Presenting the smart- sustainable supply chain model based on artificial intelligence

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<td><strong>Purpose:</strong> Artificial intelligence (AI) has the potential to transform many aspects of business operations. This technology can be used in various fields such as data analysis and demand forecasting, improving logistics and transportation routes, and identifying inefficient points in the supply chain. This research aims to identify the dimensions and characteristics of sustainable and intelligent supply chains based on artificial intelligence are investigated.</td>
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<td><strong>Findings:</strong> Using AI in supply chain will lead to improved response to changes in demand, reduced delivery times, and lower costs, and will lead to sustainable development. The integration of environmental, social, and economic aspects is continuously influencing general management decisions and especially supply chain management and operations management. Therefore, organizations are rethinking and redefining the concept of operations management using the supply chain approach based on smart technologies.</td>
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<td><strong>Originality/value:</strong> In this paper, the application of artificial intelligence in sustainable supply chain management has been investigated and the effects of this technology on this field have been investigated. Also, the issue of artificial intelligence in the supply chain and the need to use it by businesses is also discussed. In addition, the potential applications of artificial intelligence in the sustainable supply chain are also investigated and a conceptual framework is also presented for it.</td>
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1- Introduction

Artificial intelligence is defined as a network of computers that can simulate the human mind and make decisions in various situations and approaches. During the last two decades, as a result of the increase in the flow of data and the complexity that has been created in business scenarios, interest and traction. The use of artificial intelligence in various industries has increased. Currently, the potential of artificial intelligence is being exploited in various business sectors and operations [1-3]. Artificial intelligence helps design thinking of business systems and learns from data to gain insights without involving any human input. By using artificial intelligence, organizations can identify weaknesses in their supply chain and allocate resources accordingly [4] [5].

AI has the potential to help businesses produce the best possible products by quickly identifying customer expectations, gauging the market, investigating different failure modes, optimizing internal and external supply chains, and encouraging and nurturing a more creative workforce through the automation of routine tasks [6] [7]. Various organizations, such as companies active in the field of production and e-commerce, continuously use artificial intelligence technology to solve their supply chain problems. Most supply chains experienced a new level of resilience during the Covid-19 pandemic. Because they had to deal with the challenges that were created for different jobs [8] [9].

In recent years, supply chain management has become significantly more challenging, and artificial intelligence (AI)-based supply chain management solutions are expected to be a powerful tool to help organizations meet these challenges [10]. In other words, an integrated approach can address the opportunities and limitations of all functions and functions of a business, from buying to selling. AI's ability to analyze massive amounts of data, understand relationships, provide visibility into operations, and support better decision-making makes AI a potential game changer. But with all these descriptions, companies should take organized steps towards the full exploitation of artificial intelligence and not just be satisfied with using a part of it [11].

Digitization and artificial intelligence will create transparency and increase the speed of decision-making. In many organizations, supply chain management is focused on the dynamic optimization of the company's global value, instead of just improving local and internal functions. In several industries that operate in a process fashion (such as chemicals, agriculture, and metals and mining), sales and operations planning has evolved into integrated business planning. The challenges and demands that have arisen in the wake of the Covid-19 pandemic have intensified the need for companies to develop their central planning arms [12].

Today, increasing communication and the size of supply chain teams or business plans are not enough to achieve better performance! But companies have to deal with other challenges as well [13]:

- Forecasting demand in different geographic segments
- Dynamic identification of trade-offs, with hundreds or thousands of related variables and countless technical constraints
- Integrating AI solutions (such as process optimization, and predictive maintenance) to manage the broader value chain
- Ensuring that programs are implemented and can adapt to the effects of sudden changes (such as demand shocks, production stoppages, and transportation disruptions) in a timely and appropriate manner.
Artificial intelligence solutions are available for organizations to achieve better performance in supply chain management. These solutions have different features. Some of these features include demand forecasting models, transparency throughout the supply chain, integrated business planning, dynamic planning optimization, and physical flow automation. Successful implementation of AI-based supply chain management allows early adopters of this technology to improve their logistics costs by 15%, inventory levels by 35%, and service levels by 65% compared to their competitors [14].

Considering the importance of the topic, in this research, the dimensions and characteristics of sustainable and intelligent supply chains based on artificial intelligence are investigated.

2- Literature Review

Despite the great uncertainty, high supply risk, and increasing competition, the success of the supply chain depends on the organization’s ability to integrate and coordinate all resources and factors throughout the supply chain. Therefore, today many organizations seek to enrich their information sources and share information instantly with supply chain partners [15].

Modern supply chain automation is not possible without artificial intelligence. Artificial intelligence enables supply chain automation technologies such as digital workers, warehouse robots, self-driving vehicles, robotic process automation (RPA), etc. to automate repetitive and error-prone tasks. However, using artificial intelligence in logistics is not a goal in itself. In transportation, artificial intelligence not only ensures that shipments reach the recipient safely and on time, but also increases productivity [16]. Therefore, we see that everyone benefits: customers, employees, and the environment. In other words, artificial intelligence helps to speed up and simplify various necessary processes [17]. Automation of routine tasks that used to take a lot of time increases efficiency and accuracy and reduces the possibility of human error. As a result, the implementation of artificial intelligence in the logistics industry can reduce costs and increase customer satisfaction [18]. Due to the vast amount of data that can be collected from internet browsing and online shopping, people’s consumption habits are being identified thanks to the use of other technologies such as big data analytics. In addition, with machine learning, machines can predict how and when customers will buy or effectively control their entire inventory. Therefore, they adapt to reality and strengthen automation [19] [20].

In automated warehouses, management software is combined with robotics, and the combination of both provides the possibility of performing product placement and transportation operations independently. In this way, artificial intelligence makes it possible to allocate appropriate resources to each of the activities that occur on a daily basis. In this sense, it is very important to use Big Data in order to set up logistics in advance and avoid inventory shortages, avoid excess storage and thus reduce the use of resources [21].

With this technology, it is also possible to accurately control and visualize all the journeys made by goods, so the shipper’s time is better managed. All these measures can reduce the risk of error and thus improve the competitiveness of companies. With this technology, it is also possible to accurately control and visualize all the journeys made by goods, so the shipper’s time is better managed. All these measures can reduce the risk of error and thus improve the competitiveness of companies. The future of logistics transportation is multifaceted, but building that future requires the integration of complex management systems. Artificial intelligence is already offering benefits to this integrated transportation ecosystem [22].
3- Sustainable supply chain

The sustainable supply chain is the consideration of social, economic, and environmental issues in all organizational processes. These processes include the entire life cycle of the supply chain, from the purchase of raw materials to product design and development, warehousing, distribution, and delivery of the final product [23].

In fact, supply chain sustainability is a business issue that affects the organization's supply chain and organizational logistics network based on environmental factors, risk, and production waste management. Significant growth has emerged in the field of the need for the integration of environmental activities with the supply chain management of the organization. The new approach that has dominated operations management in recent years is the supply chain sustainability approach. The meaning of sustainability is to focus on the long-term effects of the company's activities and the sustainability of resources for future use at the same time as today's profitability [24]. In the literature on organization and management, sustainability has become a vital tool that guarantees competitive advantage and social responsibility. Now the sustainability suffix has been added to many organizational topics. The sustainable supply chain is also one of these topics that are closely related to the concept of a green supply chain. These concepts emerged to emphasize the importance of social and environmental concerns along with economic factors in supply chain planning. Figure 1 shows the dimensions of sustainable supply chain management [25].

![Figure 1: Dimensions of sustainable supply chain management](image)

4- Supply chain based on artificial intelligence

Artificial intelligence and machine learning are conquering more industries and different aspects of life day by day. Of course, the logistics industry is not exempt from this. Artificial intelligence and machine learning in the logistics industry can play a big and effective role in the field of the supply chain. By using this technology, processes can be optimized, mistakes made by humans can be avoided, and future
opportunities and challenges can be predicted. Therefore, the profitability and success of businesses will also be provided.

- **The Impact of artificial intelligence on supply chain automation**

  Modern supply chain automation is not possible without artificial intelligence. Artificial intelligence enables supply chain automation technologies such as digital workers, warehouse robots, self-driving vehicles, robotic process automation (RPA), etc. to automate repetitive and error-prone tasks. Through the supply chain, the following tasks can be automated [27]:

  - *Automation of office tasks:* Tasks such as document processing can be automated thanks to intelligent automation or digital workers that combine artificial intelligence with RPA.
  - *Logistics Automation:* Efficient supply chain logistics can also be achieved through artificial intelligence and automation.
  - *Warehouse automation:* Technologies equipped with artificial intelligence such as cobots; They help increase efficiency, productivity and safety through automated warehouse management.
  - *Automatic quality control:* Computer vision (CV) systems equipped with artificial intelligence can help to automatically check the quality of products. Since these systems do not get tired and are able to operate continuously, they can help improve productivity and accuracy in production lines.
  - *Automated inventory management:* Robots equipped with computer vision and machine learning can be used to automate repetitive tasks in inventory management, such as scanning inventory in real time. These inventory-scanning robots can also be implemented in retail stores. However, when implementing such solutions, one must ensure their feasibility and calculate their long-term benefits. Otherwise, such initiatives can even lead to failure.

- **The impact of artificial intelligence on predictive analytics**

  The trump card of a supply chain manager is the ability to predict the future in terms of demand, market trends, etc. However, there is no such thing as an error-free forecast. But using machine learning helps managers and leaders make more accurate predictions [28].

  - *Inventory optimization:* AI-based tools can help determine optimal inventory levels by analyzing data and historical supply and demand trends. This can help prevent excessive production and storage costs
  - *Regional Forecasts:* An AI-powered supply chain can also provide accurate regional demand to help business leaders make better decisions. For example, each region; It has its own events, holidays, trends, etc. Using region-specific parameters, AI-based predictive tools can help customize processes based on regional needs.
  - *Prevention of the whiplash effect:* The whiplash effect is one of the important issues in supply chain management. This phenomenon occurs when small fluctuations at one end of the supply chain are amplified by upstream/downstream movement.

  AI-based forecasting tools can help reduce demand and supply fluctuations by using data collected from customers, suppliers, manufacturers, and distributors to control the bullwhip effect. This can help reduce inventory [29].
The impact of artificial intelligence on improving supplier relationship management

Many of the current issues and problems we face in global supply chains are related to poor supplier relationship management. Due to the lack of cooperation and integration with suppliers, many supply chains such as food and automotive faced serious disruptions during the 2020 global pandemic. Artificial intelligence can help improve supplier relationship management (SRM) by making the supply chain more consistent and efficient [30].

- Improvement in the supplier selection process: SRM software equipped with artificial intelligence can help in supplier selection based on factors such as pricing, purchase history, sustainability, etc. AI-based tools can also help track and analyze supplier performance data and rank them accordingly.
- Improve supplier communications: AI-based tools like RPA can help automate routine supplier communications with each other, such as invoice sharing and payment reminders. Automating these procedures can avoid the challenges that generally arise due to financial and payment issues among suppliers.

The benefits of artificial intelligence in supply chain management are shown in Figure 2.

![Figure 2: Benefits of artificial intelligence in supply chain management [31]](image)

5- Sustainable supply chain based on AI

Today, the world is facing issues such as global warming, various types of pollution, increasing greenhouse gas emissions, etc., which can potentially lead to the extinction of the human race. The integration of environmental, social, and economic aspects continuously affects the general decisions of management and especially management. Supply chain and operations management has been impressive. Organizations have tried to rethink and redefine the concept of operations management by using the supply chain approach [32].

Compared to traditional supply chain management which emphasizes the financial and economic operations of the business, sustainable supply chain management is defined based on the integration of
environmental and social goals with economic approaches. In this sense, sustainable supply chain management emphasizes the forward supply chain and is completed with the closed-loop supply chain, which includes the reverse supply chain, reproduction, and product recovery. In summary, sustainable supply chain management examines economic, social, and environmental factors in the field of supply chain and logistics. In a nutshell, sustainable supply chains, in addition to paying attention to the economic benefits of business, also take into account the social and environmental effects and consequences of supply chain activities and products and seek to optimize supply chain management in all three mentioned aspects (economic, social and environmental) [33].

Sustainability is one of the increasing concerns of supply chain managers because most of the indirect problems of an organization are caused by its supply chain. Artificial intelligence can help improve supply chain operations to make them greener and more sustainable.

- **Green transportation logistics**: AI-powered tools can help optimize transportation routes to reduce mileage by taking into account factors such as traffic, road closures, and weather.
- **Green warehousing**: As AI-based predictions can help maintain optimal inventory levels, carbon emissions caused by storing and moving excess inventory can be reduced. Smart energy consumption solutions can also reduce carbon emissions related to warehouse energy consumption. Artificial intelligence combined with big data can help the supply chain to become not only sustainable but also flexible.

In Figure 3, the basic and effective roles of artificial intelligence in the development of sustainability of supply chain systems are shown.

![Figure 3: The effects of artificial intelligence on the sustainable development of the supply chain [34]](image-url)

The mentioned items are some of the most important and up-to-date applications of artificial intelligence in the supply chain and logistics that businesses can use to improve their profitability. The
speed of technological progress makes these applications increase day by day and it is likely that in the near future, it will affect all parts of this field.

6- Conclusion

Supply chain sustainability refers to the transparent integration and achievement of social, environmental, and economic goals of organizations with the effective coordination of intra-organizational processes. Key aspects of implementing sustainable supply chain management include the sustainability of the supply chain network and supply chain environment, the application of environmentally friendly strategies, and the full acceptance of social responsibilities. Therefore, by considering sustainability in the supply chain, in addition to considering financial profitability, adverse environmental effects and adverse social effects can be minimized. Companies are facing a lot of pressure to implement artificial intelligence and machine learning in order to improve operational efficiency and simplify business decisions with forward-looking systems. Advanced technologies can also help logistics businesses to create the ability to optimize production, logistics, warehousing and final delivery at multiple levels.

Artificial intelligence in logistics improves customer experience. Therefore, by using solutions based on machine learning, your products will be delivered in excellent condition and on time. Additionally, your team will gain more time and business insights that will help your management team make successful decisions and ensure your business grows. To improve supply chain efficiency, you can use artificial intelligence and machine learning to forecast demand or improve demand forecasting. Using this technology, you can receive a detailed analysis of all factors that may affect demand and make the right decisions for your business based on past experiences. Just like many other technologies, artificial intelligence, and machine learning are much more effective than traditional methods of demand forecasting. The point is, maybe you use those methods for factors that have less impact on demand. Therefore, such predictions cannot be as reliable as those made with the help of advanced technology.

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Conflicts of Interest

None.

References


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