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The Importance of Advancing from Industry 4.0 to Industry 5.0: A SWOT Analysis of Turkey's SCM Strategy

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Abstract

This research examines the role of artificial intelligence (AI) and robotic technologies in the transformation of the logistics sector at different stages. With the global economy becoming increasingly competitive, the study aims to predict the best ways to increase efficiency and reduce costs in logistics processes. In addition, it delves into the changes required in supply chain management (SCM) strategies that have been triggered by the global health crisis of COVID-19. The study uses the multi-criteria decision-making method for its analysis. First, it reviews the historical development from the first industrial revolution and emphasizes the transition from Industry 4.0 (4IR) to Industry 5.0 (5IR). The final section of the research provides a SWOT (strengths, weaknesses, opportunities, and threats) analysis of Turkey's current SCM strategy.

Keywords: Logistics industry, Artificial intelligence, AI technology, Logistics, SWOT analysis

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Introduction

The rise of digital transformation has led to the expansion of AI and robotic technologies, key drivers of the fourth industrial revolution (4IR), across a wide range of industries. Robots, now equipped with advanced human-like capabilities, are increasingly used in logistics processes such as packaging, storage, and transportation. Moreover, the incorporation of humanoid robots in logistics operations introduces features like autonomous decision-making and accountability, which in turn raises the complexity of managing robots within logistics services. The ongoing COVID-19 pandemic has further amplified the interest in utilizing robots in logistics, as their potential benefits become more evident in the face of the global health crisis.

Advancements in information technology are catalyzing significant changes within the logistics sector, and the COVID-19 pandemic has driven businesses to accelerate the adoption of technological solutions. As a result, this study highlights the significance of Logistics 4.0, an outcome of the increasing influence of 4IR technologies, and explores the relevance of future predictions within the context of historical developments in logistics.

This study is conceptual, theoretical, and informational, drawing upon examples from various sectors implementing these technologies. The research aims to present findings from existing literature that will shape the future of logistics through the integration of AI while contributing to the identification of the most accurate forecasts for the industry's future.

Literature review

In this study, a multi-criteria decision-making method was utilized to assess the advancements in logistics, particularly concerning the industrial revolutions. Statistical analyses of the integration of A.I. and robotic technologies within the logistics industry are discussed, with findings guiding the suggestions for future developments. Additionally, relevant literature on the topic is reviewed.

Robotic technologies, as a hallmark of the current industrial revolution, are rapidly transforming logistics. Organizations across various industries are striving to incorporate AI and robotic systems to reduce costs, enhance productivity, and bolster competitiveness [1]. In the logistics sector, AI applications are reshaping workflows, with innovations like autonomous vehicles, robots for warehousing, and data-driven solutions providing substantial operational advantages. These technological revolutions have unfolded progressively within the logistics domain [2]:

- The first industrial revolution saw the mechanization of transportation, replacing manual and animal-powered transport with trains, ships, and trucks on railways, waterways, and highways, beginning in the latter half of the 19th century.
- The second revolution, initiated in the 1960s, introduced partial mechanization in logistics equipment for storage and inventory management.
- The third revolution, which began in the 1980s, marked the systematization of logistics management, with information technologies being widely adopted.
- The fourth revolution, which has been evolving since 2000, involves the digitalization of logistics processes.
- The fifth revolution is currently under development, where robots are anticipated to perform tasks indistinguishable from those of humans, including recording data in cloud systems and communicating autonomously.

The logistics sector encompasses a wide range of processes, including order management, shipping, warehousing, collection, packaging, delivery, inventory management, and routing. Robotic logistics refers to the use of robotics in one or more of these processes. Key areas within logistics that are increasingly benefiting from robotic applications include warehousing, order management, shipment handling, packaging, delivery, inventory control, and recycling, among others [3]. Some of the most common robotic applications in logistics processes include:

- Robotic palletizing: Robots are used to load or unload products from pallets.
- Robotic packaging: Robots are employed to package products and then place them into larger boxes.
- Robotic collection: Robots select and sort products from shelves in warehouses.

Pallets have been pivotal in revolutionizing global logistics and have played a vital role in the world economy since the 1920s. Forklifts, introduced in the 1950s, made it easier and quicker to transport and store bulky products on pallets within warehouses. The introduction of industrial robots in 1963 marked the beginning of robotic palletizing. These robots are programmable, occupy minimal space, and can handle various product types, even in mixed orders. This innovation allows suppliers to fulfill mixed orders, rather than just bulk ones. The significance of robotic packaging and distribution continues to grow, driven by the rise of e-commerce and globalized supply chains. Using collaborative robots for palletizing and unloading offers a competitive edge. For example, here are seven notable robotic applications in food packaging [4]:

- Selection and placement of randomly arranged foods
- Packaging all types of food products
- Smoothly removing cooked products from molds
- Removing empty packaging from the batch and inserting products
- Boxing (placing individually packaged products into boxes)
- Palletizing (arranging boxes for shipment)
- Storing (automatically collecting products at designated locations)

As robotic collection systems continue to evolve, the supply chain is expected to experience significant advantages. The use of mobile robots and collaborative arms has already yielded important improvements. Collaborative robots are being integrated into various stages of the supply chain, including production and storage, enhancing operational efficiency. As a result, it is widely recognized that implementing robotic systems can boost productivity, reduce errors, and improve safety by removing workers from hazardous and physically demanding tasks. Two key factors driving the demand for autonomous logistics solutions are [5]:

- E-commerce growth: The rise of online shopping has led to significant changes in product distribution over the past decade. Today, products are individually packaged and shipped directly to customers. The need for diverse packaging and the selling of heavier products has led to an increase in distribution requirements.
- Labor shortages: The logistics industry faces a growing demand for specialized skills beyond manual labor, which can be met through robotic technologies. During the COVID-19 pandemic, robots have proven to be a vital solution to ongoing challenges in logistics operations.

Mobile robots refer to machines capable of autonomous movement to reach one or multiple destinations [6]. These robots find applications in a range of industries, including automated guided vehicles (AGVs) in manufacturing plants, unmanned exploration tools for military use, pharmaceutical and medical product delivery in healthcare, and security-related search and rescue operations.

The concept of AGVs was introduced in 1953, and they have since been primarily used to transport materials within industrial facilities, production plants, or warehouses. Common types of AGVs include taggers (robots that tow carts), unit loaders (robots with built-in tables to move part trays), and forklifts (robots designed similarly to manual forklifts). As the use of robots expands across industries such as hospitals, factories, and office buildings, their implementation continues to grow [7]. Presently, load-handling robots in warehouses utilize cameras to detect ground markings and follow the lane lines, providing guidance to navigate their paths. These robots are guided by detection systems, ceiling-mounted barcodes, lasers, and reflectors. In large-scale warehouses, these robots can assist with tasks such as product selection, packaging, and palletizing. They can pinpoint the vehicle's position within a margin of just 5 cm and are deployed in more challenging fields, including targeted wall monitoring and truck loading [7].

A modern variation of robotic technology involves a four-legged robot equipped with clamping devices on each foot, allowing it to walk and manipulate loads without needing a flat surface. This robot's design incorporates a locking mechanism that enables it to either walk or manipulate objects using passive joints at the foot's end [8, 9].

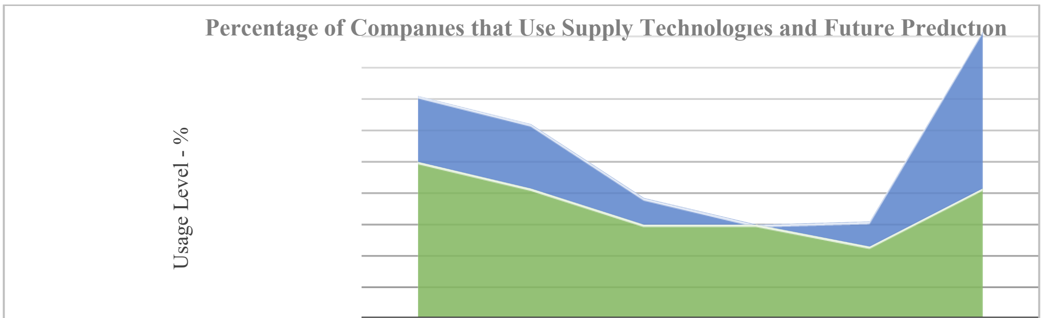
Additionally, DHL [10] identifies 29 key trends that will influence the logistics sector in the years ahead. The report, developed through collaborations with research institutions, technology companies, startups, and customers, provides a detailed analysis of both macro and micro-trends. Among these, trends like artificial intelligence (AI), robotics, quantum computing, sustainability, and global mobility are expected to shape the logistics landscape [11].

Data collected from a study by DHL suggests that the COVID-19 pandemic has accelerated the shift toward digitalization and automation within the logistics industry. Key projections include:

- Supply chain leaders are moving away from focusing solely on cost and are now prioritizing durability.
- Consumer behavior changes are driving necessary adjustments in transportation flows and warehouse operations.
- New work models are challenging traditional practices, leading to faster adoption of digital and automated solutions [12].

A retrospective analysis comparing the contribution of robots to global labor productivity reveals significant findings. According to a study [13], the introduction of steam engines between 1850 and 1910 contributed a 0.34% annual increase in labor productivity. In comparison, industrial robots used between 1993 and 2007 in 14 industries across 17 countries increased labor productivity by 0.36%. While this percentage may seem modest, it accounts for 10% of the total productivity gains. Furthermore, the computer technology (C.T.) revolution between 1995 and 2005 contributed 0.60% to labor productivity in Europe, the U.S., and Japan, doubling the impact of robotics.

As autonomous vehicles continue to make strides, their carrying capacity is expected to rise, further reducing time losses in logistics. An increasing number of companies are adopting supply chain technologies, and it is anticipated that this trend will continue over the next five years. The growing importance of robotics and AI in logistics, especially spurred by the pandemic, suggests that their usage will see significant growth shortly. Additionally, the implementation of the Internet of Things (IoT) and blockchain technologies in logistics and transport is expected to increase over the next five years, while the use of data analytics may see a decline **(Figure 1)**.



	Internet of things	Blockchain	Autonomous vehicles	Drones	3D Printers	Data Analysis
Businesses currently using	42	41	17	0	16	100
Businesses that will use it within 5 years %	100	83	60	60	46	83

Figure 1. Percentage of companies that will use them in the next 5 years (Created by the author from UNCTAD [14])

The results gathered from the literature concerning the use of robotic technologies in the logistics industry are summarized in **Table 1**. This table presents examples of scientific studies, outlining the topics and objectives related to the application of AI within the logistics sector.

Table 1. Literature on the use of AI and Robotics in the logistics industry

Authors	Article subject	Purpose of the article
DHL Logistics [10]	Logistics trend radar	The study highlights the advantages of augmented reality systems, demonstrating how vehicle windshields can function as displays. By integrating augmented reality into driver support systems, the study explains how such technology enhances road safety by projecting navigation data and hazard alerts.
Özbek & Eren [15]	Multiple criteria decision making methods for selecting third party logistics firms: a literature review	This study provides an exploratory review of existing research on third-party logistics (3PL) selection and evaluation. It examines a variety of evaluation techniques, ranging from straightforward analytical methods to multi-criteria decision-making approaches. The study categorizes the analyzed articles based on their evaluation methods and highlights the frequent use of hybrid approaches that incorporate both qualitative and quantitative factors, though often without real-world case applications.
Sayın & Erol [16]	Modeling the supply potential for establishing paper waste collection centers in reverse logistics	This research differs from conventional studies by incorporating the quality classification of collected waste into the location-allocation problem. Additionally, the study introduces a decision support system to enhance the model's adaptability and decision-making capabilities.
Ekol Logistics [17]	Warehousing practices	Ekol Logistics offers extensive multi-user operational facilities serving the pharmaceutical and medical sectors across Turkey, Hungary, and Ukraine. The study emphasizes the company's commitment to adhering to good manufacturing practices (GMP) and good distribution practices (GDP), as well as the regulatory requirements set by the respective Ministries of Health. These facilities accommodate a diverse range of product categories, including prescription medications, over-the-counter drugs, cosmetics, dietary supplements, diabetes treatments, controlled substances, clinical supplies, cold-chain pharmaceuticals, and veterinary medicines.
Jahanzeb *et al*. [18]	Covid-19	The study explores servant leadership as a concept that has garnered considerable attention in organizational behavior research. It identifies this leadership style as a significant factor contributing to numerous positive employee outcomes.
Navarro Cid *et al*. [19]	Covid-19	To push the boundaries of knowledge on work motivation dynamics, the study emphasizes the need for more rigorous temporal assessments of participant variability, moving beyond traditional informal measurement approaches.
Patrono *et al*. [20]	Covid-19	Researchers examine the physical and mental health symptoms that emerged due to lifestyle changes during lockdowns. The study focuses on university students in Northern Italy, one of the regions most affected during the initial wave of the COVID-19 pandemic.
Carvalho *et al*. [21]	Covid-19	This study investigates the competencies of clinical nurse leaders in advanced practice, demonstrating how their expertise contributes significantly to healthcare organizations.
Neogi, *et al*. [22]	Covid-19	The study concludes that, compared to broader health system indicators and global health security measures, health financing strategies and preventive interventions were more reliable predictors of COVID-19 cases and mortality per million people.
Brubacher *et al*. [23]	Covid-19	A case study protocol designed to analyze how institutional frameworks, political environments, organizational structures, and governance influenced the COVID-19 response in British Columbia, Canada.
Frost & Sullivan [24]	Industry 5.0 – The role of trained workforce and humanoid robots in production	The study outlines Industry 5.0 as the next stage of industrial development, characterized by highly intelligent supply chains and extensive personalization. It predicts that factory operations will see a convergence of roles, such as machinery maintenance and quality control, necessitating a workforce skilled in multiple

	disciplines. With humanoid robots gradually assuming physically demanding tasks, highly trained labor will continue to play a key role in manufacturing processes.

*Created by the author

An example of a storage solution incorporating AI in logistics is discussed by Baykasoğlu and Subulan [11]. Ekol's warehousing management services provide specialized storage solutions tailored to the healthcare industry, including temperature- and humidity-regulated environments for sensitive products, dedicated storage zones for varying temperature needs, order processing and shipping, sales XML file notifications to the national health authority, management of sample products, cold-chain logistics, return handling, storage for clinical trial materials, warehouse management tailored to the health sector, automated storage and retrieval systems, order processing zones, online KPI tracking, and real-time monitoring of order statuses. Ekol operates large-scale, multi-user logistics facilities serving the pharmaceutical and medical industries in Turkey, Hungary, and Ukraine while ensuring full compliance with GMP/GDP guidelines and the specific regulatory requirements of each country. These warehouses cater to an extensive range of products, including prescription medications, over-the-counter drugs, cosmetics, government-approved nutritional supplements, diabetes treatments, controlled pharmaceuticals, temperature-sensitive medicines, and veterinary drugs [25, 26].

Ekol has established a specialized bonded warehouse for Turkey's pharmaceutical and medical sectors, designed with temperature and humidity control systems. This facility features two distinct temperature zones: a standard storage area maintained between 15 °C and 25 °C and a cold storage section set between 2 °C and 8 °C. It also accommodates pharmaceutical raw materials and contains designated sections for regulated products. Additionally, Ekol provides a full suite of packaging services to meet customer needs through its secondary packaging units. Housing one of Turkey's largest Ministry of Health-certified secondary packaging areas, these facilities offer the following services [27]:

- Printing and labeling data matrices
- Aggregation for the second phase of data matrix applications
- Ink-jet printing directly onto packaging
- Replacement of product boxes
- Inclusion of informational leaflets
- Application of decals
- Conversion of standard products into promotional samples
- Preparation of products for export

The storage and distribution of promotional materials play a crucial role for pharmaceutical companies, and Ekol supports major industry players with efficient logistics solutions designed specifically for these items. The process is streamlined through a dedicated system that simplifies inventory tracking and order management. A web-based platform enables real-time updates on order statuses and warehouse stock levels, making the logistics of promotional items more efficient. Upon arrival at the warehouse, each product is photographed and submitted for managerial approval. Orders are then generated for distribution by sales teams or companies, with full traceability until final delivery within Ekol's logistics network.

The implementation of robotic storage and retrieval systems enhances warehouse efficiency by automatically managing the placement and retrieval of various load types, such as pallets, bins, and cartons, from designated storage areas. Ekol's automated storage and retrieval system (ASRS) delivers several advantages for customers [28]:

- Increased storage efficiency: By reducing aisle width and utilizing higher racks, the system maximizes space, accommodating approximately 2.5 times more products per unit area compared to conventional storage methods.
- Lower labor costs: Automated retrieval and placement eliminate the need for manual stacking operations, reducing workforce requirements and minimizing workplace accidents.
- Shorter storage and retrieval times: Compared to conventional warehouse operations, automated systems reduce product handling times by nearly 80 percent.
- Greater accuracy: Human errors in inventory management and order fulfillment are nearly eliminated, ensuring a high level of precision in stock control and order preparation.
- Improved delivery efficiency: Advanced algorithms enable rapid retrieval and transport of items, prioritizing deliveries based on location proximity to optimize the supply chain.

Materials and Methods

The rapid expansion of robotic technology in the logistics industry has been evident in recent years, with the number of robots utilized rising significantly from 19,000 units in 2015 to 189,700 units between 2018 and 2020. This sharp increase reflects the growing demand for automation in logistics. Traditional robotic systems, previously limited to enclosed storage areas, have been replaced by more advanced, high-speed technologies equipped with enhanced safety features, contributing to these developments. As AI applications continue to expand globally, human-robot collaboration has also gained traction, particularly with the adoption of collaborative robots designed to work alongside human workers.

The global market for service robots has experienced substantial growth, with sales increasing by 32%, logistics robots surging by 110%, and medical robots expanding by 28%. Examining the market value of logistics robots worldwide reveals a significant rise to $1.9 billion, representing a 110% increase in the total number of robots sold and leased between 2018 and 2019 **(Figure 2)**. Projections indicate that this market will continue expanding in the coming years, driven by the growing need for faster production and product delivery at competitive costs. AI and robotic technologies are expected to play a crucial role in meeting these demands [29].

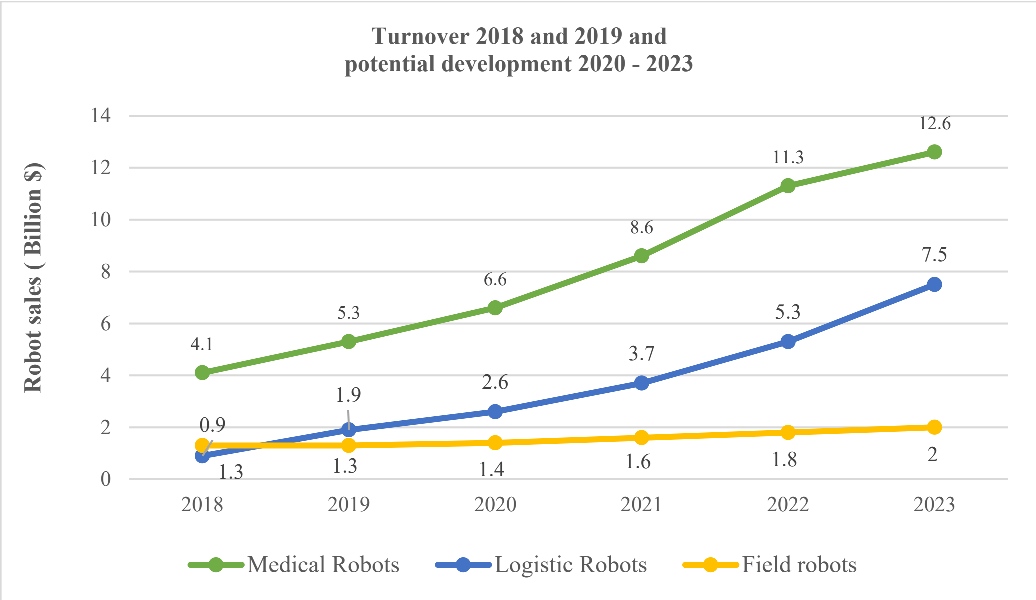
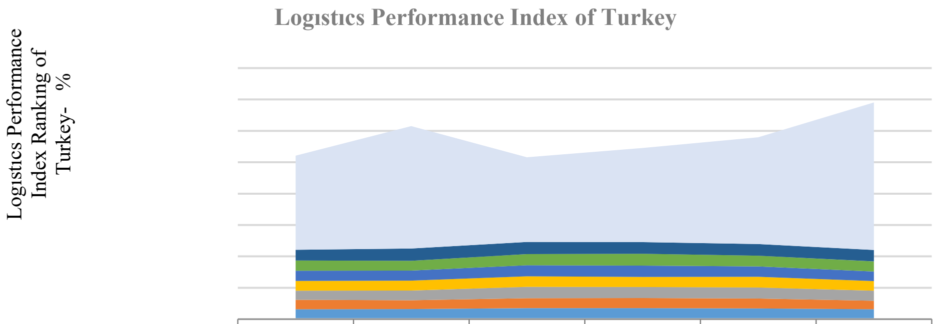


Figure 2. Service robots for professional use–major applications [29]

As robots demonstrated their effectiveness in mitigating labor shortages and handling hazardous tasks in 2019, their integration into production and supply chain logistics has continued to expand into new markets. According to Robotics Business Review [30], companies that successfully automate various stages of supply chain and logistics operations can further enhance efficiency. For instance, when a robot retrieves a product and transfers it to a packaging station, another robot can seamlessly take over and complete the next step, assisting workers or carrying out further processing. Despite their gradual adoption, robots have been utilized in logistics for some time, particularly in palletizing operations.

Innovations such as drone-based deliveries are beginning to emerge, signaling continued advancements in robotics within logistics applications. The emergence of the 5. Intelligence Robotics (5. I.R.) revolution—often referred to as Industry 5.0 in the field of unmanned and highly intelligent robotic technologies—is expected to contribute to greater equity in global trade. Within this system, robots possess the capability to self-repair, monitor operations, and reprogram autonomously [31]. The rapid evolution of AI is reshaping industries, necessitating an acceleration in logistics and supply chain operations to accommodate the increasing demands of e-commerce, particularly under the constraints imposed by the COVID-19 crisis in 2020 [32].

Countries receive logistics performance scores, which provide insights into their strengths and weaknesses, helping to identify areas for improvement in logistics services and international partnerships [33, 34]. The fluctuations in Turkey's Logistics Performance Index (LPI) scores over time are illustrated in **Figure 3**. A decline in Turkey's LPI score was recorded in 2018, with a downward trend observed across all evaluated areas between 2016 and 2018. Among the six assessed dimensions, the most significant decrease occurred in the customs category. Turkey's LPI remained consistent at 3.15 in both 2007 and 2018. The customs sector registered the lowest score within the country's logistics performance, yet digitalization efforts in customs operations could contribute to improved performance in this area [35].



	2007	2010	2012	2014	2016	2018
Ranking	30	39	27	30	34	47
Timeliness	3.38	3.94	3.87	3.68	3.75	3.63
Tracking and tracing	3.27	3.09	3.54	3.77	3.39	3.23
Logistics,quality and Competence	3.29	3.23	3.52	3.64	3.31	3.05
International Shipments	3.07	3.15	3.38	3.18	3.41	3.06
Intrastructure	2.94	3.08	3.62	3.53	3.49	3.21
Customs	3	2.82	3.16	3.23	3.18	2.71
LPI	3.15	3.22	3.51	3.5	3.42	3.15

Figure 3. LPI of Turkey (Turkey's LPI scores 2007–2018) [36]

Based on the LPI ranking, Turkey, which held the 30th position in 2007, advanced to 27th place in 2012. However, a decline followed in subsequent years, placing the country at 47th as of 2018. The primary factors contributing to this drop were inefficiencies in customs processes, bottlenecks, and cost-related challenges. Additionally, the overall quality of shipment criteria and logistics services has deteriorated in recent years [37].

Robots designed to work alongside humans, known as "collaborative robots," enhance workforce efficiency by complementing human labor and improving operational performance. The logistics sector continues to evolve, driven by technological advancements [24]. With the anticipated transition from traditional supply chain models to blockchain-based logistics under the 5IR framework, blockchain is expected to generate significant added value, particularly in customs clearance and international trade operations. Advanced technological tools play a crucial role in shaping the future of logistics within this framework [24].

The integration of robotic systems within logistics operations has demonstrated a positive impact on labor productivity.

Turkey's SWOT analysis

An evaluation of Turkey's logistics sector was conducted through a SWOT analysis, assessing key performance indicators such as:

- The distribution of exports by different transportation modes,
- The distribution of imports by different transportation modes,
- Turkey's LPI,
- An overall SWOT analysis of Turkey's logistics sector.

Table 2 presents data on how exports and imports are distributed based on transportation methods. In Turkey, maritime and road transport account for the largest share of logistics activities, whereas railway transportation represents the smallest portion of total freight movement.

Table 2. Exports and imports by mode of transport

Exports by mode of transport						
	Seaway	**Railway**	**Roadway**	**Airway**	**Other**	**Total**
2014	88.900.953	964.170	61.133.176	14.388.661	1.117.902	166.504.862
2015	79.762.173	861.740	51.946.113	17.400.190	1.011.898	150.982.114
2016	80.139.270	673.816	49.537.436	17.908.782	987.696	149.246.999
2017	93.378.625	699.915	50.988.408	17.217.240	2.210.432	164.494.619
2018	108.802.681	753.544	52.222.468	14.127.905	1.262.157	177.168.756
2019	109.114.264	971.021	54.461.860	14.849.231	1.436.347	180.832.722
2020	100.907.927	1.287.765	53.127.588	12.732.561	1.581.914	169.637.755

2021	120.387.912	1.487.369	62.304.873	16.810.158	2.103.226	203.093.538
Imports by mode of transport						
	Seaway	**Railway**	**Roadway**	**Airway**	**Other**	**Total**
2014	147.778.523	1.253.892	40.577.283	24.889.608	36.643.124	251.142.429
2015	126.868.187	1.434.902	37.840.932	20.159.751	27.315.439	213.619.211
2016	121.013.276	1.768.602	36.716.500	23.107.208	19.583.655	202.189.242
2017	138.596.809	1.294.504	40.374.083	34.439.948	24.009.784	238.715.128
2018	136.737.402	1.299.419	39.129.380	28.756.745	25.229.537	231.152.483
2019	112.967.845	1.447.897	37.177.012	29.238.406	29.514.041	210.345.203
2020	114.838.355	2.144.863	41.883.477	39.260.478	21.389.634	219.516.807
2021	141.174.732	2.626.105	44.167.395	23.833.328	30.641.730	242.443.290

Resource: General trade system, transport modes (Thousand $) [38]

Turkey experienced its highest export volume in recent years in 2021, while a decline was observed in 2020 due to the disruptions caused by the COVID-19 pandemic. Regarding total imports, the figures recorded in 2021 were lower compared to 2014 [39].

The LPI is structured around six fundamental components, with each country receiving a score based on its performance in these categories. These dimensions include [40]:

- Affordability and ease of shipping services,
- Capability to track and monitor shipments,
- Reliability in ensuring on-time delivery to recipients,
- Effectiveness of customs procedures, focusing on processing speed and ease of compliance,
- Standard of transport infrastructure, covering ports, digital tracking tools, and logistics networks,
- Efficiency and reliability of customs-related logistics services.

SWOT analysis of Turkey

A SWOT analysis is a strategic assessment tool used to analyze a country's logistics sector by examining both internal and external influences, along with its long-term growth potential. This structured approach provides an objective, fact-based evaluation of Turkey's logistics framework and competitive standing **(Figure 4)**.

The analysis explores the key strengths (S), weaknesses (W), opportunities (O), and threats (T) influencing Turkey's logistics industry, offering insights into its current position and prospects [41].

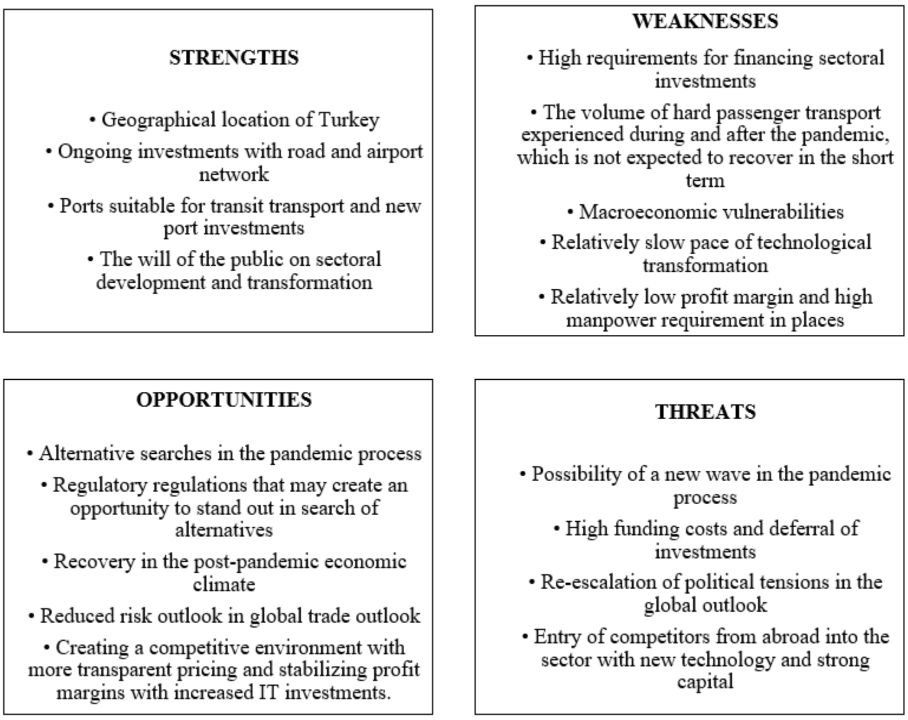


Figure 4. SWOT analysis of Turkey

Created by the authors from data of KPMG [42]

Turkey continues to expand its presence in global trade by leveraging alternative trade routes despite various challenges. The pandemic has prompted a reassessment of reliance on China, the leading global supplier. Concerns over China's role as the outbreak's origin, along with geographical distance, have intensified the search for new manufacturing hubs, particularly in advanced economies. Turkey has emerged as a key alternative production center in this evolving landscape [42].

Results and Discussion

- The integration of automation technologies is rapidly increasing in the logistics sector, with applications expanding daily. The reliance on AI and robotics solely within storage areas is proving insufficient for the logistics operations required in the Industry 4.0 era.
- Ensuring that logistics activities within production units are both traceable and efficiently managed has become a priority. Service robots are now playing a central role in logistics, with AGV systems holding a dominant share in these applications.
- The necessity for fully integrated logistics and production operations is driving businesses toward automated intralogistics solutions. Previously, separate systems were employed for logistics and manufacturing processes, but now, achieving interconnected operations is becoming essential.
- Optimizing logistics processes increasingly depends on fleet traffic management, navigation software, drones, and human-like collaborative robots. The transition from conventional supply chains to blockchain-enhanced logistics, supported by 5G technologies, is anticipated to enhance efficiency and reliability.
- In the context of storage operations, logistics companies play a crucial role in managing the storage and distribution of promotional materials, particularly in the pharmaceutical sector. Ekol, for instance, provides logistics solutions tailored specifically for handling promotional items, enabling leading pharmaceutical firms to streamline and efficiently oversee these operations.

Conclusion

This study aims to outline the evolving expectations surrounding supply chain management (SCM) strategies, which have undergone significant changes due to COVID-19, a global health crisis. A Multi-Criteria Decision Making Method was employed for analysis, beginning with an assessment of historical industrial advancements from the First Industrial Revolution to the shift from Industry 4.0 (4IR) to Industry 5.0 (5IR). Subsequently, Turkey's SCM performance was examined through a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis. Given the extensive global research on this subject, the literature presents a broad and diverse range of findings.

The pandemic underscored the role of robotic applications in enhancing collaboration and efficiency rather than replacing human workers. Outbreaks in warehouses accelerated the adoption of automation, including collaborative robotic arms designed to improve workspace safety by enabling greater distancing in confined production areas. Human-robot cooperation has been facilitated by adaptable robotic systems, demonstrating how such technologies can help maintain productivity even in unpredictable conditions.

While COVID-19 has driven the widespread adoption of robotics, it has also redefined the relationship between humans and machines in ways that are expected to endure. Concerns about job displacement due to automation can be alleviated through well-planned industry strategies. Instead of eliminating human labor, the collaboration between robotic and human workers is projected to enhance productivity and cost efficiency in various industries.

The transition between industrial revolutions aims to shift human roles toward simpler, more supervisory tasks, such as monitoring and control, while robots handle strenuous or hazardous jobs. The continued evolution of self-regulating robotic systems capable of performing human-equivalent tasks highlights the importance of ensuring improved working conditions for human employees. The widespread adoption of human-like robots appears increasingly inevitable, and future discussions must focus on defining the objectives of Industry 6.0 in response to contemporary technological developments.

Turkey remains a key player in transportation and logistics due to its strategic location and strong tourism sector. Ongoing investments in road and air transport bolster this position; however, structural inefficiencies hinder the full realization of this potential. Beyond increasing volume, the sector is expected to prioritize operational efficiency in 2021. Investment in infrastructure—particularly in pipeline transportation—will likely be accompanied by heightened cybersecurity measures. While the worst of the pandemic may be behind us, concerns over emerging variants continue to generate uncertainty.

A potential resurgence of the outbreak in the final quarter of the year could negatively impact expectations. Businesses must develop recovery strategies, support these initiatives with strategic investments, and make data-driven decisions to navigate uncertainties effectively. Strengthening corporate adaptability will be crucial in overcoming future disruptions.

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