Use of Artificial Intelligence Techniques in Supply Chain Risk Management

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Abstract

Today, the widening and complexity of supply chains and the fact that risks cause serious disruptions have caused academicians and practitioners to show interest in studies within the scope of supply chain risk management. In this framework, supply chain risk management is becoming increasingly important and processes are being managed with many new techniques. Recent research shows that artificial intelligence techniques are increasingly used in supply chain risk management. As a result of the use of artificial intelligence in supply chain risk management, it has been observed that changes occur especially in functioning and dynamics. Options such as driverless vehicles that emerged with artificial intelligence, robots used in storage and shelves, and the easy use of large data in the system ensure that errors in supply chains are minimized. Within the scope of supply chain risk management, it is possible for businesses to identify and evaluate risks and determine appropriate risk reduction strategies with the help of artificial intelligence techniques. In this study, it is aimed to examine in detail the artificial intelligence techniques used in supply chain risk management. In this context, expert systems, artificial neural networks, fuzzy logic, genetic algorithm and machine learning techniques are examined in detail. Then, these techniques were compared with each other and evaluations were made about which artificial intelligence technique would be more effective in which problems. In the conclusion part, artificial intelligence techniques that should be applied according to the problem types and some suggestions for future studies are presented.

Keywords
Supply Chains, Supply Chain Risk Management, Artificial Intelligence Techniques

1. Introduction
Supply chain management; in order to gain competitive advantage by adding additional value to the product or service and to ensure customer satisfaction, all activities (transportation, production, raw material and material storage, stocking of finished products) in the process from the first supplier to the last customer are effectively planned, implemented, motivated and controlled consists of by intermediaries. Risk is the uncertainty surrounding future events and consequences. Businesses are becoming more sensitive to risks due to reasons such as the globalization of supply chains, the increase in product diversity, the decrease in the number of suppliers, the increase in the dependence of companies on each other, the increase in customer expectations and the shortening of delivery times. Businesses facing high environmental uncertainty are faced with risks such as delays in production and delivery as well as disruptions in supply.

Today, it is seen that globalization, digitalization, competitive conditions, ever-increasing relations between supply chain partners and developing technology make supply chains more and more complex day by day. While this situation

increases the uncertainties in the process, it also brings new risks. The issue of Supply Chain Risk Management has gained great importance, especially in the current period and due to the devastating consequences of some supply chain risk events that have occurred in the past. Many of these devastating risk events in supply chains have adversely affected many businesses in different countries and caused great losses in industrial sectors. For this reason, businesses have understood the importance of detecting risks early and responding to these risks in a timely manner and have started to manage their processes in this context.

Artificial intelligence can be defined as a branch of science that focuses on developing computer operations that will reveal a similar structure by trying to understand the human thinking structure. In other words, it is a programmed computer's way of thinking. Artificial intelligence can be defined in a broader framework as computers with features specific to human intelligence such as acquiring information, perceiving, seeing, thinking and making decisions.

With the Covid-19 pandemic, significant disruptions have also emerged in the supply chains and it has been seen that risk management strategies do not work efficiently. In particular, there have been supply-side deteriorations due to reasons such as people's not being able to go to work and not being able to provide raw materials, and demand-side deteriorations have occurred with the change in consumer preferences (Karlı and Tanyaş 2020).

Although pandemics are unlikely to occur, they reach millions of people and cause huge costs, depending on their impact and speed of spread. For this reason, businesses should consider situations such as pandemics at the top of the risks that should be given importance in supply chain management. In this context, it is vital for businesses to anticipate risks in supply chains and take necessary actions. Recently, taking relevant actions in supply chain risk management by using artificial intelligence techniques has become a subject that academia and business world emphasize.

1.1. Objectives

In this study, it is aimed to examine and compare the artificial intelligence techniques used in supply chain risk management in detail. In this context, a literature research on artificial intelligence techniques that can be used in the solution of supply chain risk management problems is made and the benefits of artificial intelligence techniques in supply chain risk management are mentioned. For this purpose, in the study; first of all, the concept of supply chain risk management and artificial intelligence is emphasized. Secondly, expert systems, genetic algorithms, fuzzy logic, artificial neural networks and machine learning, which are artificial intelligence techniques that can provide solutions to the problems encountered in supply chain risk management, are explained. In which problem types these artificial intelligence techniques can be applied, and the strengths and weaknesses of these types of problems in solving these types of problems, artificial intelligence techniques are compared. In the conclusion part, artificial intelligence techniques to be used according to the problem types are mentioned and some suggestions are made for future studies.

2. Literature Review

Businesses can maintain their continuity by acting together with many different organizations such as suppliers, distributors, retailers, logistics companies. With the correct management of this process, it has been seen that advantages in competition in the market have been achieved, and supply chain management has emerged. Supply chain management is defined as a management strategy that aims to optimize the flow of materials, information and money in order to reduce costs and provide maximum value to the consumer (Andjelkovic 2017).

Basically supply chain risk; It is explained as the possibility of an error, damage or loss resulting from unexpected events. Supply chain risks can arise from many different causes, such as demand volatility, supplier errors, economic uncertainties, natural disasters and terrorism. While some of the factors that cause supply chain disruptions are controllable, some are completely beyond the control of businesses (Zsidisin and Ritchie 2009).

There are many studies in the literature on identifying risks in the supply chain. Ambulkar et al., in their study, examined the events that contribute to the resilience of enterprises against supply chain disruptions. In this study, they determined the deterioration events that the participants were exposed to in the past with a questionnaire study. Out of 199 reported outages, 62 were identified as supply errors, 42 as internal errors, and 51 as natural disasters, regulatory or policy issues (Ambulkar et al. 2015).

Without developing the supply chain management strategies of the enterprises, the efforts of risk management have been limited to the applications within the enterprise itself. If this strategy limits the risks within the business, it has

not been able to solve the risks associated with different organizations that are necessary for their sustainability. Therefore, the concept of "supply chain risk management" has emerged with the addition of risk management to supply chain management, including organizations outside the business (Revilla and Saenz 2017).

Supply chain risk management consists of certain stages. These stages are risk identification, risk measurement and assessment, selection and implementation of risk management and monitoring risk. Although the risk management stages are less for some researchers and more for some researchers, they generally consist of these stages (De Oliveira et al. 2017).

Disruption in any link of the supply chain causes the entire chain to be affected. In this direction, supply chain risk management is gaining importance day by day in order to ensure competitive advantage and sustainable success. As a supply chain resource, the supplier assumes the role of input at the core of all production processes. Thus, performance has a direct impact on delivery level, product quality, delivery cycle, stock level, product design and customer satisfaction level. Any disruption from the supplier affects the performance of the entire supply chain. Therefore, it is important to identify and control supply chain risks when evaluating the performance of suppliers. In this direction, it is possible to say that information, technology, quality, price and financing risks, which are among the supplier risks in a production process, are related to each other. Supply chain risks; It is possible to classify them as supplier and transportation risk, operational risk, security risk and environmental risks (Sheng et al. 2010).

Supply chains; although they have experienced many ruptures such as the September 11 terrorist attack, Hurricanes Katrina and Rita, and earthquakes, they still show vulnerability to risks. Although supply chain risk management is intended to be addressed in a general framework, each risk type has its own parameters. In addition, since the risks that are less likely to occur are more negligible by the managers, supply chains have greater weaknesses against such risks (Faisal et al. 2007).

Artificial intelligence was developed to make computers think logically and work like humans in terms of decision making. Artificial intelligence is a multidisciplinary field of research. It works in partnership with many independent branches such as mathematics, informatics, manufacturing and service sector, retail sector, public institutions and law (Oswal et al. 2020).

With artificial intelligence techniques, businesses gain efficiency, productivity and competitive advantage in supply chain management. With artificial intelligence techniques, new problem solving methods are developed and the solution of chronic problems in supply chain management business processes is facilitated. With artificial intelligence techniques, businesses can establish decision support systems that help them operate with low cost and high profitability in supply chain management. Artificial intelligence techniques are used in supply chain risk management, inventory control and management, transportation network design, purchasing, demand planning and forecasting, and order picking.

There are many studies in the literature using artificial intelligence techniques in supply chain risk management. Some of these studies are as follows:

Goh et al. have created a multi-stage stochastic model for the multistage global supply chain network problem by including risks such as supply, demand, exchange rate and deterioration. The aim of the model is to minimize risk and maximize profit (Goh et al. 2007).

In their study, Jing et al. developed a food quality safety early warning model using back propagation artificial neural network technique. In this study, stochastic methods are used to model the uncertain nature of risks in the supply chain. Effective mathematical models have been developed for supply chain risk management (Jing et al. 2009).

Paul & Azaeem in their study; A neural network-based model also defined the ideal level of product stock, function demand, installation, holding and material cost. The model has been applied in the manufacturing industry and it has been determined that it gives good results in the estimation of product parameters. It has been clearly seen that this model can be used in product inventory optimization of any manufacturing job (Paul and Azeem 2011).

Wu et al. developed a stochastic fuzzy multi-objective programming model for the management of supply chain outsourcing risk. In their study, they took into account quantitative risk factors (price, quality, logistics, etc.), each of

which is expressed by stochastic data with a probability distribution, and qualitative supplier selection risk factors (economic environmental factors, supplier evaluations, etc.) with a fuzzy structure (Wu et al. 2013).

Tabrizi and Razmi developed a complex-integer nonlinear mathematical model in which the uncertainties are represented by fuzzy set theory. The problem was solved by applying Bender decomposition and the model was transformed into a complex integer problem (Tabrizi and Razmi 2013).

Yu and Goh developed a fuzzy multi-objective integer programming model for supplier selection with three objectives: maximizing supply chain visibility, minimizing risk and minimizing cost. They examined the effect of supply chain visibility and risk on supply chain performance. According to their results, decision makers should focus on reducing risks before improving supply chain visibility (Yu and Goh 2014).

Garvey et al. use Bayesian networks to model risk dependency graphs which can adapt when new knowledge is acquired, thus making sure that risk propagation is modelled accurately (Garvey et al. 2015).

The most recent studies in this category use Big Data Analytics for various supply chain risk management tasks. Generic supply chain risk management frameworks based on Big Data are proposed in Fan et al., based on monitoring data both within and external to the supply chain (Fan et al. 2015).

The case of fleet management is explored in Mani and his friend's study with vehicle tracking systems employed to identify social and environmental risks (e.g., theft of vehicles and goods) (Mani et al. 2017).

Papadopoulos et al. are used big data to determine how best to achieve supply chain resilience in the face of disaster. While the latter three studies do not use data sources for any predictive or learning purposes, there is a handful of recent studies that do and are briefly described next (Papadopoulos et al. 2017).

Risk identification is also explored by Ye et al., focusing, however, on financial risk. Publicly available economic performance data for Chinese firms are collected and are used to train multi-class Support Vector Machine classifiers. These models are able to determine whether a firm is prone to supply, demand, product or external disruptions (Ye et al. 2015).

Finally, Ojha et al., perform analysis of risk propagation using Bayes networks, automatically learning the interconnections between several risk factors for different supply chain stakeholders and using this knowledge to determine probability of occurrence and cost for risks (Ojha et al. 2018).

Although machine learning techniques have been developed in recent years, they have also been applied for supply chain risks. Yang proposed a model with machine learning technique to propose a logistics financial risk ontology and adapt to the variability of risk (Yang 2019). Baryannis et al., also proposed a supply chain risk estimation framework with the machine learning technique. The survey method is a technique that is widely used for risk analysis in studies (Baryannis et al. 2019).

Park in his study, analyzed the data produced in the supply chain using a machine learning algorithm and tried to manage the flexibility of the supply chain in order to ensure the sustainability of the supply chain model consisting of manufacturers, distributors and wholesalers (Park 2021).

Femi et al., in their study, stated that developing algorithms and analytical tools that predict where potential risks are in supply networks and operations using artificial intelligence techniques reduce financial risks (Femi et al. 2021).

3. Methods

In this section, a comprehensive literature search was conducted to identify the most widely used artificial intelligence techniques in supply chain risk management. Analyzes were made by making comparisons in terms of the superiority of artificial intelligence techniques determined within the framework of literature research. The application areas of the determined artificial intelligence techniques were mentioned, and classifications were made according to the strong and weak conditions of these artificial intelligence techniques.

We can list the most commonly used artificial intelligence techniques as follows:

- ✓ Expert Systems
- ✓ Artificial Neural Networks
- ✓ Fuzzy Logic
- ✓ Genetic Algorithms
- ✓ Machine Learning

A detailed description of these techniques is given below:

3.1. Expert Systems

Expert systems are one of the most important application areas of artificial intelligence. In expert systems, solutions are sought based on the expertise of people who are experts in a particular field. This can be thought of as computer-organized counseling systems. Expert systems are used in applications that require both machine and human intervention. These systems are frequently used in application areas such as medicine, financial planning, computer configuration, real-time systems, traffic management and control, insurance (Erkalan et.al. 2012).

The difference between artificial intelligence and expert systems; While the aim of the artificial intelligence program is to solve the problem that any human can solve, the aim of the expert system is to solve the problems that an expert person can solve.

In his study, Yunusoğlu developed a fuzzy rule-based expert system to support portfolio managers in their medium-term investment decisions. (Yunusoğlu 2012).

3.2. Artificial Neural Networks

Artificial neural networks investigate the structure of the human brain consisting of neurons and learning methods. The efforts of psychologists and neuropsychologists in the 19th century to understand the human brain formed the basis of artificial neural networks. However, the first modern studies on these subjects started with McCuloch and W.Pitts. Artificial neural networks are based on simulating a very simple neuron model of the brain. The learning with the network obtained in this way takes place. Usage areas of artificial neural networks; control and system identification, image and sound recognition, estimation and estimation, failure analysis, medicine, communication, traffic, production management. Artificial neural networks, especially focusing on learning, are used in non-linear systems or in systems where the information of the system is not complete and erroneous. The most important disadvantage of artificial neural networks is the difficulties encountered in transferring existing expert knowledge to problem solving (Zakaria et.al. 2014).

Bruzzone and Orsoni used Artificial Neural Networks (ANNs) for risk assessment of production losses in their earliest supply chain risk management study involving some form of machine learning. The ANNs are supplied with specific scenarios with production times, quantities, and capacities (input), along with corresponding cost estimates (output). Based on these training data, the ANNs learn how to correlate input and output, gaining the capability of calculating cost estimates for different scenarios (Bruzzone and Orsoni 2003).

Qazi et al. in their study, propose a holistic supply chain risk management approach that uses FMEA to identify risks and risk sources, then employs Bayesian networks to build a risk dependency network and use it to determine risk propagation, rank risks based on appropriate measures and determine a fair allocation of budget to mitigation strategies (Qazi et al. 2017).

In a follow-up work the authors use fault tree analysis instead of FMEA and extend their approach to employ expected utility theory to capture different risk strategies and to include different decision criteria apart from cost (Qazi et al. 2018).

3.3. Fuzzy Logic

The concept of fuzzy logic was first introduced by L. Zadeh in 1965. The concept of fuzzy logic generally tries to model the way people think. While in the classical set concept, a member is a member of a set or not, in the fuzzy logic concept, whether a member is a member of a set is determined by membership functions. With this concept, it is tried to comment on events by using inference techniques used by fuzzy logic. The strongest side of fuzzy logic is

the use of existing expert knowledge. This situation creates a great disadvantage in cases where expert knowledge cannot be obtained fully. The concept of fuzzy logic consists of thoughts and practices that can take and apply multi-valued, intermediate values instead of 0-1 binary logic. It exhibits expansions in the form of some right and some wrong instead of right and wrong. He talks about working with gray tones, not black and white. Today, home appliances working with fuzzy logic, various parts of cars and electronic devices are produced (Bezdek 2014).

Hermawati et al., investigated the risks in the supply chain activity of CV. Multiguna which located in Yogyakarta. First, the risks are identified using the SCOR approach. Then, fuzzy logic, HOR, and AHP to know the risk mitigation and rank the priority. From the HOR method, it can be seen the mitigation option, but to make sure, AHP was conducted. From the AHP process, it obtained the consistency value which is equal to 0.09 or considered valid for CR < 0.1 (Hermawati et al. 2019).

3.4. Genetic Algorithms

A set of repeated recipes to solve a problem is called an algorithm. Algorithms can also be thought of as procedures. We can define genetic algorithms as software programs that learn in a similar way to living systems. In short, it can be defined as a research technique that follows the process that triggers the development in the computer. In general, the genetic algorithm starts searching with a situation where there is no or very little solution information. The solution depends on the interaction from the environment and genetic operators. The genetic algorithm starts from independent points in parallel with the search, so it is less likely to get stuck in sub-optimal solutions. Therefore, genetic algorithm is known as the best optimization technique for complex search problems. Genetic algorithms are used in the design of communication networks, electronic circuit design, optimization of gas pipe networks, image and voice recognition, database query optimization, aircraft design, control of physical systems, solution of traveling salesman problems, transportation problems, and optimal control problems (Haldurai et.al. 2016).

In the study of Pavlov et al., address the problem of assessing the resilience of a supply chain using a hybrid methodology that combines fuzziness and the genome method. Supply chain reliability is modelled through possibility of failure, while the genome method is used to determine the most efficient structure for the supply chain network that achieves a certain (or maximum) reliability level (Pavlov et al. 2018).

In the study of Jabbarzadeh et al., use fuzzy c-means clustering to score supplier sustainability based on several criteria. These scores are then used as input parameters to a stochastic model that aims to minimise total cost and maximise sustainability performance, when the percentage of a supplier's capacity that is disrupted is uncertain (Jabbarzadeh et al. 2018).

3.5. Machine Learning

Machine learning is an artificial intelligence technique that uses statistics and computer computing power to detect complex patterns from data and make rational decisions. Machine learning techniques are used successfully in classification problems. Machine learning is the process of using mathematical models to help a computer learn without direct instructions. Machine learning uses algorithms to identify patterns in data. These patterns are used to create a predictive data model. The results of machine learning become more accurate as the amount of data and experience grows, just as humans improve with more practice. Machine learning-based technique, on the other hand, can be examined under three basic classes: techniques with tutorials, semi-tutorials and no tutorials. It can also be used as supervised learning, supervised learning or supervised learning, unsupervised learning, unsupervised learning or unsupervised learning, and semi-supervised learning can also be used as semi-supervised or semi-supervised learning (Gürsakal 2017).

Constante et al., use machine learning techniques to predict fraud in an intelligent supply chain. They enable an assessment and classification of whether a transaction can be classified as normal or fraudulent to reduce product quality risks (Constante et al. 2020).

Fu and Chien, present a data-driven analysis framework that integrates machine learning technologies and temporal aggregation mechanisms to predict the requirements of intermittent electronic components and, thereby, to reduce supply risks. The empirical study was conducted in a distribution company for electronic components (Fu and Chien 2019).

Pereira et al., present a conceptual technique for a predictive and adaptive omnichannel supply chain management for the retail industry. Machine learning and simulation-based optimization are applied to minimize uncertainty and incompatibility between supply and demand (Pereira et al. 2018).

Rodriguez et al., use ML to model disruptive events and their impact on the supply chain to identify potential risks in a timely manner (Rodriguez et al. 2019).

Wichmann et al., discuss whether and to what extent supply chain maps can be automatically generated by evaluating unstructured texts in natural language, such as news reports or blog posts, in order to reduce supplier risks (Wichmann et al. 2020).

Yong et al., present a vaccine blockchain system as well as ML technologies, which are based on blockchain, to enable vaccine traceability and prevent vaccine record fraud, thereby reducing supply risks (Yong et al., 2020).

4. Results and Discussion

In this section, artificial intelligence techniques are compared.

4.1. Comparison of Artificial Intelligence Techniques

In which problem types, the application areas, strengths and weaknesses of these techniques are examined in detail. In this context, the fuzzy logic, artificial neural networks techniques used in clustering problems, its application area, strengths of the technique are given in Table 1:

Table 1. Comparison of artificial intelligence technique used in clustering problems

APPLIED TECHNIQUE	APPLICATION AREA	STRENGTHS AND WEAKNESSES OF THE TECHNIQUE
Fuzzy Logic	Identifying and mitigating procurement risks	They can be sensitive to noise and artifacts due to their straightforward implementation, fairly robust behavior, applicable to multi-channel data, and lack of spatial information.
Artificial neural networks	Risk management in the finance and manufacturing supply chain	Compared to other techniques, it is faster and has the ability to learn. Parallel working ability is a self-development by learning. Training method, easy implementation in hardware, generalization ability, and low dependence of system response on cell death are its strengths. However, it has been observed that the number of nodes of the network has increased a lot and the generalization feature has decreased due to the shortcomings caused by the learning algorithms being fitted with local best-fits and their structure (Bozüyük et al. 2005).

Artificial neural networks, genetic algorithms, fuzzy logic, expert systems and machine learning techniques used in estimation problems, application areas, strengths and weaknesses of the technique are given in Table 2:

Table 2. Comparison of artificial intelligence techniques used in estimation problems

APPLIED TECHNIQUE	APPLICATION AREA	STRENGTHS OF THE TECHNIQUE
Artificial neural networks	Production time estimation for products produced by similar processes	Low error rate, fast calculation, low cost Doesn't need a functional structure between input and output variables, ability to give an accurate output despite major inaccuracies during input, difficulty in transferring expert knowledge to problem solving Can diagnose error-free without learning. It works well even in non-linear time series. Going to conclusions with little data can sometimes give negative results as they show black box characteristics. Modeling both linear and non-linear relationships, no need for pre-assumptions (Hamzaçebi and Kutay 2004)
	Applications in traffic	
	Determining the optimal production and order quantity for suppliers and retailers	
	Electric energy consumption estimation	
	Estimation of transport risks	
Genetic Algorithms	Supplier selection and order allocation	High performance, minimum error value Ability to solve complex problems (Sarafraz et.al. 2016).
	Efforts to mitigate procurement risks	
Fuzzy Logic	Information risks prediction model in supply chain risk management	Ability to simulate with available data, work with non-homogeneous data, assign all possible rules Due to the fuzzy nature of most concepts in medicine, it is suitable for processing medical data, rapid decision-making (Nogueira et.al. 2015).
	Applications in medicine	
Expert Systems	Data sharing with supply and downstream supply chain stakeholders	Continuous self-improvement, detecting anomalies, working with irregular data (Seok et al. 2016).
Machine learning	Determining the price strategy in the raw material market	Good predictive ability, minimal data for training process, short processing time (Tsanas et al. 2012).

Fuzzy logic and expert systems techniques used in classification problems, their application areas, strengths and weaknesses of the technique are given in Table 3:

Table 3. Comparison of artificial intelligence techniques used in classification problems

APPLIED TECHNIQUE	APPLICATION AREA	STRENGTHS AND WEAKNESSES OF THE TECHNIQUE
Fuzzy Logic	Determining a decision model on the demographic distribution of tuberculosis disease	It provides great convenience in decision making process by visualizing the low-cost classification (Demirhan et al. 2010).
Expert Systems	Message processing and classification	Processing time is short, low cost, high quality, may require specialists in many fields for training, system development time is long (Seok et al. 2016).

Artificial neural networks, machine learning techniques used in clustering and classification problems, their application areas, strengths and weaknesses of the technique are given in Table 4:

Table 4. Comparison of artificial intelligence techniques used in clustering and classification problems

APPLIED TECHNIQUE	APPLICATION AREA	STRENGTHS AND WEAKNESSES OF THE TECHNIQUE
Artificial neural networks	Quantitative precise prediction of production, purchasing and logistics performance using statistical machine learning tools	Quick analysis, efficiency, ease of solution in the problems encountered in the processes (Uğur and Kınacı 2006).
Machine learning	Identification of activities by differential modeling using sensors in factory environments	Fast analysis, low cost (Tsanas et al. 2012).

5. Conclusion

At the end of this study, the following results were obtained regarding the use of artificial intelligence techniques in the solution of clustering, prediction and classification problems:

- ✓ Expert systems are developed with artificial intelligence technique, and it is aimed to achieve results by taking action automatically instead of individual operations.
- ✓ With artificial neural networks artificial intelligence technique, methods and tools can be developed to measure jobs at low cost. Thanks to this technique, efficient calculations can be made in large structures and mathematical models can be set up in a short time. Generally, mathematical optimization options can be applied in small networks, while heuristic methods are preferred for large networks.
- ✓ With the fuzzy logic artificial intelligence technique, the problems encountered in daily life are solved more easily. Clearer solutions can be developed by making a clustering application with the fuzzy logic technique.
- ✓ With the artificial intelligence technique of genetic algorithms, better results are obtained in solving non-linear problems. More precise predictions can be made for the future in problem solutions.
- ✓ With machine learning artificial intelligence technique, machines are trained, human-specific behaviors are transferred to machines, productivity is increased and human potential is used in different fields.

As can be seen from the above results, artificial intelligence techniques give very positive results in daily life applications. Engineering, medicine, daily life applications, etc. As it is known, these are the branches that require great attention and need good design and planning and implementation. At the same time, experimental studies are carried out especially in order to obtain some information before the applications, qualified personnel, materials and time are required to carry out these studies, and such parameters directly affect the economy and environmental order. By providing the necessary parameters using artificial intelligence techniques, significant time and economic savings will be achieved.

There are many risks related to supply chain management, both at the production stage and at the point of delivering the product or service to the customer. It is possible to reduce the impact of these risks by using artificial intelligence techniques. In this context, artificial intelligence techniques should be used more effectively in supply chain risk management processes. In particular, it is possible to use some artificial intelligence algorithms such as expert systems, artificial neural networks, fuzzy logic and genetic algorithms in solving problems in the supply chain that require optimization, optimizing stock levels, and solving large and complex stock control and planning problems of the supply chain.

Considering today's competitive conditions, supply chain risk management is one of the important issues that business managers and academicians should focus on. Using artificial intelligence techniques in supply chain risk management, it is extremely important for the continuity of the enterprises to anticipate the risks that the enterprises may face and take precautions.

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