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APPLICATIONS OF ARTIFICIAL INTELLIGENCE METHODS FOR ENHANCING INFORMATION SHARING IN SUPPLY CHAINS: SYSTEMATIC REVIEW

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ABSTRACT

Supply chain Management SCM, improving Information Sharing IS becomes increasingly important to promote business, achieve a significant competitive advantage, and, ultimately, assure the survival and growth of firms. This paper reviews how artificial intelligence AI methods can improve SI in SCM by performing a systematic literature review. Its goal is to find out current AI techniques that can improve IS in SCM. According to our findings, Demand forecasts are the main shared information that attracted more attention. In addition, we found that AI methods are most commonly applied in production management. Furthermore, Machine learning (ML) is the most widely employed AI subset for enhancing IS in SC and the artificial neural network (ANN) is the most popular ML method.

Keywords: *Artificial Intelligence, Information Sharing, Supply Chain Management, Artificial Neural Network, PRISMA*

1 INTRODUCTION

SCs are exposed to a variety of risk sources that are hard to predict. Indeed, without IS, companies are forced to adopt traditional management approaches. As a result, uncertainty increases, and information flow fluctuates. Therefore, it is crucial to monitor actions and to be aware of what is happening upstream, downstream, and possibly in other entities not directly related to the SC.

The effect of IS in SC is widely studied in the literature. Indeed, IS has been cited in the literature as the key to improving SC performance [1]-[3]. For this reason, [4] investigated the impact of IS on SC performance. They measured the value of IS and compare it with the value of reducing lead time and increasing lot size. The results showed that the IS resulted in an average cost reduction of 2%, and a maximum reduction of 12%. The lead time was reduced by almost a half, which led to an average cost reduction of 21%. Decreasing the size of the delivery lots resulted in a 22% reduction. In addition, [5] examined the effect of sharing forecast information on the performance metrics of an industrial SC. They showed that potential cost savings could be improved by using shared improved forecasts. Moreover, [6] studied three cases of IS in SC; case 1: there is no IS, case 2: there is a partial IS, and case 3: total IS. They conclude that moving from the second to the third case allows a 35% cost reduction.

Some works highlighted the relationship between IS and SC partnerships. For instance, [7] established decision rules for the level of IS to be adopted between wholesalers and retailers based on the substitutability of finished products. Moreover, [8] showed that the value of IS decreases when the number of retailers increases whereas [9] noticed that the benefits of IS differ based on the type of the request and the customer's behavior.

On the other side, some works sheeted light on the distortion of IS flow. This distortion is called the Bullwhip effect BWE. It is a distortion of information flows in the SC that generates increasing variability in demand, from retailers to manufacturers [10]. The first paper describing this phenomenon dates back to 1961 [11]. Forrester (Forrester, 1961) discovered the bullwhip effect, also known as the Forrester effect.

Consequently, [4] recommended accelerating IS to improve the efficiency of a

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distribution SC and reduce the BWE. SC structure is involved as well. Indeed, [10] noticed that the structure of the SC is an aggravating or mitigating element of the BWE. This effect is quantified for simple, two-stage SCs consisting of a single retailer and a single manufacturer [12]. They conclude that demand forecasting and the lead-times are the main cause of BWE.

Recent advances in information technology have been helpful in this regard. Today, different types of data, such as point-of-sale data, inventory, forecasting data, and sales trends, are shared among SC partners quickly and cost-effectively. The use of New Information and Communication Technologies (NICT) for improving IS is examined as well [13]. Indeed, [14] recommend the use of (NICT) in partner collaboration as it facilitates collaboration between SC partners. For instance, an ERP provides unified, integrated, consistent, and homogeneous information to all company stakeholders. However, [15] noticed that direct contact with clients is important because even if information technology facilitates IS practices, it can only be achieved if members of the SC are effectively engaged in a collaborative and inclusive approach [16].

For IS modeling, [17] used discrete event analysis to study the impact of IS in SC. Others employed an analytical approach considering different sets of assumptions that might not capture realistic situations in actual organizations [18]. Furthermore, [5] employed a simulation approach, followed by a numerical investigation on real data validation whereas, [19] modeled existing collaborative projects in SC using the Unified Modeling Language UML, such as third-party logistics (3PL), supplier-managed inventory (VMI), or collaborative planning, forecasting, and replenishment (CPFR).

1.1 AI and information sharing IS:

Artificial Intelligence (AI) is a discipline of computer science that is one of the primary pillars on which today's technology sector is built, and the word AI may be described as the ability of digital machines and computers to execute certain activities that replicate. It is analogous to what intelligent beings do, such as the ability to think and learn from previous experiences, or other mental processes [20].

AI is largely used for enhancing SC performance. To increase their functionality, many firms are switching from remote monitoring to control, optimization, and potentially sophisticated autonomous AI-based systems [21], because issues solving becomes more accurate, faster, and with a larger number of inputs when AI is well used [22]

Indeed, many works seek to identify the contributions of AI in that field through the existing literature. For instance, [23] demonstrate the use of AI techniques to propose an approach for the design of fuzzy control charts.

In addition, [24] used decentralized data analysis for information extraction and data reduction; their methodology can help spot production problems and save money on machine maintenance. Moreover, [25] reviewed the contributions of AI to SCM. They conclude that the most popular AI technique is the artificial neural network ANN, which can be seen across all economic fields.

Furthermore, a survey is conducted by [26] to identify the most effective AI methods of SC for forecasting methodologies. To increase inventory performance, [27] develop a forecasting model for retailers based on AI methods. According to [28], machine learning ML can be an effective way to understand the collaborative behavior of SC partners and the motivations behind it.

The benefits of AI increase productivity, efficiency, and financial gains, reducing waste, energy consumption, and labor costs, allowing transnational corporations to reinvest and exploit more natural resources to increase global production and thus reinforce the global environmental crisis. although there is an abundance of works dealing with the contribution and benefits of AI in various industries [25]-[28]–[30]. A few review papers that either directly or indirectly address AI methods for enhancing IS in SC. Table 1 provides a summary comparison of these review papers. Based on the literature existing reviews, there are some research gaps. This gap is addressed by the current study through a systematic review. Thus, the objective of this study is to assess the impact of AI on IS in SCM. In other words, this paper aims to examine how AI methods enhance IS in SCM by highlighting: the economic sector, the SC process in which AI is more applied, shared information most mentioned, and the AI subsets and methods most used.

This paper is organized as follows: the first section presents the methodology, the second discusses content analysis, and the third section discusses findings, which includes a classification of assessed papers by item type, AI methods most usually used, and research topic. The next section is devoted to a comprehensive assessment of the findings, with a focus on our previously established goal. The final section discusses the study's limitations and conclusions.

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Table 1: Comparison of related review papers.

Authors	supply chain area	Review time	Decision-making levels	AI subsets	Outcomes	IS (shared data)
[25]	Marketing Logistics Production Procurement	2008–2018	No	Artificial neural networks Fuzzy logic and models Multi-agent and agent-based systems Genetic algorithm Data mining Case-based reasoning	Systematic review	No
[31]	Inventory control and planning Transportation network design Purchasing and supply management . Demand planning and forecasting Order-picking problems Customer relationship management And e-synchronised SCM	1986-2008	Yes	artificial neural networks (ANN), rough set theory, machine learning, expert systems, and Gas, fuzzy logic, agent-based systems	Review	Yes
[32]	Decision Making Finance Forecasting Inventory Management Logistics Manufacturing Performance Measurement Planning Procurement Quality Management Risk Management Supplier Selection Supply Network Design Sustainability And others	1998-2019	No	Machine learning Decision making	Review	No
[33]	Supply Chain management Decision-Making Sustainable Development Sustainable Supply Chains Information Management Product Development Operations Management Multi-objective Optimization Reverse Logistics	2018–2019	No	Artificial intelligence, genetic algorithms, agent-based systems, expert systems, big data analytics	Review	No
[34]	Supply chain risk management	1996–2018	No	No specific AI subsets	review	No

2 METHODOLOGY

2.1 Sections and Subsections

To answer our objective, this chapter evaluates methods of AI used to improve IS in the SC by conducting a systematic review. This is a particular type of literature review, that is methodical, comprehensive, transparent, and reproducible. Indeed, the systematic methodology and presentation are intended to minimize subjectivity and bias [35].

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In the review process, all articles are collected using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses method PRISMA [36]. PRISMA focuses on how writers can guarantee that systematic reviews and meta-analyses are reported transparently [37].

The methodology is identified through several phases. We identified the randomized search for articles published up to 2000, from electronic databases Taylor and Francis, Wiley online library, Jstor, ERIC, Scopus, IEEE, and Google scholar. We developed search requests properly for each database by combining relevant search keywords related to the topic. The request "artificial AND intelligence AND for AND enhancing AND information AND sharing AND in AND supply AND chain" is used to launch the research. After the first search, duplicate articles were excluded. An abstract and title analysis is examined as well, Studies were excluded if the abstract is not relevant. After this phase, Pre-selected articles were evaluated by a full analysis of the articles. Articles were included if they met the following inclusion criteria. In the final list, we have a set of 125 articles. This sample is analyzed according to the year of publication, type of items, framework, objective, methodology, artificial intelligence method(s) used, sector, SC process, results and discussion, limitations, and hypotheses. Findings are compared and discussed as well by focusing on our previously established objective.

This process is shown in appendix 1. This PRISMA diagram explains the different phases for selecting the sample of articles.

2.2 Inclusion/exclusion criteria

- Only articles published in English are accepted.
- Only articles published after 2000 are accepted.
- Systematic review studies and associated meta-analyses are accepted.
- All types of studies (e.g., observational studies, case studies) were included.
- Theses and books were excluded.

Literature and company reports or texts from non-indexed local magazines or books were excluded.

Because of the unlimited number of studies on this topic, study relevance was used as an exclusion criterion.

3 RESULTS

25901 articles were identified. Table 1 displays article numbers for each database. After duplication removal, 5643 articles were eligible for screening based on titles and abstracts, and 3874 articles were excluded (they don't meet inclusion/exclusion criteria), leaving 1769 articles for full analysis and other inclusion/exclusion criteria. The final article set is 125 selected articles.

Table 2: Article number by database

Scientific databases	Request	Article Number
SCOPUS	Artificial AND intelligence AND for AND enhancing AND information AND sharing AND in AND supply AND chain	1113
IEEE		6
EMERALD INSIGHT		1000
Taylor and Francis		1585
Wiley online library		2492
JSTOR		2105
Google Scholar		17600

3.1 Type of item

The overall classification of the items by item type is shown in Figure 1. 67% of the items studied are conference items while 32% are journal articles.

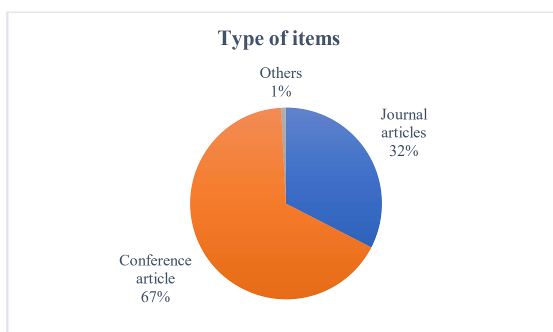

Figure 1: Type of items

Table 3: Summary of the categorisation of the literature.

Items type	Study
Journal articles	[38][25][39][40][41][42][43][44][45][46][47] [48][49][50][51][52][53][54][55][56] [57][58][59][60][61][62][63][64][65] [66][20][67][68][69][70][71][33][72] [73][74][75]
Conference articles	[76][77][78][79][80][81][82][83][84] [85][86][87][88][89][90][91][92][81] [93] [94][95][96][97][98][99][100][101][102][103] [104][105][106][107][108][109][110][111][112][113] [114][115][116][117][118][119][120][121][122][123] [124][125][126][127][128][129][130][131][132][133] [134][135][136][137][138][139][140][141] [142][143][144][145][146][147][148][149] [150][151][152][153][154][155][156][157]
Others	[158]

3.2 Scientific Production

The first analysis concerns the scientific production per year since 2000. As shown in figure 2, the number of papers on the use of AI in AI CLs has increased with slight fluctuations over the years. This figure shows a considerable interest in this topic in the scientific research field.

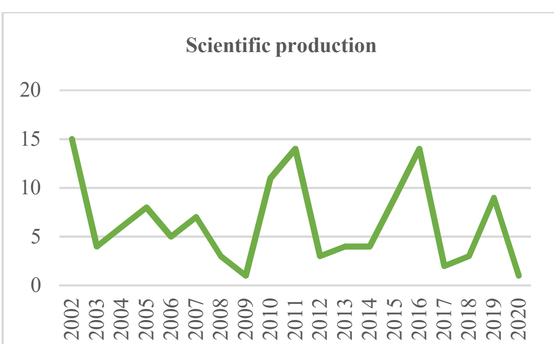

Figure 2: Scientific production per year

3.3 Classification by economics sector

The classification by economic sector is examined as well. As shown in figure 3, the sector most common is the automotive industry. The second sector is food/agricultural industries' while the third most common sector is retail and food service.

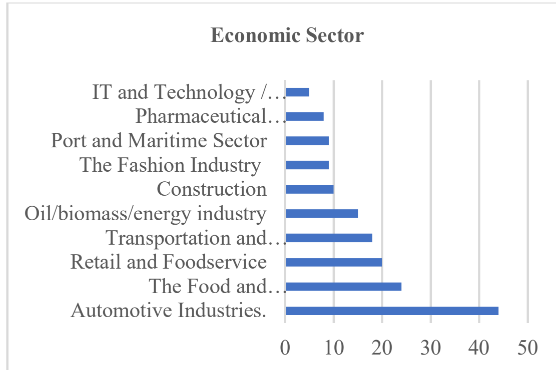

Figure 3: Classification by economics sector

3.4 Classification by SC process

For the SC processes, 64% of the works applied AI methods to the production management process. The procurement and purchasing process is in the second position with a percentage of 24%. The remaining 11% percent is for the other processes.

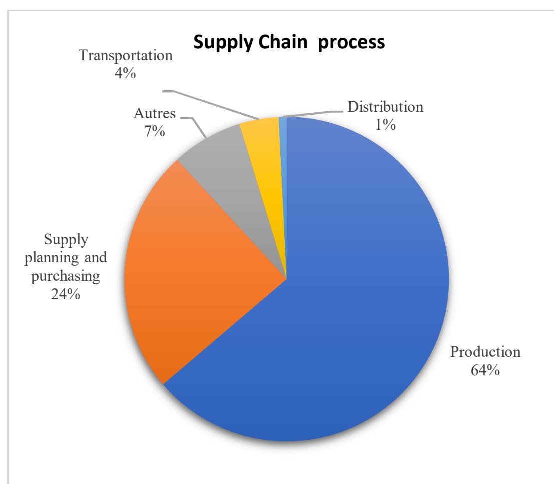

Figure 4: AI methods by SC process

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3.5 Classification by type of shared information

Table 4: Classification by shared information

Shared Information	Frequency
Demand forecasting	23%
Production schedule	11%
Supplier information	10%
Inventory	9%
The product went on backorder	9%
Row material	9%
Sales forecasting	8%
Order status	7%
Customer satisfaction	5%
Leadtime	5%
Vehicle routing information	4%

Table 2 displays classification by shared information in SC. 21% of works investigated how to enhance demand forecasts by using AI. 11% and 10% investigated respectively production schedule and supplier information. Inventory, Product went on backorder and row material is made up of 9%. 8% and 7% investigated respectively sales forecasts and order status. Customer satisfaction, lead-time, and vehicle routing information are made up of almost 5%.

3.6 Classification by AI subsets and ML methods

In this study, the AI branch most used to improve IS in the SC is the ML, with a percentage of 59%. Agent systems are in the second position with a percentage of 15%. 11% for optimization methods.le percentage of other AI subsets is shown in figure 5.

The classification of ML subsets is done as well. As shown in figure 6, the ML technique most common is the artificial neural network "ANN" while The second most method is fuzzy logic/fuzzy inferences. The genetic algorithm "GA" is in the third position. The fourth method is Support Vector Machines " SVM ". k-means or " k-means clustering " and " trees based models " are in the last position with a slightly equal frequency.

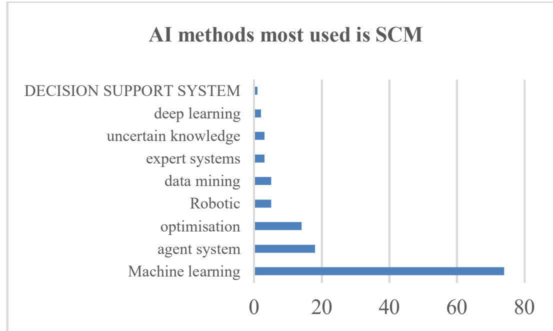

Figure 5: AI methods most used in SCM

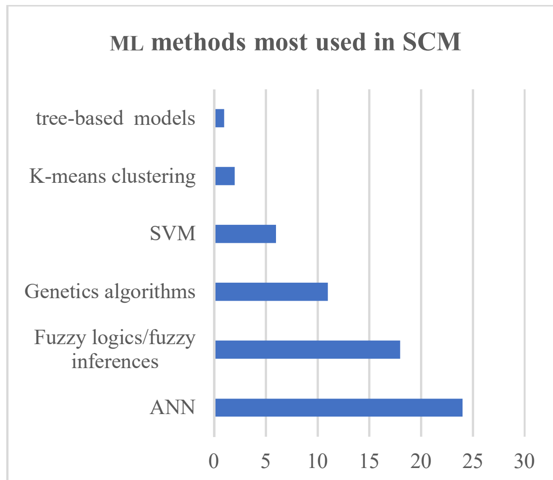

Figure 6: ML methods most used in SCM

4 DISCUSSION

4.1 Classification by Economic Sector:

4.1.1 Automotive Industry.

AI is largely applied in the Automotive industry. Indeed, [80] studied the opportunities, benefits, and risks of applying AI technology along with the automotive SC. In addition, [55] defined the ability of AI to facilitate the execution of SC management. Moreover, [69] developed a performance evaluation model, for the entire SC management system, that links specific problems to the most relevant key performance indicators for each subsystem. the green SC is examined as well. Green SCM is involved as well. Indeed, [53] provided holistic assessment and support for strategic decision-making in green SCM.

To promote coordination under decentralized decision structures, [104] studied the interest-risk mechanism and the related mechanism.

Furthermore, [144] evaluated and selected SC partners with low risk and high reliability with AI methods

To enhance procurement, [77] presented a multi-object negotiation model of a multi-agent system and proposed the negotiation strategy between the purchasing agent and multiple procurement agents.

For the production process, [149] created a general scheme for synergistic SC production and a new approach to synergistic production process control based on numerous monitoring modes for manufacturers and partners to coordinate SC production planning.

The sustainability and environment are also involved. Indeed, [159] presented the special properties of a green SC management system under the moderating effects of product complexity and purchasing structure whereas [47] proposed a multi-objective model for cost and CO2 minimization.

4.1.2 The Food and Agricultural Industry

The agriculture domain [56] highlighted the use of AI for sustainable food systems and design to address change.

According to [111] "AI is making all industries innovative, especially with the availability of digital tools available and the agricultural industry has several properties that make it a prime target for AI. They presented the benefits, applications, and negative consequences of AI on the agricultural industry"

In addition, [127] presented a process of constructing a vegetable SContology and provided a framework for expressing knowledge about vegetable SC.

The risks of food SC are analyzed. [108] evaluated the risk factors and their influence on the entire chain. Managers have an interest in managing the risks of the chain to maintain a competitive position in the market[108].

Using the Internet of Things IoTs approach, [117] ensured that food SC management activities are convenient, collaborative, and communicative.

Predicting raw material consumption is also investigated. For instance, [99] proposed a forecasting model to anticipate the trend of the white sugar consumption rate in Thailand to support the information flow by implementing forecasting factors. In fact, due to the growth of the sugar industry in Thailand, and the fluctuation of sugar consumption over the years, it is crucial to forecast sugar consumption to support production capacity and customer demand in the SC.

Moreover, [38] modeled the sales behavior and predicted export sales for a given period given difficulties in predicting export sales under unstable economic circumstances (market problems and sales fluctuations).

4.1.3 Retail and Foodservice

An important success factor for retailers is demand forecasting, which ensures quality service to customers and reduced costs. For achieving this goal, [160] defined an intelligent system of series classification. Moreover, [85] improved forecast accuracy, reduced time complexity, and achieved lower error rates.

The difficulty of inventory replenishment in the face of diversifying customer demands results in lost sales opportunities or excessive inventory across the chain. for this reason, [116] proposed an inventory control model for a mobile SC by making the control parameters changeable according to changes in customer demand. Moreover, [152] investigated the ability of collective intelligence to manage a distributed SC in a cloud manufacturing environment and define learning strategies for each role to achieve optimization of the overall utility function.

The importance of information in managing suppliers in the retail SC, the mass of data requires advanced techniques for analysis and decision making. To improve computerization and introduce technical means for SCM to gain a competitive position, foreign trade enterprises are needed. whereas, [161] analyzed the SCM system from the perspective of AI and proposed application methods to lay the foundation for sustainable development.

4.1.4 Transportation and distribution

In correspondence with market changes, SC must quickly configure its structure to satisfy customers and their demands, in this context reducing transportation costs is one of the factors to increase customer satisfaction.

For instance, companies are working to improve their transportation network of their to increase the sustainability of their products and their processes,

Due to its widespread use and great economic importance, the vehicle routing problem (VRP) has been one of the most fundamental difficulties in logistics. Indeed, [162] summarized different individual methods inspired by biology to get a powerful extension of these hybrid approaches

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whereas. [141] calculated the steady-state behaviors of sustainable SC transport networks with possibly conflicting goals.

4.1.5 Oil/biomass/energy industry

Due to the uniqueness of the product, its frequency of purchase, and its importance to the economy and security of each country, supplier selection has a direct effect on the production and distribution of petroleum products.

To reduce the time and cost of the selection process and also reduce human errors [44] made an optimal selection and ranking of suppliers. In addition, [96]evaluated and analyzed the performance of the oil SC to design the decision table. Moreover, [97] established a short-term energy forecasting and inventory forecasting model for upstream SC.

Some work has focused on biomass as a green energy source for its collaboration in achieving sustainability. The most commonly used biomass feedstock is corn stover. Indeed, [70] have designed an SC network model to convert all available corn stover into bioethanol. The challenge here is to minimize the cost of converting corn stover to bioethanol. In addition, ANNs were used to construct a smart energy management algorithm for biomass and geothermal power plants [163].

4.1.6 Building Construction

The need to improve SC performance in a constantly changing business environment. [39] designed a forecasting model to handle non-linear data and improve SC flexibility. Thus [134] proposed a partner evaluation model that analyzes and presents construction defect information. Moreover, [164] analyzed the application method of SC and key chain in the EPC (engineering, procurement, and construction) contract model. Furthermore, [95] studied the demand for cement in Taiwan over the past 20 years and established a quarterly and monthly cement forecasting model using AI methods.

The exchange between supplier and buyer is based on an electronic market or contract market, each market has its advantages and disadvantages, and the interest is to take the advantages of both markets. Thus, [148] proposed a model that allows the buyer to supply with less risk, taking into account the supplier's production capacity and fulfilling its business objectives; and allows the supplier to reduce the operational risk and improve its profits.

4.1.7 The Fashion Industry

The fashion and apparel industry, which is a major contributor to the economy of several countries, faces various problems such as overproduction and product returns that increase waste costs.

For solving decision-making problems in SC in the fashion industry, [63] presented the definition, importance, and classification of AI techniques used. Furthermore, [46] analyzed the current trend of AI in the fashion industry over the past decades to understand the exploitation of AI techniques employed in different stages of SC and to understand the usage from a business perspective.

4.1.8 Port and Maritime Sector

Ports are an important factor in the development of a country's economy. Most research has focused on performance and risk identification. However, the works dealing with the development of this sector with the available advanced means seem to be poor. Thus, SC security is a global and multidisciplinary problem that needs to attract more attention, collaborations, and international partnerships.

For instance, [165] built an intelligent knowledge service model of port SC to realize integrated operations to provide basic research knowledge. To resolve conflict situations in collaborative SC security, [166] presented a new model based on expert systems. In addition, [165] analyzed the research status of knowledge service demand and knowledge service of port SC during development and operation. They applied the ontological method to construct the ontological knowledge base of port SC. Despite its significant political and economic impact on the port domain [50] discussed the impact of the Belt and Road Initiative on the design and management of SCs given the lack of study of the Belt and Road Initiative in SCM.

4.1.9 Industry/medical sector

According to [61], The healthcare system is shifting from a centralized to a decentralized model, which implies the use of new strategies in the SC to offer the right suppliers, devices, and pharmaceuticals. He studied the current and potential role of new technologies and their impact on the CL of health care.

In parallel, [135] analyzed CL routes using AI techniques to reduce transportation costs and identify the best approach for the optimization process.

4.1.10 IT / Electrical and Electronic Equipment

The interest was shown by companies to improve the quality of their products to gain more customers and satisfy them. Indeed, [83] have improved the quality of their products to increase consumer satisfaction and to provide an optimal configuration of process parameters within the SC. In addition, [52] studied the behavior and performance of agents in the sales agent competition to analyze the impact of rule changes on early sourcing incentives. To create an effective demand forecasting tool for the examined firm, a back-propagation neural network for demand forecasting was constructed in a SC [113]. The awareness of the importance of environmentally friendly consumers puts pressure on companies to integrate the concept of sustainability into their business practices. [115] revealed the trade-offs between cost, time, and carbon footprint in the context of SC as determined by product design.

4.2 Classification by SC process.

In our results, the majority of work has applied AI methods to the production management process. The procurement and purchasing process is in second place.

Production refers to the entire process by which a company creates a good or service capable of meeting a demand using market-based production parameters. Production management involves all the processes from planning, initiating, and controlling manufacturing, and strategic strategy to finished product availability and distribution.

Many people seem to confuse the terms "purchasing" and "procurement," although, despite their similarities, they have different meanings.

The "purchase" operation refers to the acquisition of goods and services from outside sources. The objective of the purchasing department is to coordinate the supply of materials, spare parts, and services, as well as semi-finished items, that the company needs to produce the desired product, from an outside source.

The strategic process of sourcing a product or service is known as the procurement process. It includes the determination of a specific product or service need, as well as the steps a company takes to discover new or existing suppliers, build supplier relationships, evaluate cost savings, reduce risk, and focus on value and return on investment. The purchasing process then focuses on how products and services are obtained and purchased, such as establishing purchase orders and arranging payment, whereas procurement focuses on the strategic process of finding products or services, such as researching, negotiating, and planning.

By communicating the quantities of products sold directly to its supplier, the distributor enables the latter to develop more reliable demand forecasts and to anticipate more accurately the needs of its distributor customer. The supplier can therefore increase its reactivity while lowering its inventory levels and those of the distributor (Agi, 2004). Consequently, the distortion of the information flow generates the appearance of uncertainty in the supply and production processes which can be seen in additional costs related to overproduction, over-stocking, and stock-outs...

4.3 Classification by Type of shared information

According to our findings, Demand forecasts are the main shared information that has attracted a lot of interest among researchers.

Forecasting is defined as the field of predicting the occurrence of events before they occur. Forecasts thus provide knowledge that allows managers and planners to make decisions before the occurrence of the anticipated events that influence or are affected by their actions. Forecasting is at the heart of planning in this way [167].

Forecasting accuracy in SC was a crucial issue and it is largely studied in the literature. Indeed, due to accurate shared information, the variability of IS in SC fluctuates and generates a big gap between the real value and the predicted one. Thus, uncertainty increase and IS decrease.

Production schedule and supplier information are also investigated. Indeed, the production involved many services. It refers to the allocation of resources, operations, and processes required to manufacture goods and services.

Thus, the more that the information is precise and shared more the production schedule is accurate.

Supplier information refers to all information that could be useful for improving supply and procurement performance.

Indeed, the selection of supplier(s) is one of the keys to the success of an SC. Two concerns are particularly important when selecting the best supplier or set of suppliers: what criteria should be applied, and what approach can be used to compare suppliers [168].

Inventory management is also cited as well. Inventory is a crucial area in which any firm must focus to set themselves besides from their competition. Customers' perceptions of each product are shifting as a result of the expanding demand for numerous types of items offered all over the world. If a firm wants to be successful in the long run, it must focus on SC and inventory management [169].

4.4 The artificial intelligence AI methods most used:

As the analysis shows, ANN, SVM, GA, fuzzy logic/fuzzy interference, K-means Clustering, and "tree-based models " are the most used.

4.4.1 Artificial Neural Network ANN.

ANN is based on the biological mechanisms of the human nervous system. In the realm of flow prediction, ANN is increasingly becoming one of the most well-known and successful data-driven methodologies [170]. For this reason, it is necessary to revisit some aspects of how biological systems perform information processing [171].

The idea of ANN is to simulate the human mind using a computer. The predictable development in this field is due to the many studies that have been conducted in the field of neural processing. The simulation process is done by solving the problems encountered, following self-learning processes that depend on the experiences stored in the network that obtains the best results.

A biological neural network with billions of interconnections exists in the human brain. These connections are established, changed, or eliminated as the brain learns. Neurons receive electrical impulses through dendrites and send information through axons. The contact between two neurons (between the axon and the dendrite) is made through synapses. The signals do not work according to a linear model.

For the formal neural model, the inputs Xi are multiplied by a real coefficient (synaptic coefficient). Then, the weighted signals arriving at the neuron were summed by the summation function. Finally, the outputs Yi are obtained after applying a transfer function. In other words, Inputs to an artificial neuron are weighted, which implies that each input value is multiplied by the weight assigned to it. The sum function, which adds up all the weighted inputs and the bias, is located in the center of the artificial neuron. The sum of the weighted inputs and bias flows via the activation function, also known as the transfer function, at the output of an artificial neuron [172]. Therefore, the basic elements of each ANN have three sets of simple rules: multiplication, summation, and activation. In neural networks, two nonlinear activation functions are often used: The hyperbolic tangent and the logistic sigmoid function.

To establish the potential power of ANN in time series forecasting, a large number of comparisons between neural networks and traditional time series forecasting techniques were done. For instance, [79] concluded that neural networks outperform traditional approaches in time series forecasting. Furthermore, [173] noticed that ANN model outperforms the smart persistence model in forecasting.

According to[57], the ANN approach was able to execute the full set of commands and significantly increase the resource utilization of all SC agents.

In addition, [113] developed an ANN-based model capable of mapping nonlinear relationships between marketing demand and factors influencing demand, learning these relationships from incomplete and ambiguous data, and allowing the model to effectively include any relevant element.

According to [126], ANN is an important problem-solving tool, but two obstacles prevent their successful deployment in SCM, namely the difficulty in obtaining enough data and the fact that the neural network can provide answers but fails to help with understanding.

Other advantages of ANNs include (1) Adaptive learning: The ability to learn to complete tasks based on training data or prior experience. (2) Self-organization: During the learning process, an ANN can organize or represent the information it receives. (3) Real-time operation: ANNs can execute parallel computations, and special hardware devices have been conceived and manufactured to make use of this feature [171].

4.4.2 Genetic Algorithms GA.

GA is an innovative technique for obtaining the optimum that is based on an approach similar to the biological processes of natural selection and evolution. Large and complex decision spaces, as well as non-convexity scenarios, are possible using GA [174]. As it examines several points in the parameter space concurrently, GA has the advantage of being more likely to converge to the global solution. It is essential to assume that the search space is either differentiable or continuous.

To actual sales, [38] computed sales forecasts using GA and compared them. The results are very close and confirm the accuracy of the model. In addition, [135] made a comparison of GA with a model based on ant theory which is the most accurate. The results reveal that the ant theory approach outperforms the GA approach for a small number of generations; however, the GA technique outperforms the ant theory approach over 10 generations.

4.4.3 Fuzzy logic/fuzzy interference

This is a reasoning method that includes all intermediate possibilities between the numerical values YES and NO. In other words, it includes a range of possibilities between YES and NO in a human decision.

to maximize retailer satisfaction,[82] determined the optimal combination of SC partnerships using fuzzy logic. In addition, the quality specifications of the finished products are recorded and the optimal process setting at each stage of the production flow is examined as well [83].

Moreover, [144] proposed a model for partner selection in SC. They used two multi-criteria evaluation methods, setting the weight of partner index by decision-makers, calculating the distance between candidate companies, ranking them according to the proximity coefficient, and selecting the best partners.

In addition, [145] proposed a model that can appropriately select suppliers and connect suppliers and customers.

4.4.4 Support Vector machine SVMs

The support vector machine was invented by Vapnik in 1998. It is widely utilized in numerous applications such as face recognition, classification, and regression prediction because of its robust performance against limited, sparse, and noisy data.

SVMs are used to solve classification and regression problems. They are sometimes used for "bug" detection. SVR is an SVM method adapted to quantitative data. The objective is to learn the relationship between a quantitative variable of interest and other observed variables, possibly for prediction purposes when the time series data is very complicated, SVM can generate better experimental results than the AutoRegressive Integrated Moving Average (ARIMA) model. One of the most significant disadvantages of SVM is the longer processing time required for limited optimization programming [175].

According to [97] SVM is a promising alternative for time series forecasting where the SC inventory is a concrete time series taking into account the non-uniform distribution and the huge fluctuation of the information flow offered by the training data. Furthermore,[99] proposed a model that decreases the error score and can also be implemented with the IS flow in the SC.

4.5 The importance of hybridization

One of the ideas that are adopted by most of the papers is that of hybridization. Hybridization is a trend that has been observed in many works on AI methods in recent years.

Hybridization has proven to be considerable power in many areas, especially in prediction. Indeed, intelligent hybrid models have seen an unprecedented resurgence of interest in recent years and have been recognized as an emerging approach in the fields of AI. In particular, the principle of hybrid machine learning is divided into two stages; the first stage aims to filter out non-representative training data using a classification or clustering technique. Then, the output of the first step can be used to build a prediction model based on a classification technique [176].

This result is consistent with many previous works. The main reasons for creating hybrid systems are improvement of techniques, a multiplicity of application tasks, and achieving multifunctionality [177]. In addition, hybrid models are created to improve performance, provide opportunities for multiple task applications, and improve the ability to handle multiple functions [178].

In addition, it allows the organization to allocate its resources with the utmost confidence for long-term profit. By helping to define future demand patterns, it facilitates the development of future needs.

Regardless of the type of hybridization used in previous studies, the results show that hybrid models are superior to simple models [176]. Because the limitations of individual techniques are eliminated by hybridization to achieve synergistic efficiency in designing an intelligent system [179]. For instance, [95] designed a hybrid model and the results of the hybrid model are more accurate than other forecasting models. because the most reliable and accurate forecasts provide better visibility of demand and thus ensure effective SC management by reducing the impact of inevitable market fluctuations and uncertainties on demand [180]. Furthermore, [44] used a hybrid model based on ANNs to achieve good performance in supplier selection by reducing errors, improving accuracy and efficiency.

Despite the power of AI in CL, the authors relativize the generalization of their results by recalling the limitations imposed by the assumptions. Sometimes the experiment was done with only a limited number of learning models.

Fuzzy logic requires rule generation by experts while ANN requires a historical data set to train a network in a complex way.

Blockchains cannot handle the same number of transactions as ERP systems. Difficulty in testing systems that require a long time and data validation [100]. There are also limitations related to the lack of expertise in the fashion domain.

5 CONCLUSION

This paper reviewed the scope of literature from 2000 to 2020 on improving IS by using hybrid models based on AI methods. To conduct an inclusive yet practical literature review, 125 articles are selected, examined, and discussed based on the objective previously established. Results showed that the most AI subset used for enhancing IS in SC is ML. The most commonly employed and most widely relevant ML method is ANN, which is used to detect complex patterns and deal with nonlinear data.

Demand forecasts are the main shared information that has attracted a lot of interest among researchers. Indeed, forecast errors are the major source of uncertainty in SCM, and uncertainty is an intrinsic element of the IS process. Therefore, if we identify the main sources of uncertainty, their origins, and we reduce them we can enhance IS in SC. Other major techniques that can be considered revlevent in the literature are GAs, SVM, and Fuzzy logic/fuzzy interference. Indeed, the primary goal of these models is to find better forecasting performance in terms of forecast accuracy. Furthermore, we find that AI methods are mostly employed in production management. This paper highlighted the hybridization role in enhancing AI power.

Rationally, every research output is followed by certain limitations. Similarly, this article possesses some limitations. Although sufficient attention was taken in selecting the keywords by keeping the main topic in mind, it is still chosen at the discretion of the authors. A caveat of our review is that it does not provide an in-depth analysis of AI methods. indeed, IS in supply chain depends on several factors such as SC structure, suppliers and or customers number, uncertainty, decision mode etc... Thus, it would be beneficial to suggest an appropriate AI method according to specific situation, because in-depth real case study can provide valuable insights.

Furthermore, for analysis, we identified articles published up to 2000, therefore, there is a risk of missing a relevant study.

Although this work shed light on the application of AI in SCM, there are still several scientific gaps that require more investigation.

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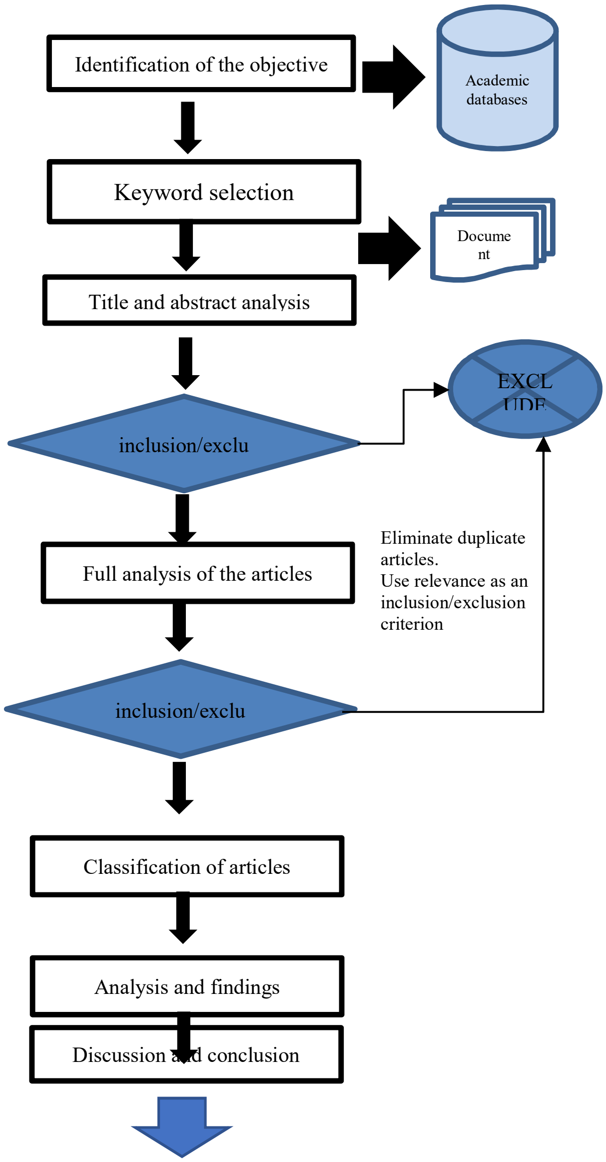
APPENDICES



127 selected articles
Classification of articles according to year of publication, type of items, framework, objective, methodology, artificial intelligence method used, sector, supply chain process, results and discussion and limitations/hypotheses

Figure 7: PRISMA chart