-wise Publication

China has published the most papers in this field, followed by India and the United States. Figure 7 indicates the country-wise percentage of publications.
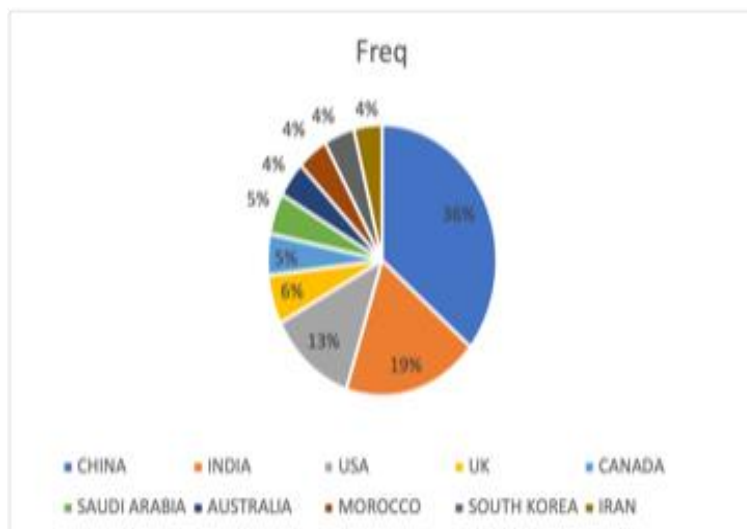

Figure 7: Country-wise Publication Percentage

Figure 8 represents the most influential institutions where the most research is done on the application of deep learning techniques in supply chain management.
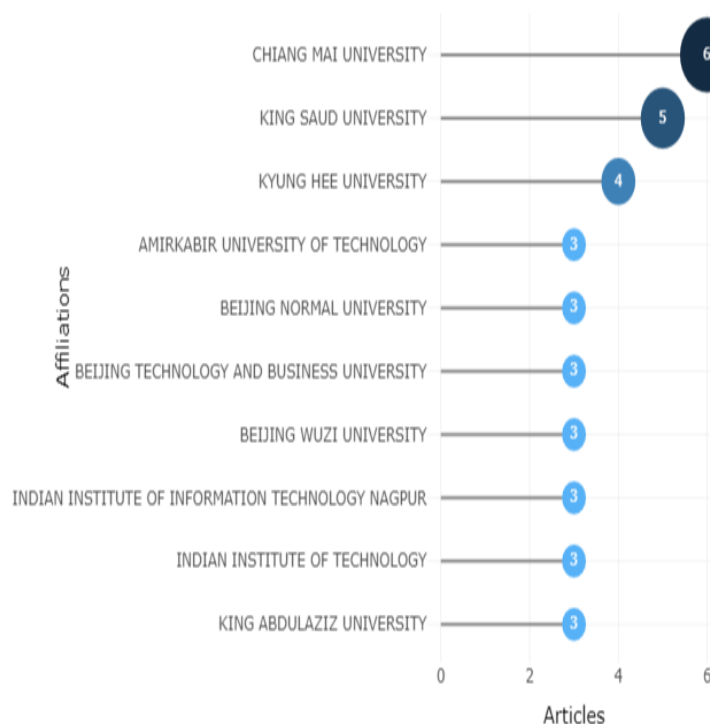

Figure 8: Most Influential Institutions

Chang Mai University, King Saud University, and Kyung Hee University are considered the most influential, having published six, five, and four papers in this area, respectively.

3.2. Most explored areas in the literature on deep learning applications

In this section, the authors conducted an analysis to understand the most explored areas of supply chain management using deep learning techniques. In a concurrence network analysis,

the most frequently used words and word clouds are analyzed to understand the most explored areas.

Figure 9 represents the concurrence network.

Figure 9: Concurrence Network

Figure 10 represents the most frequently used words in the papers considered for the study.
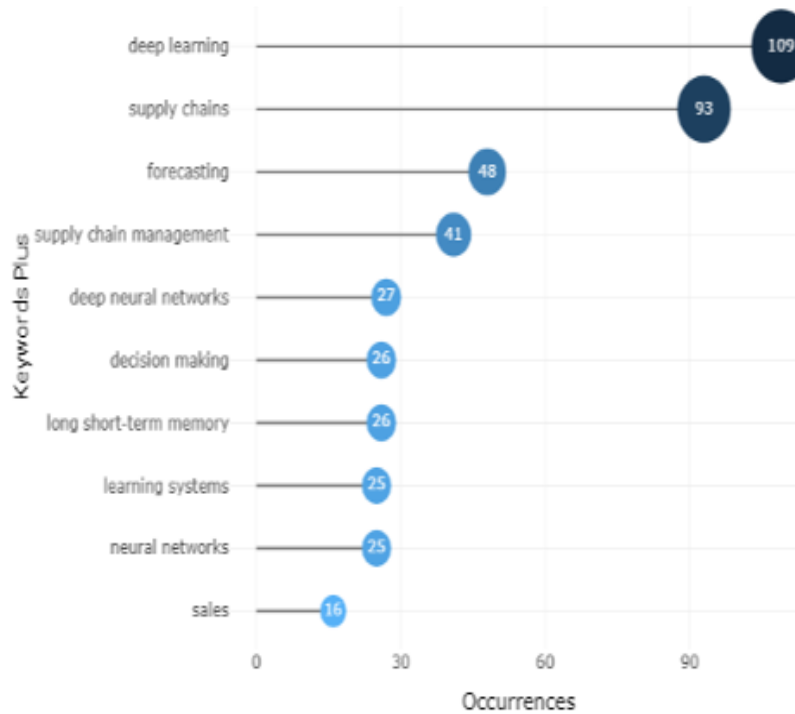

Figure 10: Most Frequently Used Words

Figure 11 represents the word cloud generated from R Studio software.

Figure 11: Word Cloud

It has been found that forecasting is one of the most explored areas in the supply chain domain. The widely used techniques in the analysis are deep neural networks, long short-term memory, and neural networks.

3.3 Trends in the Literature
The authors analyzed the thematic map, trend topics, and thematic evolution with respect to the papers considered in the study.
Figure 12 represents the thematic map of the study. It is observed that supply chains and supply chain management are found to be the most relevant themes in this study. The key words like deep learning, deep neural networks, neural networks, and convolution are found to be the most trending techniques used for the analysis.
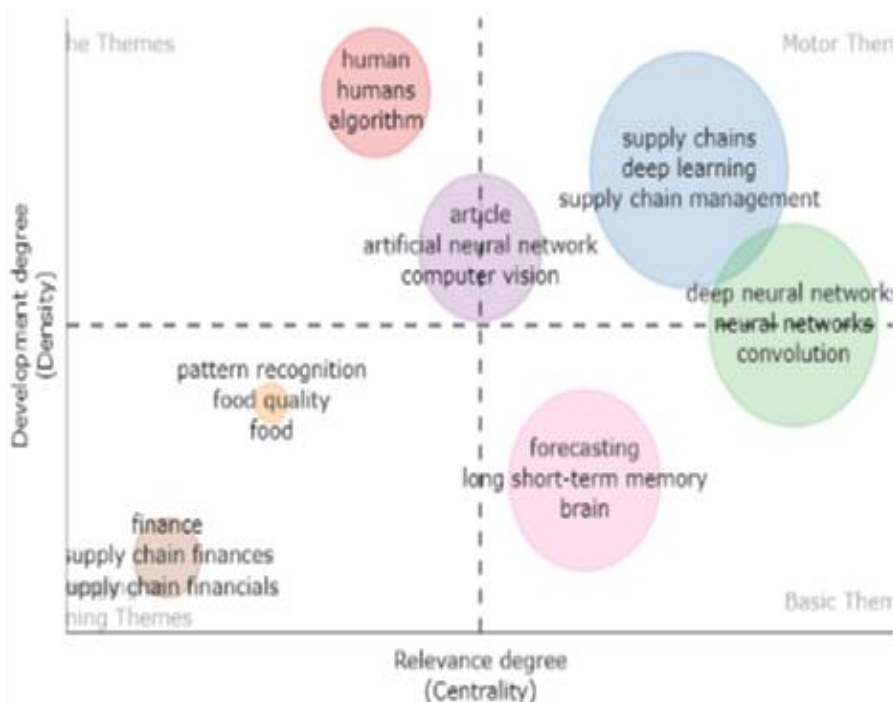

Figure 12: Thematic Map

While analyzing Figures 13 and 14, it is observed that there is a shift in the topic from 2007 to 2022. Earlier, most of the discussions were carried out on supply chains, agriculture, and humans, with a high concentration on supply chains. Recent trends include supply chains and human and behavioral research.

Analysis of Figure 13 indicates a complete shift in the trend topics where long-short-term memory and reinforcement learning techniques are used frequently for the analysis compared to computer simulation in 2014.
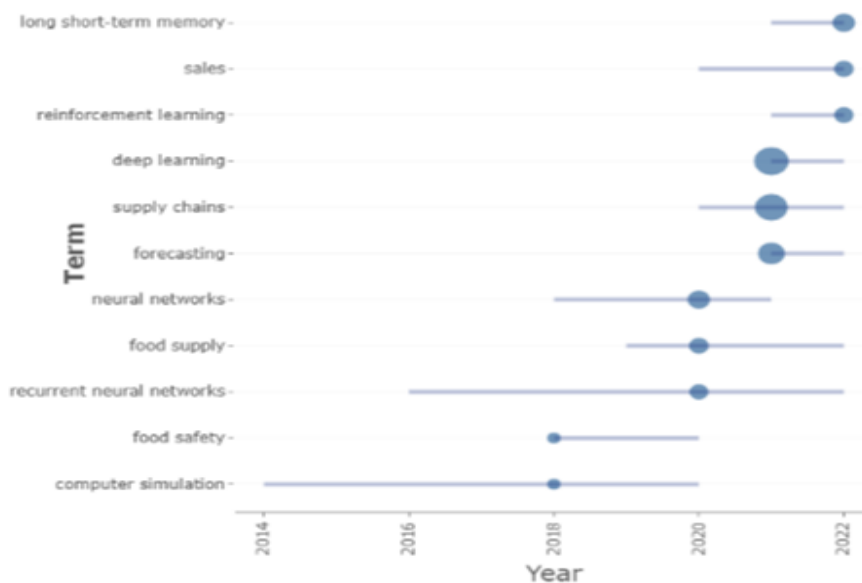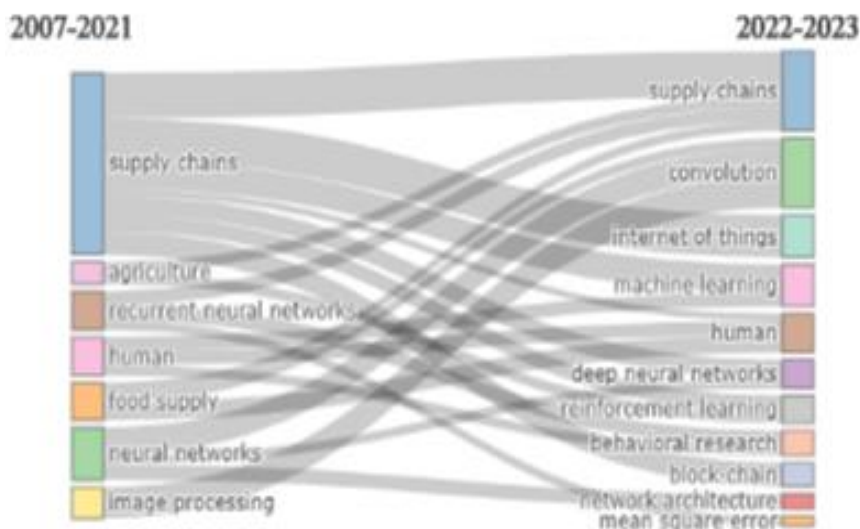

Figure 13: Trend Topics

Figure 14: Thematic Evolution

4. Conclusion

According to this analysis, China published the most papers in this field, followed by India and the USA. There are six authors—Guo, L., Khan, S., Li, C., Li, Z., Liu, Y., and Wang, X.—who have published four papers in this area. Chang Mai University, King Saud University, and Kyung Hee University are the most influential, with six, five, and four papers published in this area, respectively. Also, it was found that forecasting is one of the most explored areas in the supply chain domain. The widely used techniques in the analysis are

deep neural networks, long short-term memory, and neural networks. Earlier, most of the discussions were carried out on supply chains, agriculture, and humans, with a high concentration on supply chains. Recent trends include supply chains and human and behavioral research.

This study only looked at publications from the Scopus database. The gray references and other references are neglected in this study. Future research can include these areas that are not currently considered.

5. Disclosure and conflict of interest
Conflict of Interest: The authors declare that they have no conflicts of interest.

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