A Review of Artificial Intelligence applications in Supply Chain

Mariam ATWANI[1*], *Mustapha* HLYAL[2], and *Jamila* ELALAMI [1]

[1]LASTIMI Laboratory, High School of Technology in Sale, Mohamed V University in Rabat, Morocco
[2]Centre of Logistics Excellence, ESITH, Casablanca, Morocco

Abstract. Nowadays, the supply chain faces several challenges, among others, uncertainty relating to demand, stochasticity, and bullwhip effect, as well as external disruptions, risks and crises which can temporarily or durably impact customer's service, Science has therefore become increasingly interested in an industrial revolution, namely Industry 4.0 which Artificial Intelligence is the most commonly used technology that is capable of revolutionizing many industries and fields. The aim of this article is to review the literature on the Artificial Intelligence applications in Supply Chain and the most used approaches in planning, prediction, purchasing, procurement, transportation and distribution to improve the performance, resilience and efficiency of the Supply chain.

1 Introduction

The supply chain (SC) of a product, which is the succession of links in the supply chain for this product, involves several challenges. On the one hand, those of the logistical operations that make it up (operations, transport, storage, etc.), and those that are more transversal, namely: planning, forecasting, risk prediction and their mitigation. These latter issues, it seems, have more impact on its agility, flexibility, performance and resilience.

The objective of this study is to identify the use of AI in SC, which was based, firstly, on a targeted keyword search of the databases, Google scholar and Scopus. The combinations of keywords were made as follows:

• "Supply Chain" and "Artificial Intelligence"
• "Supply Chain" or "forecasting" or "demand planning" or "Procurement" or "purchasing" or "production" or "planning" or "transportation" or "distribution" or "inventory management" and "ANN"
• "Supply Chain" or "forecasting" or "demand planning" or "Procurement" or "purchasing" or "production" or "planning" or "transportation" or "distribution" or "inventory management" and "Machine learning"
• "Supply Chain" or "forecasting" or "demand planning" or "Procurement" or "purchasing" or "production" or "planning" or "transportation" or "distribution" or "inventory management" and "Rough set theory"
• "Supply Chain" or "forecasting" or "demand planning" or "Procurement" or "purchasing" or "production" or "planning" or "transportation" or "distribution" or "inventory management" and "Fuzzy logic"
• "Supply Chain" or "forecasting" or "demand planning" or "Procurement" or "purchasing" or "production" or "planning" or "transportation" or "distribution" or "inventory management" and "Expert system"
• "Supply Chain" or "forecasting" or "demand planning" or "Procurement" or "purchasing" or "production" or "planning" or "transportation" or "distribution" or "inventory management" and "Genetic algorithms"
• "Supply Chain" or "forecasting" or "demand planning" or "Procurement" or "purchasing" or "production" or "planning" or "transportation" or "distribution" or "inventory management" and "Agent based systems"

2 ARTIFICIAL INTELLIGENCE: DEFINITION AND SUBFIELD

2.1 Definitions

Thanks to the development of computer science and research in the fields of 4.0 technologies, Artificial Intelligence (AI) has undergone a considerable evolution since last decades of the 20st century, thus its definition has continued to evolve since its inception in 1950 with the mathematician Alan Turing [1]. Then, the modern phase of AI has begun in 1956 with the Dartmouth Summer Study Group on Artificial Intelligence.

In the literature, we find several definitions of AI that complement each other. AI is one of the most notorious industry 4.0 technologies and it is defined as the design of intelligent systems that can learn from the data and make decisions and predictions accordingly. Its aim is to develop and create "thinking machine" capable of imitating, learning and replacing human intelligence [2].

Marvin Lee Minsky (1956) define AI as "the construction of computer programs that engage in tasks that are, for the time being, more satisfactorily performed by human beings, because they require high level mental processes such as: perceptual learning, memory organization and critical reasoning". As for Bringsjord and Schimanski, they consider "Some agent is intelligent if and only if it excels at all established validated tests of intelligence" [3]

2.2 Subfields of AI

Nowadays, many researchers are interested in the fields of AI, however, they are not unanimous about the

* Corresponding author: atwani.mariam@gmail.com

classification of its techniques, e.g., [2] classifies techniques of AI by four sub-field:

- Artificial neural networks (ANN) and Rough set theory,
- Machine learning, expert systems, and Genetic Algorithms,
- Fuzzy logic,
- Agent-based systems

An artificial neural network (ANN) is a set of artificial neurons whose purpose is to simulate the way the human brain processes and analyses information, in order to solve problems that are evaluated as difficult for humans to solve.

ANNs are composed of several nodes, linked together by links. Thanks to a set of learning rules, the ANNs use the "input" information and generate, through an internal weighting system, the "outputs". Their self-learning system allows them to provide the best results.

The Rough Set Theory is a mathematical tool used to solve vague, uncertain, imprecise and noisy data, it consists in drawing two precise boundaries to describe an imprecise concept: lower and upper approximation of the original data sets.

Machine Learning (ML) is a process that takes advantage of experience to learn without being obviously programmed and improve its performance. By referring to past information from electronic data collection.

The well-known types of ML are: 1. supervised: tasks are classification and regression, 2. unsupervised: tasks are Association Rules, Self-Organizing Maps, Multidimensional Scaling and Nonlinear Dimension Reduction, 3. reinforcement learning: the system finds its own solutions autonomously through directional rewards and punishments.

An Expert System is capable of answering questions, using reasoning based on known facts and rules. It can be used in particular as a decision support tool.

Genetic Algorithms (GAs) are random research algorithms that imitates natural genetics. They aim to solve a high level of problem using a randomized information exchange [4].

Fuzzy logic is a continuation of Boolean logic which is based on the mathematical theory of fuzzy sets, and generalization of the classical set theory.

Fuzzy logic provides a very valuable flexibility for reasoning by introducing the notion of degree in the verification of a condition, thus enabling a condition to be in a state other than true or false. Which makes it possible to take into account inaccuracies and uncertainties [5].

Agent-based system is a system made up of a set of agents (a process, a robot, a human being, etc.), located in a certain environment and interacting according to certain relationships. An agent is an entity characterized by the fact that it is, at least partially, autonomous.

In addition, other authors consider more general forms of AI that are less used in SC, e.g. Data mining, Case-based reasoning, Swarm intelligence, Support vector machines, Simulated annealing, Automated planning, Decision trees, Association rule, Tree-based models, Hill climbing, k-means clustering, Expert systems, Heuristics, Robot programming, Stochastic simulation, Bayesian networks, Physarum model, Rule-based reasoning, Gaussian models [6].

3 APPLICATIONS IN THE SUPPLY CHAIN MANAGEMENT

This review aims to map the subfields of Artificial Intelligence and identify their application in the supply chain field. This paper focuses on 4 main supply chain processes, namely: Forecasting and demand planning, Procurement and purchasing, Production and inventory management and finally transportation and distribution.

3.1 Forecasting & demand planning

Forecasting and demand planning are two crucial functions for the company, they are used to plan production, procurement, inventory management, new product development, marketing campaigns, etc. Thus, their accuracy is the major concern of managers.

The common feature of all traditional forecasting techniques is that future demand follows the same pattern as past demand, such as exponential smoothing, moving average, time series and Box-Jenkins methods. Therefore, the accuracy of these techniques depends on the reliability of consumption histories, so it remains difficult to predict future demand for new products or services for which no history is available.

Furthermore, in an era of fast-changing data, the usefulness of forecasts in a business depends critically on their prediction, so researchers have increasingly turned their attention to this area, and combined traditional forecasting techniques with artificial intelligence algorithms to generate more accurate forecasts and improve demand planning. For example, [7] studied the use of AI in demand forecasting for irregular demands and selected the more performing ones.

The ANN was widely used in forecasting and demand planning. For [8], the authors evaluate the application of the Neural Decision Tree (NDT) approach for prediction of petroleum production and compares it with ANN approach. [9] suggest an ANN based solution for forecasting the electricity production of a photovoltaic power plant. In the petroleum engineering, in [10], the authors compare the application of neural network model and a Gamma classifier to reproduce and further predict future. In the same context, [11], [12] develop AI forecasting models to improve forecast's accuracy and inventory management.

Indeed, ML consists in predicting behaviour, so it is widely used to solve several supply chain issues in forecasting and demand planning. [13] indicates that ML is used to To solve forecasting problems during a catastrophe, predict future demand, to deal with the bullwhip effect through the prediction of distorted demand information and share it with the SC partners, make accurate forecasts over a six month horizon, use data provided by social media to establish sales forecasts. According to [14], the authors have studied the ability of ML to generate more accurate forecasts

than traditional methods thanks to a long short-term model. As for [15] show that ML algorithms are largely applied in planning.

On the other hand, the expert system can be more sophisticated forecasting method to forecast demand at each stage of SC, in terms of forecast accuracy, calculation speed, user understanding and profitability [2].

Thus, Genetic Algorithms contributes to develop accurate forecasting algorithms and reduce bullwhip effect [16].

Agent-based systems were mainly used to reduce bullwhip effect, and to solve the problem of demand fluctuation in [17], on the other hand, the authors refer to the measurement of the bullwhip effect in [18].

3.2 Procurement & Purchasing

Procurement consists of making available to the various departments the raw materials, supplies, accessories, services, energy, semi-finished products, etc., to produce or sell. Thus, the company must decide whether to make or buy, depending on its production capacity, its main activity and the expertise of its employees. From a strategic point of view, the company is required to define budgets, its supply strategy and the requirements level of suppliers, etc. All this constraints complicate decision-making. Thus, the researchers discussed the use of AI techniques in improving purchasing and procurement management.

For upstream supply chain and supplier's relationship, we found much contributions. In [19], the authors used ANNs to solve the key problems of the CBR (Case based reasoning) system of supplier selection. Thanks to its strong self-adaptability, the ANNs improve the accuracy of updating phases and the efficiency of the decision-making in the companies' process of selecting suppliers. In [20] we found a learning algorithm to the supplier selection process improvement. Bayesian learning was used in [21]) to evaluate the suppliers' reliability, and to show that although several parameters have not been considered, the model remains flexible and can be extrapolated taking into account other factors. In [22], the authors modelled risk dependency graphs. The latter model is able to adapt depending on new knowledge is acquire, thus making sure that risk propagation is modelled accurately. [23] Regarding to [24] rough set theory was used to evaluate sustainability performance for suppliers through the identification of the key performance indicators (KPIs) allowing this assessment. For [25], the rough set theory was used to select the most desirable supplier among a pool of qualified suppliers with respect to multiple but conflicting supplier selection criteria.

In [26], the authors found that ML was used to detect and evaluate supplier risk, and contributes to the creation of a supplier selection system, to create a solution able to negotiate contracts and to identify reliable candidates for future customer-supplier relationship. Also, [14] studied the ability of ML to generate more accurate forecasts than traditional methods thanks to a long short-term model.

Furthermore, Expert System is used in supplier and subcontractor evaluation [27] and in the development of a partner selection system [28].

The GAs were employed in purchasing for supplier selection [29], to evaluate supplier risk and select reliable supplier [16].

As for the fuzzy logic, it was mainly used in supplier performance evaluation and selection [2], [30], [31].

3.3 Production & Inventory management

Production management refers to all the activities involved in planning, launching and controlling production from the strategic plan to the delivery of the finished product. Scheduling, a critical task in production management, aims to optimise human resources, machines, stocks and physical movements in the conduct of operations in order to reduce production costs while meeting service objectives.

Thus, AI has been widely used in various levels of production management to optimise it. One of the most successful ANN applications is the hierarchical SC planning to determine setup times, optimal lot-size across SC processes, and required inventory levels to demand and production planning. Moreover , the rough set theory is also used in inventories management, e.g, in [32] the use of rough set theory allows a reduction of bullwhip effects and resulted in optimal inventory management and a better service rate, the model developed establishes rules and correct uncertain information obtained by ABC analysis.

For [26] ML is used in Order management to Establish an optimal ordering strategy on several levels of the SC, to classify SKUs (Stock Keeping Unit) according to demand and performance attributes, to evaluate order priority and to identify the manufacturing priority of an order. In inventories management, it is used to determine the elements that impact inventory management, to optimize reorder points and safety stocks for product, to identify obsolete products in a warehouse and to calculate order point in the replenishment method. In Production management, ML allows to identify manufacturing location of products: ratified factory or unknown origin, to calculate the cycle time and to estimate the lead time.

The application of Genetic Algorithms is discussed by [16] in inventory management, it allows to determine lot-size scheduling issues, to elaborate multiproduct economic production quantity model, including various constraints, in inventory optimization, to calculate economic order quantity and to solve inventory issues. And in Planning to define an optimal process planning, decreasing delays, solve job-shop scheduling problems, solve capacitated lot-size problems and optimize the process planning in Enterprise resource planning (ERP).

We found specific applications of the fuzzy logic in inventory cost control [33], and in order fulfilment [34]. Also, we found relevant valuable application for joint production planning in [35]

Agent-based systems have also been used as simulation tools for inventory management to reduce costs and improve fill rate in [36] and to study interaction between inventory models in [37]. As for

[38], an Agent-based model is proposed to solve SC planning and scheduling problems.

3.4 Transportation & Distribution

Transportation & Distribution is strongly dominated by three activities. Determining distribution networks (scheduling of routes, choice of means of transport, choice of transhipment and storage infrastructures, etc.); managing transport flows (packing, loading/unloading of vehicles, organisation of rounds, management of collective transport, management of the return of vehicles and empty packaging, etc.); managing stocks throughout the distribution network (internal and external). Essentially devoted to the management of goods flows, the purpose of transportation & distribution is to complete the delivery of customer orders in the best economic conditions and within the shortest possible time.

The speed of today's world increases the demands and expectations for rigour and accuracy, so distribution and transportation professionals must be able to adapt to the pace of technological innovations that change practices and improve performance.

ML is used to solve vehicle scheduling problems in the cross-docking in Distribution planning, and to differentiate between moving and static pallets and avoid False-Positive RFID Tag Reads in Transport management [26].

The Expert systems is widely applied in air traffic, airline yield management and vehicle maintenance [39]. GA was employed to solve well-known logistics problems involving facility layout [40], delivery reliability assurance [41], freight consolidation [42]; and express courier services [43], to reduce transportation charges, find solutions for problems related to logistics centres' location and optimize warehouse order picking routes [16].

4 Discussion

Table 1. Sub-field AI Application's in the SC.

	ANN	Rough set theory	Machine Learning	Expert System	Genetic Algorithm	Fuzzy Logic	Agent-based system
Purchasing & procurement	X	X	X	X	X	X	
Production	X		X	X	X		X
Inventory Management	X	X	X			X	X
Distribution			X		X		
Transportation			X		X		
Forecasting & demand planning			X	X	X	X	X

The table below summarises the papers reviewed and shows the application of the sub-categories of artificial intelligence across the supply chain.

We can clearly see that machine learning has been used throughout the supply chain, followed by the genetic algorithm. As for neural networks, they have shown their results in purchasing and supply, especially in supplier relationship management and in solving problems related to the supplier selection process. The ANN has also been used in production management, in particular planning, where traditional OR techniques have been applied extensively, to determine set-up times, optimal batch sizes in all SC processes, and stock levels.

5 CONCLUSION

This review examined the existing literature on the application of artificial intelligence in the Supply Chain. It mapped the applications based on their use in four main supply chain processes: forecasting & demand planning, procurement & purchasing, production management & inventory management, and transportation & distribution. In conclusion, according to the above, the most commonly used technique of AI is ANNs, which are generally used to find complex patterns that humans cannot find. Then, the second most prevalent AI technique is Fuzzy Logic, which is a form of multiple-valued logic that handles the concept of partial truth. The third technique is ABS/MAS. However, the majority of papers propose a hybrid approach for an agile, flexible and efficient Supply Chain.

Future work will focus on applications of artificial intelligence in forecasting and demand management, including mathematical models.

References

1. R. J. Solomonoff, "The time scale of artificial intelligence: Reflections on social effects," Hum. Syst. Manag., 1985, doi: 10.3233/HSM-1985-5207.
2. H. Min, "Artificial intelligence in supply chain management: Theory and applications," Int. J. Logist. Res. Appl., 2010, doi: 10.1080/13675560902736537.
3. S. Bringsjord and B. Schimanski, "What is artificial intelligence? Psychometric AI as an answer," in IJCAI International Joint Conference on Artificial Intelligence, 2003.
4. W. Roetzel, X. Luo, and D. Chen, Design and operation of heat exchangers and their networks. 2019.
5. P. Killeen and S. Behavior, "Fuzzy Logic Fuzzy Logic," vol. 35, no. 2007, pp. 93–100, 2013.
6. R. Toorajipour, V. Sohrabpour, A. Nazarpour, P. Oghazi, and M. Fischl, "Artificial intelligence in supply chain management: A systematic literature review," J. Bus. Res., vol. 122, pp. 502–517, Jan. 2021, doi: 10.1016/J.JBUSRES.2020.09.009.

7. K. N. Amirkolaii, A. Baboli, M. K. Shahzad, and R. Tonadre, "Demand Forecasting for Irregular Demands in Business Aircraft Spare Parts Supply Chains by using Artificial Intelligence (AI)," IFAC-PapersOnLine, vol. 50, no. 1, pp. 15221–15226, Jul. 2017, doi: 10.1016/J.IFACOL.2017.08.2371.
8. X. Li, C. W. Chan, and H. H. Nguyen, "Application of the Neural Decision Tree approach for prediction of petroleum production," J. Pet. Sci. Eng., vol. 104, pp. 11–16, Apr. 2013, doi: 10.1016/J.PETROL.2013.03.018.
9. A. Gligor, C. D. Dumitru, and H. S. Grif, "Artificial intelligence solution for managing a photovoltaic energy production unit," Procedia Manuf., vol. 22, pp. 626–633, Jan. 2018, doi: 10.1016/J.PROMFG.2018.03.091.
10. L. B. Sheremetov, A. González-Sánchez, I. López-Yáñez, and A. V. Ponomarev, "Time Series Forecasting: Applications to the Upstream Oil and Gas Supply Chain," IFAC Proc. Vol., vol. 46, no. 9, pp. 957–962, Jan. 2013, doi: 10.3182/20130619-3-RU-3018.00526.
11. P. K. Bala, "Improving inventory performance with clustering based demand forecasts," J. Model. Manag., vol. 7, no. 1, pp. 23–37, Jan. 2012, doi: 10.1108/17465661211208794/FULL/XML.
12. N. A. Mobarakeh, M. K. Shahzad, A. Baboli, and R. Tonadre, "Improved Forecasts for uncertain and unpredictable Spare Parts Demand in Business Aircraft's with Bootstrap Method," IFAC-PapersOnLine, vol. 50, no. 1, pp. 15241–15246, Jul. 2017, doi: 10.1016/J.IFACOL.2017.08.2379.
13. H. Wenzel, D. Smit, and S. Sardesai, "A Literature Review on Machine Learning in Supply Chain Management Supply Chain Management," in Proceedings of the Hamburg International Conference of Logistics (HICL) - 27, 2019, no. September, p. 30.
14. H. Bousqaoui, S. Achchab, and K. Tikito, "Machine learning applications in supply chains: Long short-term memory for demand forecasting," in Lecture Notes in Networks and Systems, 2019.
15. M. T. Hoppe, "Machine Learning in Supply Chain Management," no. August, 2019, [Online]. Available: https://run.unl.pt/handle/10362/69191.
16. S. K. Jauhar and M. Pant, "Genetic algorithms in supply chain management: A critical analysis of the literature," Sadhana - Acad. Proc. Eng. Sci., 2016, doi: 10.1007/s12046-016-0538-z.
17. J. Du, V. Sugumaran, and B. Gao, "RFID and multi-agent based architecture for information sharing in prefabricated component supply chain," IEEE Access, 2017, doi: 10.1109/ACCESS.2017.2665778.
18. S. Balan, P. Vrat, and P. Kumar, "Reducing the Bullwhip effect in a supply chain with fuzzy logic approach," Int. J. Integr. Supply Manag., 2007, doi: 10.1504/IJISM.2007.012630.
19. K. Zhao and X. Yu, "A case based reasoning approach on supplier selection in petroleum enterprises," Expert Syst. Appl., 2011, doi: 10.1016/j.eswa.2010.12.055.
20. C. Jiang and Z. Sheng, "Case-based reinforcement learning for dynamic inventory control in a multi-agent supply-chain system," Expert Syst. Appl., 2009, doi: 10.1016/j.eswa.2008.07.036.
21. M. Chen, Y. Xia, and X. Wang, "Managing supply uncertainties through Bayesian information update," IEEE Trans. Autom. Sci. Eng., 2010, doi: 10.1109/TASE.2009.2018466.
22. M. D. Garvey, S. Carnovale, and S. Yeniyurt, "An analytical framework for supply network risk propagation: A Bayesian network approach," Eur. J. Oper. Res., 2015, doi: 10.1016/j.ejor.2014.10.034.
23. G. Baryannis, S. Validi, S. Dani, and G. Antoniou, "Supply chain risk management and artificial intelligence: state of the art and future research directions," International Journal of Production Research. 2019, doi: 10.1080/00207543.2018.1530476.
24. C. Bai and J. Sarkis, "Determining and applying sustainable supplier key performance indicators," Supply Chain Manag., 2014, doi: 10.1108/SCM-12-2013-0441.
25. X. Geng and Q. Liu, "A hybrid service supplier selection approach based on variable precision rough set and VIKOR for developing product service system," Int. J. Comput. Integr. Manuf., 2015, doi: 10.1080/0951192X.2014.959058.
26. H. Wenzel, D. Smit, and S. Sardesai, A Literature Review on Machine Learning in Supply Chain Management Supply Chain Management. 2019.
27. E. Shahvand, M. H. Sebt, and M. T. Banki, "Developing fuzzy expert system for supplier and subcontractor evaluation in construction industry," Sci. Iran., 2016, doi: 10.24200/sci.2016.2163.
28. K. Sari, "Modeling of a fuzzy expert system for choosing an appropriate supply chain collaboration strategy," Intell. Autom. Soft Comput., 2018, doi: 10.1080/10798587.2017.1352258.
29. R. Venkata Rao, "Vendor selection in a supply chain using analytic hierarchy process and genetic algorithm methods," Int. J. Serv. Oper. Manag., 2007, doi: 10.1504/IJSOM.2007.013097.
30. D. A. Carrera and R. V. Mayorga, "Supply chain management: A modular Fuzzy Inference System approach in supplier selection for new product development," J. Intell. Manuf., 2008, doi: 10.1007/s10845-007-0041-9.
31. H. C. W. Lau, W. Kai Pang, and C. W. Y. Wong, "Methodology for monitoring supply chain performance: a fuzzy logic approach," Logist. Inf. Manag., 2002, doi: 10.1108/09576050210436110.
32. M. Mehdizadeh, "Integrating ABC analysis and rough set theory to control the inventories of distributor in the supply chain of auto spare parts," Comput. Ind. Eng., 2020, doi: 10.1016/j.cie.2019.01.047.

33. J. Wang and Y. F. Shu, “Fuzzy decision modeling for supply chain management,” Fuzzy Sets Syst., 2005, doi: 10.1016/j.fss.2004.07.005.
34. Y. Amer, L. Luong, S. H. Lee, and M. A. Ashraf, “Optimizing order fulfillment using design for six sigma and fuzzy logic,” Int. J. Manag. Sci. Eng. Manag., 2008, doi: 10.1080/17509653.2008.10671038.
35. R. M. Lima, R. M. Sousa, and P. J. Martins, “Distributed production planning and control agent-based system,” in International Journal of Production Research, 2006, doi: 10.1080/00207540600788992.
36. F. T. S. Chan and H. K. Chan, “A simulation study with quantity flexibility in a supply chain subjected to uncertainties,” Int. J. Comput. Integr. Manuf., 2006, doi: 10.1080/09511920500324381.
37. B. Ponte, E. Sierra, D. de la Fuente, and J. Lozano, “Exploring the interaction of inventory policies across the supply chain: An agent-based approach,” Comput. Oper. Res., 2017, doi: 10.1016/j.cor.2016.09.020.
38. C. Y. Hsu, B. R. Kao, V. L. Ho, L. Li, and K. R. Lai, “An agent-based fuzzy constraint-directed negotiation model for solving supply chain planning and scheduling problems,” Appl. Soft Comput. J., 2016, doi: 10.1016/j.asoc.2016.07.030.
39. M. E. Jefferies and W.-K. Yeap, Robotics and cognitive approaches to spatial mapping. Springer, 2008.
40. K. Balamurugan, V. Selladurai, and B. Ilamathi, “Solving unequal area facility layout problems using genetic algorithm,” Int. J. Logist. Syst. Manag., vol. 2, no. 3, pp. 281–301, 2006.
41. J. Antony, R. Swarnkar, M. Kumar, and M. K. Tiwari, “Design of synchronised supply chain: A genetic algorithm based six sigma constrained approach,” Int. J. Logist. Syst. Manag., 2006, doi: 10.1504/IJLSM.2006.009555.
42. H. Min, H. J. Ko, and C. S. Ko, “A genetic algorithm approach to developing the multi-echelon reverse logistics network for product returns,” Omega, 2006, doi: 10.1016/j.omega.2004.07.025.
43. [43] C. S. Ko, H. Min, and H. J. Ko, “Determination of cutoff time for express courier services: A genetic algorithm approach,” Int. Trans. Oper. Res., 2007, doi: 10.1111/j.1475-3995.2007.00580.x