Research Article

The Applications of Artificial Intelligence in Logistics and Supply Chain

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Abstract: The range of potential market shows high growth, which can be achieved by the market in next years. It is expected that strategic allocation and asset positioning can help competitive goals. Estimation of certain regulations introduced by the governments of several countries increases the market revenues. It has been predicted that the availability of appropriate means to make powerful distribution channels can specify the expansion of the market's future in the predicted period. The stability of economic government can mostly help favorable development of global market power. It is also predicted that advances in research and development equipment can affect market growth in the prediction period. Need to provide conditions for emergencies such as natural disasters, pandemics, and international commercial wars can enable the market to fight the challenges. In other words, four aspects have been covered: 1- the most common AI techniques in SCM, 2- potential AI techniques to use in SCM, 3- secondary fields of SCM improved by AI, and 4- secondary fields with high potential to be improved by AI. A certain collection of regulations of inclusion and lack of inclusion are used to investigate the articles in four fields of SCM: logistics, marketing, supply chain, and manufacturing. This study provides insights by systematic analysis and synthesis.

Keywords: artificial intelligence, supply chain management, logistics

1. Introduction

Regional analysis of artificial intelligence (AI) in the supply chain market shows that North America was the most important artificial intelligence in the supply chain in 2017, which followed regions such as Asia, Oceania, and Europe respectively. Technical advancement, considerably developed infrastructures, and enhancement of technical knowledge in AI technology are multiple main factors to create motivations to combine AI-based solutions in the industrial supply chain in the region.

The United States is the major market in North America. The E-commerce market and intensification of development of the market of the retail industry are being increased because of demand to have access to advanced solutions for stock management. It is predicted that Asia and the Pacific Ocean can be developed in the supply chain market with the best installation equipment during the prediction period. Expansion of the e-commerce market that is stable because of the growing process of online purchase and making network infrastructures and digital technology can provide some main factors of motivation to enhance the AI market in the regional supply chain.

The world has been conducted toward a digital future, and the4 Industry4.0 technologies have been considered as a path toward the future (Kumar et al. 2020). One of the main technologies (blockchain, IOT, cloud computing, etc.) is AI technology (Dirikan, 2015) that is defined as the capability of machines to change human communication and to imitate human capabilities (Schutzer, 1990). Using AI results in solving the problems accurately, rapidly, and with large input volume. AI is neither a new subject, nor a new educational field (Hevin et al. 2003); although the recent technological advancements have shown that AI includes an expanded collection of applications (Min, 2010), and can create headlines with adjustment of processes in various fields (Martinez-Lopez, and Casillas, 2013; Jarahi, 2018) including supply chain management (SCM). Although some fields of information technology (IT) have been changed into a situation with simple competitive necessity, AI technology has emerged as a competitive advantage (Twaik and Ho-Fong, 1990). From this perspective, many companies have been conducted from remote controlling towards advanced automated control, optimization, and AI-based systems to improve these functions (Cohmatki et al. 2019).

Along with the increased importance of AI in the industry, it showed an expanded presence in the academic fields. Such presence covers many fields such as commercial investigations. Now, AI has been investigated in this study from a more holistic aspect (e.g., Canhoto and Klear, 2020; Dirikan, 2015; Soni et al. 2020), so that SCM is recognized as one field using AI applications. Although experts and scholars pay specific attention to this issue (as shown with numerous studies on AI) (Jarahi, 2018; Kaplan and Hoenlein, 2020; Nishant et al. 2020; Ransbotham et al. 2017), further studies are needed to analyze the use of AI in the field of SCM. Multiple studies have talked about this need (Dubi et al. 2020; Min, 2010; Vargas Flores et al. 2015).

2. Method

To overcome the mentioned weaknesses of a review (Tranfield et al. 2003) or review of elites with temporary literature selection (Kichenham et al. 2009), the present study used an evidence-empowered and systematic review. The study followed the 5-step process explained by Denir and Tranfield (2009) including an elementary pilot in phase 1, to gain a deep understanding of the current literature, making regulations to choose literature, and derive research questions and next steps.

2.1. Elementary pilot and research question

Network management controls the relations within a company and among organizations and commercial units composed of material suppliers, purchase, manufacturing departments, logistics, marketing, and relevant systems, which facilitate the forward and backward processes, services, financial resources, and information from the main manufacturer to the customer with value-making advantages, maximization of profitability though the return and achievement of customer satisfaction.

2.1.1. Competitive analysis of artificial intelligence (AI) in the supply chain market

The development range of potential market shows high growth, which can be achieved by the market in next years. It is expected that strategic allocation and asset positioning can help competitive goals. Estimation of certain regulations introduced by the governments of several countries increases the market revenues. It has been predicted that the availability of appropriate means to make powerful distribution channels can specify the expansion of the market's future in the predicted period. The stability of economic government can mostly help favorable development of global market power. It is also predicted that advances in research and development equipment can affect market growth in the prediction period. The need to provide conditions for emergencies such as natural disasters, pandemics, and international commercial wars can enable the market to fight the challenges (Denir and Tranfield, 2009).

2.1.2. Research question

Making a research question is the most fundamental and maybe the most difficult part of research design. Recommendation of a research question can result in choosing research methods and strategies. In other words, a study is conducted based on research questions (Bryman, 2007). Conducting an elementary pilot made a question, based on which this study is created: what is the role of AI in the SCM studies?

The advantages of machine learning and artificial intelligence for supply chain management

Artificial intelligence (AI) can be one of the best technologies of the 21st century. The innovations of AI can be observed in all fields from health to agriculture. Supply chain management (SCM) is one field, in which AI has created multiple software and solutions.

Here, two important terms used in this study have been defined:

- Artificial intelligence (AI): it refers to a branch of computer science, which simulates behavior similar to human intelligence in machinery.
- Machine learning (ML): it is a branch of AI, which uses statistical methods and algorithms to facilitate the performance of computer systems in specific activities only by using the data and with no explicit programming.

Advantages of machine learning and artificial intelligence for supply chain management

1- Predictive analysis

The demand forecast is a way to analyze the demands of customers to optimize the supply chain processes, optimal inventory levels, and low costs as the main advantages of demand forecast.

The specialty of machine learning models is a predictive analysis of demand forecasts. These models can show the patterns hidden in historical data. For example, they can correlate the purchase behavior of customers with climate models.

2- Inventory management

One of the most underlying cases of using AI is the enhancement of the visual capability of ERP systems and machines. The computerized visual capability is a field of computer science, which enables computer systems to observe, identify, and process images.

Currently, machine learning has helped to sort mages more than before. It means that computer systems can recognize and classify the image components more accurately than a human.

In terms of supply chain management (SCM), computer vision can bring more careful inventory management. For example, designing an experimental system with a camera-equipped robot can check the stock inventory shelf by shelf.

3- Optimal management of purchase and logistics

Chatbot has been developed a lot over the years. It is applicable for purchase management and logistics in addition to using it in the field of customer services.

For example, Chyme provides verbal communication between the human operator and automated marketing-selling strategies. A big drink manufacturer implemented Chyme because of the inefficiency created by searching relevant data of purchase demands by the employees. The personnel had to call the support center and wait for operators to provide the required information by searching in multiple systems. By implementing Bot, AI-equipped purchase, and integrating it with ERP systems for immediate access to information; such inefficiency was significantly decreased.

Chatbot provides immediate information for the users in the field of the status of the commodity, stock inventory, stocking costs, and other affairs of purchase and logistics. This is a clear example of the advantages of AI for supply chain management, which improves the role of employees by creating a focus on more valuable tasks instead of wasting time to met simple problems.

4- Automated quality control

The manual quality control used in the procurement centers is performed mostly to inspect the packages or containers to find the spoiled goods while transportation. With the growth of AI, quality control can be also automated.

IBM Matson is an AI system used for the automatic analysis of defects in industrial equipment. The system used AI techniques by visual detection to control failure. Using AI to improve automatic quality control can decrease the delivery of spoiled goods.

5- Improved compliance

In some industries, the manufacturers have to comply with the special regulations of industrial product quality. Quality of supply is very important in the industries such as aerospace and health industries. For example, a lack of observance of regulations of the aerospace industry can endanger the life of passengers.

Supply chain management is a costly and time-consuming issue because the manufacturers in the highly supervised industries have to control thousands or even millions of suppliers to make sure that the suppliers comply with the standards. Machine learning models can facilitate the auditing and supervision of observing constructive elements.

6- Faster transport with higher efficiency

The unmanned machine industry is in the early stages of creation. Along with the advancement of the industry, it has created a high potential to decrease transport time. The truck drivers can be on the road only for a limited time during a certain period. The automatic AI and ML-equipped vehicles remove the limitation of driving time.

3. Results

The advantages of artificial intelligence (AI) and machine learning (ML) are specified in supply chain management (SCM). The technologies highlight the role of specialized laborers and enable them to make more value for their organization.

For digital delivery, AI may be what is needed to enhance operational efficiency and competitive advantages.

Literature review

Different papers are attributed to marketing, logistics, manufacturing, and SCM-related supply chain. Now, secondary fields and the content of the classifications are presented in summary.

Table 1. Search results

	ScienceDirect	Emerald Insight	JSTOR	Wiley	Taylor & Francis	
	Secondary fields					Total AI
Marketing	16 (10)	22 (1)	75 (1)	44 (1)	3 (2)	160 (15)
Logistic	44 (3)	5 (2)	41 (0)	13 (0)	2 (1)	105 (6)
Supply chain	25 (15)	5 (2)	15 (1)	1 (0)	4 (2)	50 (20)
Manufacturing	209 (14)	23 (6)	94 (1)	112 (0)	5 (2)	443 (23)
Total	294 (42)	55 (11)	225 (3)	170 (1)	14 (7)	758 (64)

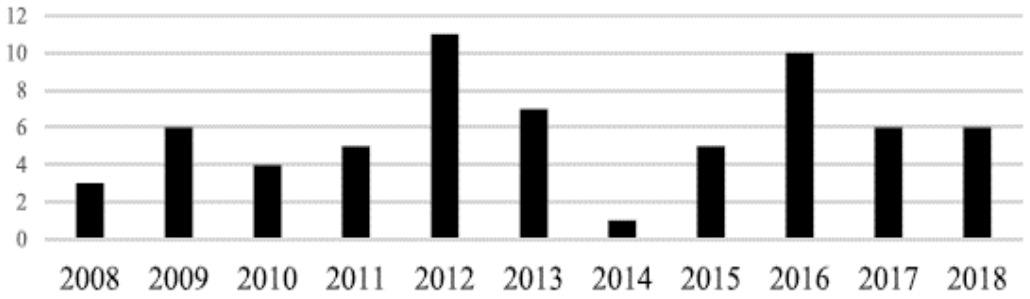

Figure 1. Time distribution

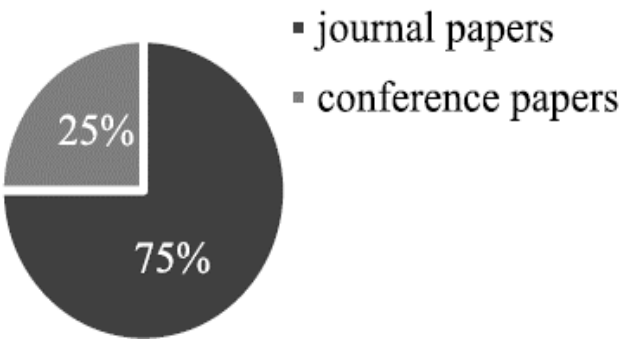

Figure 2. Distribution of the paper type

The AI techniques are used to recommend a pricing system for various products and services. Peterson and Flangan (2009) use heuristic methods through a decision support system (DSS) to estimate the number of rebounds required to attribute containers to the right places; although Cardoso et al. (2013) use automated programming to recommend a system for container loading. Wang et al. (2012) have recommended an intelligent system for industrial robots in the field of logistics. Nolle et al. (2016) have applied the inside predictive logistic planning method; although Clamp (2018) developed a multidimensional conceptual framework to differentiate human-artificial cooperation systems with the best and worst performances in the field of logistics. Schlikiz et al. (2015) have investigated the inter-organizational IOT by implementing a set of autonomous factors or activists. In the end, Lee et al. (2011) have shown that how AI and Radio Frequency Identification (RFID) methods can improve logistics workflow responsiveness.

AI techniques

Another feature analyzed in this study was the AI techniques used by other articles. The aim of AI techniques is the algorithms, architectures, data or knowledge formalisms, and methodological techniques, which can be des cribbed carefully (Bundy, 1997). To do this, the academic references reporting a comprehensive list of AI techniques in academic literature were reviewed at the first. The findings of Chen et al. (2008), and Min (2010) introduced a group of AI techniques and their uses. Also, Bundy (1997) provided a comprehensive catalog of AI techniques as references for different applications. Other references have been mentioned independent from the reference, where they were quoted. Table 4 has presented the AI techniques used in every field of literature, and Table 5 presents all AI techniques and their frequencies.

The majority of AI techniques can be observed in the field of manufacturing. In addition to a large number of papers, this is mostly because of the nature of literature in this field, which encompasses empirical studies, case studies, and the problem-solving papers of the real world. ANNs, GA, and ABSs are the most applicable techniques

in the field of manufacturing. Marketing is in the second rank in terms of variety among the 12 techniques used. The majority of techniques, ANNs and GA have possessed four papers. The third most used field was supply chain with 21 papers and 11 AI methods. ANNs, Fuzzy models, and GA are the most frequent techniques in this field. Finally, logistics had the least variety and encompassed 8 techniques out of 7 papers.

Table 2 has presented the frequency of AI techniques in the whole literature. As some papers have applied more than one AI method, the total frequency of AI techniques is more than the number of articles. In other words, 451 papers (64.1%) have a single-technique method; 13 papers (20.4%) have a two-technique method; 3 papers (4.6%) have a multi-technique method, and 7 papers (10.9%) have used a generalized approach on AI.

4. Discussion

The GAs can be mostly considered as function optimizers, and a wide range of problems use GAs (Whitley, 1994). The GA as an AI method considers different classifications of combined decision problems. These problems encompass complicated managerial challenges about the supply chain activities including the sale, source finding, making, and delivering products and services. The role of GAs has been increased for the development of managerial decision-making processes and as a result of improvement of return on supply chain (Min, 2015). The GA has been changed into the popular method in many SCM studies, and this is because of a wide range of uses of GA including multipurpose optimization of supply chain networks (Altiparmak et al. 2006), choosing a partner in the field of the green supply chain (Yeh and Chong, 2011), multiproduct supply chain networks (Altiparmak et al. 2009), and problem-solving method for closed-loop supply chains (Kennan et al. 2010).

Data mining is a new field, which is created by combining several fields and can be stimulated mostly by the growth of a huge database (Hund, 2013). The motivating stimulant in the early part of data mining is that the large databases contain valuable data for the owners of the database because they can provide information on decision-making and other processes. In the field of SCM, data mining can be used in several ways such as stock control and supervision, food supply chains, and sustainability in supply chains (Ting et al. 2014; Wang and Yu, 2017), improvement of knowledge management and marketing (Shaw et al. 2001), and improvement of innovative capabilities of the supply chain (Than et al. 2015).

Multiple studies on CBR have applied a psychological concept-based method, in which people use their knowledge through solving multiple problems (Clifton and Frohnsdorff, 2001). The CBR working as a cognitive science model and AI, in which inference is modeled based on the main memory, solves the new problems by getting cases collected and saved from periods of solving similar problems and by adjusting the answers to match them with new needs (Leik, 2001). CBR has been applied in SCM studies in form of methods including mechanism design for supply chains under demand uncertainty (Kion et al, 2007), supply chain risk management (Gianakis and Luis, 2011), supply chain performance evaluation (Homfriz et al, 2003), agile SCM (Lu et al. 2004), and supply chain negotiations (Fang and Wang, 2010).

Congestion intelligence (CI) studies forming some part of collective elites analyze the behavior of social insects by determining their return on solving complicated problems such as finding the shortest way to nest, and food resource or nest organization (Saka et al. 2013). During the last 20 years, such a method gained attention in almost all fields of engineering, science, and industries (Yang and Karamanoghlu, 2013). In the SCM studies, the methods used to design the pricing systems include production line optimization (Tesafarakis et al. 2013), refilling inventory (Sinha et al. 2012), optimization of supply chain network architecture (Kadadvaramas et al. 2012), supply chain cost minimization (Kumar et al. 2010), and agile supply chain network designation (Bachalus et al. 2008).

The SVM is another method used in the AI-SCM literature, which uses a linear classifier for data classification (Peter et al. 2019). The method is capable to recognize the fundamental models in the noisy and complicated dataset (Hongmao, 2016). SVMs have been introduced in the 1990s, and have been widely used in different fields (Gholami and Fakhari, 2017). From SVM perspective, it has been applied in various studies and for different purposes such as supply chain demand forecast (Charbonneau et al. 2008), time series classification in supply chains (Garcia et al. 2012), choosing a supplier (Goshang and Gohang, 2008), and designing systems for supply chain networks (Surana et al. 2005).

One of the most promising cases includes natural language processing (NLP): studying computer programs using human language (natural) as input. The NLP applications vary by tasks from low level (attributing the parts of the word to words) to the top-level (giving certain answers to questions) (Cohen, 2014). In other words, NLP refers to using computers for understanding and processing human language in form of text or speech (Jiman and Johnson, 2001). Machine translation (automatic translation of text or speech from one language to another) was started by very old computers (Chai et al. 1994) and is being now used in different businesses. Also, the NLP user interfaces enable computers to use natural language to communicate with people, such as database queries (Jiman and Johnson, 2001). Such feature allows NLP to be changed into an important facilitator in SCM, which is mostly because of its potential in improving and simplifying the man-machine interactions. Text mining is an example of

NLP in its practical application; meaning finding information in different types of texts (Cohen, 2014) to help manufacturing, construction, and logistics. Also, such a process can accelerate industrial procedures, and improve data production and collection processes as a result of simplified machine-man interactions. The majority of NLP systems are based on formal language (a description of language). Such systems distinguish language from sentences and recognize the descriptions with defining sentence phrases, their relevancy, and certain aspects of their meanings (Jiman and Johnson, 2001). Advanced use of the process is evident in the chat robots (chatbots), which are being used in today's world more than before. Chatbots are new computer-based innovation in marketing communications in the platforms and websites of social networking (Van Den Broek et al. 2019). Using NLP in form of the chatbot has huge potential in marketing battles, online advertisements, brand management, customer relationship management (CRM), and data collection. Chatbot as a tool to improve customer relationships (Latern and Glavas, 2017) is a professional commercial tactic introduced to Facebook in 2016 as a tool for companies to accelerate and facilitate customer service processes (Van Den Broek et al. 2019).

The example of using AI in supply chain and logistics for companies

A new study has estimated that jobs spend about 6500hrs per year on doing works, which can be done more effectively and efficiently by digital automation: document processing, registering purchase orders, and answering supplier questions. Hence, many companies have begun the implementation of AI technology in the field of logistics and supply chain-related activities. As a result, manpower finds free time to do more complicated activities, which are not within the limit of the power of computers. However, they can't still do them.

Artificial intelligence has countless uses in the supply chain. The affecting fields in supply chain and logistics domains include operational procurement using intelligent data, and chatbots, supply chain planning for supply and demand forecast, stock management for inventory optimization, fast transportation to reduce delivery time, and transport costs, and optimal selection of supplier using the up-to-date data.

Here, 13 examples of the way of using AI to improve logistics activities are presented:

1. Echo Global Logistics Company

Location: Chicago, Illinois

Website link: https://www.echo.com

The way the company uses AI in the supply chain and logistics: Echo Shipping Company uses AI to provide supply chain solutions, which optimize logistics transportation needs so that the customers can ship their products fast, safely, and at low cost. The services provided by this company include price-related negotiations, shipping logistics; execution and follow-up of transportation; management, selection, reporting, and adapting the above-mentioned cases to company policies; provide executive dashboard and detailed transportation reports, and so on.

2. HAVI Company

Location: Downers Grove, Illinois

Website link: https://www.havi.com

The way the company uses AI in supply chain and logistics: The AI enables HAVI Company to use predictive analysis to provide multiple solutions in the field of supply chain management and logistics. The first state includes programming, optimization, resource, and data management. The second state includes logistics, transportation management, stocking, and distribution.

3. C3 Company

Location: Santa Ana, California

Website link: https://c3.ai/

The way the company uses AI in the supply chain and logistics: The manufacturers use AI-based C3 inventory optimization platforms to manage the inventory in desired time relevant to purchased parts, elements, and final product. Using advanced AI algorithms (machine learning), the C3 system is learning things from the manufacturing orders, purchase orders, and delivery to the relevant offers of simple products, and so on.

4. Symbiotic Company

Location: Wilmington, Massachusetts

Website link: http://www.symbotic.com/

The way the company uses AI in the supply chain and logistics: The Symbiotic Company takes designing, making, and examining AI-based robots, which provide manual flexible or automated solutions based on the company's products, operating process, and customer needs.

5. TTEC Company

Location: Englewood, Colorado

Website link: https://www.ttec.com/

The way the company uses AI in supply chain and logistics: the TTEC intelligent virtual assistants make robots to optimize the customer experience. These robots are designed with simulated human empathy, they can learn things from past interactions, listen to people throughout the audio and text channels, and understand the questions and emotions. If a robot is unable to answer a question, it introduces an operator to answer the question.

6. Uptake Company

Location: Chicago, Illinois

Website link: https://www.uptake.com/

The way the company uses AI in supply chain and logistics: Uptake uses AI and machine learning for the analysis of telematics data (relevant data of remote shipping) to predict failure to decrease the spoil of vehicles and machinery such as trucks, cars, railway, combine machinery, and airplane.

7. Coyote Logistics Company

Location: Chicago, Illinois

Website link: https://www.coyote.com/

The way the company uses AI in the supply chain and logistics: using UPS, the Coyote Company applies different methods such as prediction analysis, AI, and machine learning to adjust customer shipping information with outside data (traffic in real-time, and weather). The company sends the data to help the product submitters in the field of predicting events relevant to the supply chain, such as delays. As a result, the submitters can provide periodic programs, so that the goods can be delivered on time.

8. Zebra Technologies Company

Location: Lincoln, Illinois

Website link: https://www.zebra.com/us/en.html

The way the company uses Ai in the supply chain and logistics: the supply chain and logistics solutions of Zebra Company include intelligent packaging of Trailer, which uses software and data analysis to integrate in real-time in the loading process and enhance the efficiency. The special advantages of such a strategy include optimization of shipping space as a result of lack of space, and decreased operating costs. Fast and efficient processing of packages, decreased damages and spoil of package, and improvement of the safety of laborers are the most underlying advantages.

9. Epicor Software Company

Location: Austin, Texas

Website link: https://www.epicor.com/default.aspx

the way the company uses AI in the supply chain and logistics: Epicor Company uses Microsoft Azure as an AI-based platform to provide intelligent commercial solutions for the manufacturers and suppliers (especially in the field of supply chain and logistics). Since the last spring, the company has been aimed at using the capability of converting speech to text, and advanced Microsoft search to improve the interaction of customers with their programs.

10. LivePerson Company

Location: New York

Website link: https://www.liveperson.com/

The way the company uses AI in the supply chain and logistics: The AI-based conversation platform of the Live Person Company called Maven facilitates customer support by measuring the intention of the consumer in addition to determining the place of conversation. Also, Maven holds every conversation simultaneously whether by a human, robot, third-party technology, or a combination of all of them.

11. ASPENTECH Company

Location: Belford, Massachusetts

Website link: https://www.aspentech.com/

The way the company uses AI in the supply chain and logistics: Aspen Company uses AI to optimize the relevant programs of logistics, manufacturing, distribution, and inventory supply programs, which meet customer demand and revenue goals of the company. Aspen supply chain programmer uses value-oriented analysis to consider several assumptive scenarios. Also, the company separated the scenarios, which optimize inventory management, minimize shipping costs, and provide a supply-demand balance.

12. Data Art Company

Location: New York

Website link: http://www.dataart.com/

The way the company uses AI in the supply chain and logistics: using AI and machine learning, the company helps customers to improve their operating productivity, predict purchase behavior, and make consumers be involved in this process reasonably. Also, the company provides moment analysis of supply chain data and compliance of logistics processes and other vital factors.

13. Infor Company

Location: New York

Website link: https://www.infor.com/

The way the company uses AI in the supply chain and logistics: the intelligent supply chain programs of Infor Company use advanced algorithms, optimizations motors, and machine learning to connect supply chain digital information to the real world. Through this, the companies can make decisions relevant to their business more consciously.

5. Conclusion

The recent progress in the calculation power of computers has enabled the growth and complexity of AI applications. According to the purpose of this study, the results showed that the most common AI technique is ANN, which is usually used to find complicated models that can't be used by humans, the ANNs can be used for techniques such as packaging operations, container terminal, and the operations revealing high robotic effects. Therefore, multiple classes of problems can be solved including model classification, proximation, optimization, clustering, function, forecast, content recovery, and process control. The second popular method is FL, which is a kind of multi-value logic for the management of the concept of partial reality. As Bundy (1997) infers, FL generalizes simple Boolean Operators by providing some inferences. Contrary to the basic set theory, in which an object is a member of a set or it is not, a fuzzy set gets a value in the range of (0, 1). Hence, the fuzzy models can describe ambiguous phrases using natural language (Chen et al. 2008). The results showed that FL is widely used as a modeling tool, and is also a popular method to make combined intelligent systems. The third method is ABS/MAS, which is widely used in the field of SCM. The dominant method takes measure to solve a special problem with understanding the surrounding environment, and taking measure automatically. The operators have been widely used in the field of SCM to solve multiple types of problems in supply chain programing, supply chain systems simulation and designation, analysis of complicated behavior of supply chain, and negotiation-based participation modeling.

Other dominant methods observed in the literature are: GA as a kind of searching method that imitates natural choice, and can solve types of combined decision problems; data mining used to provide information and attitudes for decision-making based on big datasets; CBR as a cognitive psychological method that is responsible for solving new problems with the recovery of collected and saved information from simultaneous problem solving, and adjusting answers for the new requirements; congestion genius, which imitates the behavior of social insects to solve complicated problems; and SVM that uses a linear classifier to classify the data to extract basic models in the chaotic dataset. Less popular AI methods used in the field of SCM studies include Simulated Annealing, Automated Programming, Association Law, Tree Models, Hill Climbing, k-means Clustering, Elite Systems, Heuristics, Robot Programming, Progress Simulation, Bayesian Networks, Physarum Model, RBR, decision trees, and Gaussian models. These techniques have been applied in SCM studies; although they have not been used as much as ANN, FL, ABS, GA, Data Mining, CBR, and SVM are used. This can make an interesting gap, which should be investigated in future studies. Also, the results have revealed some AI techniques needed for future studies and industrial applications such as NLP (man-machine interaction), TS (optimization, robot dynamics, and programming with emphasis on creation of intelligent robots), and MDP (a framework for decision process modeling). Besides, it could be found that the logistic and SCM network-based nature creates a natural framework, by which the AI is implemented. A network of suppliers, for instance, produces big data and necessitates agile decision-making. Hence, using AI tools is firmly recommended for the analysis of big data and DSS. The SCM companies are also dependent on physical and digital networks, which work on large volumes, lean asset allocation, low margins, and time-sensitive deadlines. AI facilitates the optimization and improvement of network compliance

efficiently, which is impossible for humans. Therefore, conducting studies on interactive decision systems promotes a deep understanding of AI responses. Hence, it can improve the capabilities of such responses. Using such systems enables AI to help the industry to redefine today's methods with the evolution of operations from passive to preconceived types, annual to automated processes, standardized to personal services, and production planning from the prediction to forecast. Improvement of computer chip technology is a basic part of the wide use of AI. As logistics is associated with transportation, using computer chips is vital for tracking. As tracking produces a large volume of data that can be analyzed and interpreted for many purposes, it is essential to conduct studies on such processes. As an underlying part of networking, customer interaction automation is a new but promising field. Chatbots are a new generation of customer services with high productivity and acceptable return on investment. As virtual assistants have been developed to enable more complicated conversations with customers, they can be used for customer service automation effectively.

6. Limitations

The present study includes some limitations just the same as any other work. Taking a literature review to identify the academic gaps and evaluation of current knowledge in this field can provide a wide expanded attitude. As this study was aimed at covering a wide set of knowledge or multiple secondary fields, all details of the used papers are not explained. Hence, a more careful and focused study is required in this field.

This study includes managerial and theoretical inferences, which can be used to the theory and implementation in the field of SCM. First, this study participates in the theory with the analysis of the progress of AI in the field of SCM. From this perspective, the most common AI techniques used in SCM have been covered to provide a comprehensive aspect of the works conducted in this field. To answer the second research question (SRQ), it could be mentioned that potential AI techniques used in SCM studies have been discussed. Here, the study is aimed at presenting a wide range of less popular techniques, which can be effective in future studies. The third SRQ was associated with secondary fields and tasks in SCM, which have been improved by AI previously. The study was aimed at analyzing the existing literature, which can be a basis for future studies. Also, the study allows the authors to find out that what works have been conducted before this. With answering the final SRQ, the secondary fields and AI-improved tasks are discussed to obtain attitudes and information in this field for further studies. In addition to these four sections, this study explains the existing gaps, and the future work opportunities, which can improve the literature. This can not only pave the way for future authors, but it can also act as a structure-based instruction that prevents iteration and biases in further AI-SCM studies.

The results of the present study have provided multiple inferences for the managers and experts in this field. Here, the notes and instructions are recommended:

GA includes an expanded collection of applications, which can not only attend academic investigations but can also play role in the development of management decision-making processes, and improvement of return on the supply chain (Min, 2015). GA has been changed into a popular method, which is because of its applicability for multipurpose optimization of supply chain networks (Altiparmak et al. 2009), and the problem-solving method for closed-loop supply chains (Kennan et al. 2010). Therefore, the study recommends the managers use GA-based solutions in the form of ordering software to solve the supply chain problems.

NLP is another AI technique with the potential of changing the future of SCM. Various uses of this method have been presented before this; although the perfect potential of NLP is still undiscovered. Today. NLP has been used in the form of chatbots in marketing battles, online advertisements, brand management, customer relationship management (CRM), and data collection.

Glover et al. (2008) have presented a wide range of TS applications from an SCM perspective: workforce planning, machine time scheduling, transportation network design, service network design, flexible manufacturing, "right on-time" production, multi-item inventory planning, volume allocation acquisition, project portfolio optimization, vehicle routing, and multi-mode routing.

Robots have been widely used as it was observed in manufacturing, and stock logistics (e.g., Amazon Robotics). However, the dynamics of robot and robot programming are not new in the field of SCM (especially from practical perspectives, manufacturing, and stocking), and the expanded potentials of these fields are not completely used. In the wide expanded secondary fields of SCM, the present study has revealed restricted use of these techniques such as packaging, and terminal container operations with high robotic effect. Therefore, not only scholars can conduct an expanded review or empirical investigations on automated robots, but the managers can also take benefit of robots in the field of logistics, stocking, and manufacturing.

Similar to other decision models, managers can use MDPs in the processes and SCM tasks. Although there are limitations to use this method, it has strong potential to be used in the field of SCM. The MDP can be mostly used to optimize programming and allows the decision-maker to decide in special situations.

The expert systems can help SCM managers in the form of DSS, especially in the field of dealing with module measurement and supplier/buyer selection. Also, other AI-based techniques including distributed problem-solving, and hierarchical planning are useful for SCM managers. Such methods can be potentially used in this field because of the futuristic nature of supply chain planning.

Further studies

Although some studies have provided information about using AI in the SCM, there are still academic gaps in this field. With the analysis of relevant literature, several academic suggestions have been identified, which have been presented by the authors or have been achieved by literature analysis or synthesis. For example, it was found that further studies are needed in this field to find more details; although supply chain combination was studied by AI scholars (Regal and Priera, 2018). According to such an academic gap, further studies can be conducted using ABS with the capabilities of managing advanced complexity to solve problems in the field of supply chain combination. Such ABSs can be also used for supply chain risk or disaster management problems. Both of the mentioned fields are detected gaps (Min, 2010).

Real-Time Pricing (RTP) is a management factor for the key demand party to regulate the load curve to achieve load peak. As it was mentioned in the literature (Min, 2010), it has the potential of being covered in a deeper level using AI. Also, it was found that studying RTP is somehow dependent on the country so that the majority of studies are focused on China (Jiang et al. 2019; San et al. 2018; Wang et al. 2018). Therefore, further studies should be conducted with a focus on non-Chinese markets.

Reverse sales, in which sellers offer a price to sell their products (Min, 2010), is another gap in the literature. In the field of AI, further studies are required on reverse sales including supply chain partners using AI techniques such as heuristic pricing methods.

Statement 1: ANNs and ABS/MAS are the most common AI techniques in the field of SCM, and have been the most effective methods in this field.

Statement 2: ANN and ABS/MAS have been mostly focused on the SCM literature. Hence, they have been the most effective techniques in the field of implementing SCM.

Statement 3: Using an AI method in both theory and implementation steps is dependent on the availability of software/applications of that method.

Statement 4: Using AI in the field of SCM happens through using suitable AI-based software (on the AI side) and well-defined SCM problems, which can use this software (on the SCM side). Hence, both scholars and experts need special software and well-structured problems to use AI in the field of SCM.

Statement 5: The empirical studies producing AI-based models, systems, and frameworks can leave positive and direct effects on the practical use of AII.

Statement 6: Improvement of less popular AI techniques and discovering their modern applications can improve the secondary fields of SCM, which have not been emphasized significantly.

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