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Evaluating the Effects of Artificial Intelligence Applications on the Logistics Sector

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Abstract

The most important technological development of recent years has been the widespread use of Artificial Intelligence applications in every part of our lives. It is a fact that artificial intelligence applications will become more widespread in the coming years and will become a very important element in political, economic, social, and cultural fields. In this period of widespread applications, the benefits and drawbacks of using artificial intelligence and the further expansion of its areas of use are discussed. This research aims to develop the use of artificial intelligence applications in logistics, evaluate the elimination of drawbacks, and provide suggestions for the future. The study will use the meta-synthesis method to evaluate the research on the use of artificial intelligence comparatively and thus provide appropriate, applicable, and acceptable suggestions. It is evaluated that this study will be a useful resource for those working in the logistics sector and researchers working on this subject.

Keywords:

Artificial Intelligence Applications: Technology, Information Technologies, Automation, Autonomy in Logistics Sector

Yapay Zekâ Uygulamalarının Lojistik Sektörüne Etkilerini Değerlendirilmesi

Özet

Son yılların en önemli teknolojik gelişmesi Yapay Zekâ uygulamalarının hayatımızın her parçasında yaygın olarak kullanılması olmuştur. Önümüzdeki yıllarda yapay zekâ uygulamalarının daha fazla yaygınlaşacağı, siyaset, ekonomik, sosyal ve kültürel alanlarda çok önemli bir eleman haline geleceği bir gerçektir. Uygulamaların yaygınlaştığı bu dönemde yapay zekâ kullanımının fayda ve mahzurları ile kullanım alanlarının daha fazla genişletilmesi tartışılmaktadır. Bu araştırmanın amacı; yapay zekâ uygulamalarının lojistik alanında kullanımının geliştirilmesi, mahzurlarının giderilmesini değerlendirme ve geleceğe yönelik



öneriler sunmaktır. Çalışmada meta sentez yöntemi kullanılarak yapay zekanın kullanımına ait araştırmalarının mukayeseli olarak değerlendirilmesi ve bu suretle uygun, uygulanabilir ve kabul edilebilir öneriler sunmak şeklinde yapılacaktır. Bu çalışmanın lojistik sektöründe çalışanlar ile bu konuda çalışma yapan araştırmacılar için faydalı bir kaynak olacağı değerlendirilmektedir.

Anahtar Kelimeler:

Yapay Zekâ Uygulamaları: Lojistik Sektöründe Teknoloji, Bilgi Teknolojileri, Otomasyon, Otonomi

1. Introduction

The most important technological development of recent years has been the widespread use of Artificial Intelligence applications in every part of our lives. It is a fact that artificial intelligence applications will become more widespread in the coming years and will become a very important element in political, economic, social and cultural fields. In this period of widespread applications, the benefits and drawbacks of the use of artificial intelligence and the further expansion of its areas of use are discussed.

1.1. The importance of Logistic Activities for Global Economy

Logistic activities are crucial to the functioning of the global economy. They facilitate the movement of goods, services, and information across borders, ensuring that businesses can operate efficiently, consumers have access to products, and economies can grow and develop. The importance of logistics in the global economy can be understood through several key areas:

Logistics is the backbone of global trade. It supports the movement of raw materials, finished goods, and products between countries, driving economic growth. Efficient logistics systems ensure that businesses can source materials and sell products worldwide, opening up new markets and opportunities.

Global supply chains rely on the effective coordination of logistics activities, including transportation, warehousing, inventory management, and distribution. Logistics ensure that raw materials, components, and finished products are delivered at the right time and place, helping businesses maintain production schedules, avoid disruptions, and meet consumer demand.

Facilitates International Business Expansion: Logistics enables companies to scale operations internationally by connecting distant markets. With effective logistics management, companies can expand their supply chains globally, sourcing from low-cost countries and selling to new markets without the added complexity of geographical distances.

Logistics activities contribute significantly to a country's GDP by providing infrastructure, jobs, and driving industrial growth. As countries develop their logistics infrastructure—ports, highways, airports, and railways—they open up new economic opportunities, attract investments, and create employment.

Efficient logistics systems allow businesses to reduce operational costs, improve delivery times, and enhance service quality. This not only helps companies stay competitive in local markets but also positions them to compete on the global stage. Lower transportation and logistics costs make goods cheaper for consumers, contributing to a higher standard of living.



Logistics plays a key role in reducing the costs of production and distribution. Efficient logistics systems enable companies to reduce inventory costs, optimize transportation, and minimize waste. By optimizing routes, choosing the right transport modes, and leveraging technology, businesses can save significant amounts of money in supply chain operations.

Effective logistics activities, such as just-in-time (JIT) inventory management, help businesses minimize the cost of holding stock. By synchronizing production and inventory levels with demand, logistics ensures that businesses don't overstock or run out of products, thus improving cash flow and reducing storage costs.

Logistics ensures that goods are available to consumers, no matter where they are located. Without efficient logistics networks, products would be less accessible, leading to higher prices and limited variety in the market. Logistics enables retailers, wholesalers, and e-commerce companies to deliver products to consumers quickly and reliably.

With the rise of e-commerce, logistics has become even more crucial in fulfilling customer expectations. Faster shipping times, real-time tracking, and flexible delivery options enhance the customer experience. Efficient logistics operations allow companies to offer same-day or next-day delivery, which is a key differentiator in the competitive global market.

The global economy is increasingly focused on reducing its carbon footprint. Logistics plays a significant role in sustainability efforts by optimizing routes, reducing fuel consumption, and embracing green technologies like electric vehicles and renewable energy sources. Efficient logistics can help lower greenhouse gas emissions and contribute to environmental goals.

Logistics systems help identify potential risks in the supply chain (e.g., bottlenecks, labor strikes, or disruptions in transportation routes) and mitigate them through careful planning and diversification of suppliers. This ensures continuity in the supply chain and reduces vulnerability to external shocks.

The logistics sector is a major source of employment worldwide, providing millions of jobs in warehousing, transportation, distribution, inventory management, and customer service. As global trade and e-commerce grow, the demand for logistics professionals, truck drivers, warehouse operators, and supply chain managers also rises, contributing to economic development.

Logistics connects the world, linking countries, markets, and regions. By enabling the smooth movement of goods, logistics fosters international cooperation, trade agreements, and cultural exchanges. The development of infrastructure like ports, airports, and highways enhances global connectivity, benefiting businesses and consumers alike.

Logistics activities facilitate economic integration by reducing barriers to trade and fostering cooperation between countries. By lowering the costs of transportation and improving the efficiency of cross-border trade, logistics plays a critical role in regional economic integration, such as within the European Union or the Association of Southeast Asian Nations (ASEAN).

Logistics activities are fundamental to the functioning of the global economy. They enable international trade, facilitate business operations, reduce costs, enhance customer satisfaction, and promote economic growth and competitiveness. In an increasingly globalized and interconnected world, the logistics sector continues to evolve through technological innovation, sustainability efforts, and improved efficiency. The importance of logistics cannot be overstated, as it supports virtually every aspect of economic activity, from the movement of goods to job creation and global integration. Without effective logistics systems, global economies would



1.2. Artificial Intelligence

The introduction of Artificial Intelligence (AI) in research studies has ushered in a new era of possibilities, transforming the way researchers approach data analysis, experimentation, and problem-solving across diverse fields. AI, a branch of computer science that simulates intelligent behaviour, has proven to be a powerful ally in addressing the complexities and challenges inherent in research. AI empowers researchers to sift through vast amounts of data rapidly and accurately, uncovering patterns and insights that may be challenging to discern manually. Researchers can utilise these capabilities to predict outcomes, anticipate trends and make informed decisions based on historical data. AI technologies automate routine and repetitive tasks, allowing researchers to focus on the more complex and creative aspects of their work. This not only increases efficiency, but also reduces the possibility of human error.

AI is the frontier in the form of self-learning systems emerging in robot applications, intelligent centres, intelligent data analytics, etc. In fields such as medical research and environmental science, AI also improves image and signal processing capabilities. It enables images such as medical scans or satellite images to be automatically analysed and complex signal data to be interpreted. Researchers can analyse academic articles, books and other textual sources to identify relevant information, trends and connections.

AI facilitates the creation of realistic simulations and models, allowing researchers to test hypotheses in virtual environments before conducting physical experiments. This speeds up the research cycle and minimises costs. There are also AI-powered robots. They are increasingly used in research environments for tasks such as laboratory automation, sample handling and experiments. This not only increases efficiency but also ensures precision in experimental procedures. Researchers are leveraging AI to analyse climate data, study environmental changes and model the impact of various factors on ecosystems. This helps to understand and address pressing environmental challenges. As AI continues to evolve, its integration into research endeavours holds the promise of accelerating scientific discoveries, increasing the robustness of findings, and pushing the boundaries of what is possible in research areas. Three are 3 essential applications related to AI:

Big data: The relationship between AI and big data goes two ways. While big data analytics processes already exist, much of big data's true value is only able to be realised using AI techniques. In the other direction, big data offers AI an immense and rich source of input data to develop and learn from. In this sense, AI and big data are strongly intertwined.

Machine learning: Machine learning is a computer science technique that allows computers to 'learn' on their own. It is often characterised as AI, but that is only one element of it. The characteristic that separates machine learning from other forms of AI is its dynamic ability to modify itself when exposed to more data. Through ingesting data, the machine is training itself by developing its own logic according to the data it has analysed (OVIC, 2018).

Deep learning: Deep learning is a subset of machine learning, most commonly used to refer to deep neural networks. In generalist terms, a neural network processes data through a layered approach, where each successive layer takes its input from the output of the layer before it. The term deep refers to the number of layers in the neural network. Deep learning is an extremely powerful tool, and many credit it for the recent explosion of AI.

Artificial Intelligence (AI) is reshaping the landscape of education, ushering in a new era of personalized learning experiences for students around the globe. In an increasingly interconnected world, AI holds the promise of democratizing access to quality education and levelling the playing field for learners of all backgrounds. ITmunch (2024) states that "With AI at the forefront, education is undergoing a profound transformation. By harnessing the power of AI, educators can create tailored learning pathways that cater to the unique needs and preferences of each student. This personalized approach not only enhances student engagement but also fosters deeper understanding and mastery of complex concepts



1.3. Technology Innovation and Digital Transformation

Logistics is a key sector driving innovation in technology. The integration of AI, robotics, Internet of Things (IoT), blockchain, and automation is revolutionizing how goods are moved and tracked globally. These technologies enhance supply chain transparency, improve route optimization, enable predictive maintenance, and automate warehouse operations.

Supply Chain Visibility: Technologies like IoT and big data analytics allow businesses to track goods in real time, improve decision-making, and reduce delays. This enhances transparency in the supply chain, helps mitigate risks, and allows businesses to respond quickly to disruptions, whether due to weather, political instability, or other factors.

2. Method

The logistics sector has to follow the constantly developing technology and, accordingly, this is important also for establishment of a sustainable world economy. This sector has to benefit from AI both in terms of improving a suitable, applicable and acceptable worldwide logistics system.

The aim of this research is to develop the use of artificial intelligence applications in the field of logistics, to evaluate the elimination of drawbacks and to provide suggestions for the future.

The study will be conducted by using the meta-synthesis method to comparatively evaluate the research on the use of artificial intelligence and thus to provide appropriate, applicable and acceptable suggestions.

3. Research

3.1. Advantages of AI in the Logistics Activity

Most important area in logistics is Route Planning. AI-powered algorithms can analyse vast amounts of data, including traffic patterns, weather conditions, and road closures, to determine the most efficient delivery routes. This reduces delivery time, fuel consumption, and costs, while improving customer satisfaction by offering faster and more predictable deliveries.

AI enhances warehouse operations through automation technologies like robotic arms, automated guided vehicles (AGVs), and drones. These robots can move goods around, pick and pack orders, and restock inventory, significantly improving warehouse efficiency and reducing labour costs. AI optimizes inventory management by predicting stock levels and automating replenishment processes.

To plan demand forecasting is important for feasible operations. AI can analyse historical data and market trends to predict demand for products. This enables logistics companies to plan for inventory needs and optimize supply chains by minimizing stockouts or overstocking, which can result in better overall efficiency and lower operational costs.

AI is essential in the optimization of last-mile delivery, which is often the most expensive and time-consuming part of the supply chain. AI models help determine the most efficient routes, whether using delivery trucks, drones, or autonomous vehicles, and can even predict optimal delivery windows based on customer availability.

AI tools can provide real-time tracking and monitoring of shipments, giving logistics companies and customers visibility into where goods are at any moment. This improves accountability, reduces theft or damage, and allows for proactive decision-making when disruptions occur.



Self-driving trucks and drones are being tested and used for transportation and delivery tasks. These vehicles can reduce labour costs, operate around the clock, and improve the consistency and speed of deliveries. AI systems help them navigate complex environments, avoid obstacles, and ensure safety.

AI-powered chatbots are becoming more common in customer service, handling routine inquiries, tracking shipments, and answering questions about deliveries. These chatbots can provide quick responses without any interruption, enhancing customer satisfaction.

AI helps logistics companies identify potential risks and frauds by analysing vast amounts of transactional data and detecting unusual patterns or behaviours. This allows companies to mitigate risks before they escalate, ensuring smoother operations.

AI can help optimize pricing strategies by analysing market conditions, competitor pricing, and customer demand. Dynamic pricing algorithms adjust prices in real time to maximize profitability while ensuring competitive pricing.

AI systems should be capable to monitor the health of vehicles in a logistics fleet, predicting when maintenance or repairs are needed based on historical performance data and real-time diagnostics. This reduces downtime, prevents breakdowns, and extends the lifespan of vehicles.

AI is increasingly used to improve security in logistics operations, particularly in areas like cargo pilferage prevention. AI tools can analyse patterns of theft or security breaches, and cameras equipped with AI can monitor loading docks, warehouses, and transportation routes for suspicious activity.

AI-powered robotics are used to manage inventory in warehouses, including scanning barcodes, checking stock levels, and carrying out restocking tasks. Drones, guided by AI, can fly through warehouses to conduct inventory checks and assist with fast replenishment, enhancing accuracy and speed.

By integrating AI into these areas, logistics companies can achieve improved operational efficiency, cost reductions, better customer experiences, and more resilient supply chains.

3.2 Negative effects of AI usage

AI-driven automation can lead to job losses, especially in roles related to routine tasks such as driving, warehouse picking, and inventory management. However, this can be mitigated by:

- Logistics companies can invest in reskilling programs to help workers transition to new roles in tech and AI-related fields, such as AI system management, robotics maintenance, or data analysis. By fostering a culture of continuous learning, companies can ensure that their workforce remains relevant in an AI-powered environment.
- AI can create new job opportunities in areas such as AI system development, robotics, data science, and machine learning. Companies can focus on creating these new positions to help offset job losses from automation.
- AI systems in logistics require large amounts of data, including personal and sensitive information. This raises concerns about data privacy and security. To address these issues:
- Logistics companies must adhere to data privacy regulations (such as GDPR in Europe) to protect customer and employee data. AI systems should be designed with robust encryption and security features to prevent data breaches.
- Companies should inform customers and employees about what data is being collected, how it is used, and for how long it will be stored. Transparency helps build trust and ensures that AI solutions are used ethically.



- AI algorithms can inherit biases from the data they are trained on. It's important to regularly audit AI systems to ensure that they do not make biased decisions, particularly in areas such as hiring, routing, or customer service.

Over-reliance on AI can lead to problems if the technology fails or faces unexpected disruptions. To mitigate this risk:

- While AI can handle many tasks, human oversight is critical to ensuring that AI systems perform as expected and that problems are caught early. For example, human supervisors should monitor AI-driven logistics operations and be able to intervene when necessary.
- Implementing backup systems and fail-safe mechanisms, such as manual overrides or backup power sources, ensures that critical logistics functions can continue smoothly even if AI systems encounter technical issues or glitches.
- Combining human expertise with AI capabilities can create a hybrid approach where AI handles repetitive or data-intensive tasks, while humans focus on strategic decision-making and complex problem-solving. This can reduce the risk of complete dependency on AI systems.

AI in logistics can sometimes make decisions that are difficult to trace back to human accountability, especially in areas like autonomous vehicles or automated decision-making. To reduce this risk:

- Establishing clear guidelines on who is responsible for AI decisions and actions is important. For instance, if an autonomous vehicle causes an accident, it should be clear whether the responsibility lies with the manufacturer, the operator, or another party.
- Regular auditing of AI systems can ensure that the algorithms are functioning as expected and that any issues are identified and corrected promptly.

While AI can optimize logistics operations for fuel efficiency, overuse of AI technologies, such as AI-powered drones and vehicles, may increase energy consumption and carbon emissions. To reduce negative environmental effects:

- Logistics companies can invest in energy-efficient AI technologies, such as electric autonomous vehicles and renewable energy-powered data centers, to reduce their environmental footprint.
- AI can help companies optimize routes, reduce fuel consumption, and consolidate shipments, leading to a decrease in overall emissions. Companies should prioritize sustainability in AI solutions by considering their environmental impact as part of their operational goals.

AI systems are vulnerable to hacking and system failures, which could disrupt logistics operations. To ensure security:

- Strong cybersecurity protocols, such as multi-factor authentication, firewalls, and encryption, should be implemented to protect AI systems from malicious attacks.
- AI systems should be continuously monitored for vulnerabilities and tested against potential cyber threats. Companies should perform regular security assessments and updates to address emerging risks.

As AI is increasingly used in logistics, building and maintaining public trust is essential. This can be achieved by:

- Logistics companies should openly communicate how AI is used to improve services, emphasizing benefits like faster delivery times, lower costs, and better customer experiences, while addressing potential concerns.
- Allowing customers to opt-out or control certain aspects of AI-driven services, such as data collection or route optimization preferences, can help build trust.



Developing AI solutions with ethical considerations in mind is critical to minimizing negative effects. Companies should:

- Ensure that AI systems are designed with fairness, accountability, transparency, and non-discrimination in mind. This includes conducting regular impact assessments to evaluate potential social, economic, and environmental consequences.
- Working with industry regulators, policymakers, and ethics boards can help establish guidelines and regulations that ensure AI is used responsibly.

By addressing these potential negative effects, logistics companies can harness the power of AI to create more efficient, cost-effective, and ethical systems that benefit both businesses and

3.3 The Future of AI in Logistics

The future of AI in logistics is set to bring even more transformative changes, with advancements in automation, sustainability, data analysis, and customer experience. Below are some key future developments that are expected to shape the logistics industry:

Fully Autonomous Vehicles and Drones

- **Self-Driving Trucks:** Autonomous trucks will continue to evolve, improving road safety and efficiency by eliminating human error. These trucks could operate 24/7, reducing transportation costs and delivery times. Additionally, they could reduce the need for long-haul drivers, helping address labor shortages in the transportation sector.
- **AI-Powered Drones:** Drones will become more prevalent in last-mile delivery, offering faster and more efficient service, especially for urban areas. Drones could also be used in warehouses for inventory management or in remote areas where road infrastructure is poor.
- **Autonomous Delivery Robots:** Last-mile delivery could also see robots or self-driving vehicles navigating sidewalks or airways to make small deliveries, allowing for greater flexibility and speed while reducing operational costs.

AI-Driven Predictive Analytics and Demand Forecasting

- **Smarter Supply Chains:** Future AI systems will be even better at predicting market trends, weather disruptions, and fluctuations in demand. This will enable logistics companies to proactively adjust supply chains, inventory levels, and delivery routes to minimize delays and cost overruns.
- **Real-Time Demand Forecasting:** AI systems will leverage big data, including social media trends, economic forecasts, and consumer behavior patterns, to refine demand forecasting models. This could significantly reduce stockouts, overstocking, and inventory holding costs.

AI and IoT Integration

- **Smart Warehouses:** The integration of AI with Internet of Things (IoT) devices will further enhance warehouse automation. Sensors, cameras, and RFID tags will enable real-time tracking of inventory, machinery, and even the condition of products. AI can analyze this data to optimize inventory levels, predict potential equipment failures, and streamline warehouse workflows.
- **Connected Fleet Management:** AI will also be used to connect entire fleets of delivery vehicles, monitoring and optimizing everything from fuel usage to driving behavior. With AI, fleets can communicate in real-time to reduce congestion, improve safety, and adjust to changing road conditions.

Blockchain and AI for Secure, Transparent Supply Chains



Combining AI with blockchain technology will enhance security, transparency, and traceability throughout the supply chain. Blockchain ensures data integrity and transparency, while AI can provide insights from this data in real-time, helping prevent fraud and improving accountability. This is especially useful for high-value goods and industries requiring stringent tracking, such as pharmaceuticals or electronics.

AI-Powered Predictive Maintenance

- **Fleet and Equipment Monitoring:** AI systems will be able to predict when trucks, drones, and other logistics equipment need maintenance, reducing downtime and preventing costly repairs. Sensors embedded in vehicles or machinery can collect data on wear and tear, and AI algorithms will predict failures before they occur, leading to more efficient fleet management and longer asset life.
- **Smart Maintenance Solutions:** AI tools will continuously monitor the health of equipment and make autonomous adjustments when necessary, such as changing routes to avoid high-risk areas or altering vehicle speeds to reduce strain on components.

AI in Sustainability and Green Logistics

- **Route Optimization for Sustainability:** AI will continue to drive efficiencies in fuel consumption by optimizing delivery routes based on real-time traffic, weather, and fuel usage. Future systems will also factor in carbon emissions, allowing companies to prioritize more sustainable delivery methods, such as electric vehicles (EVs) or green shipping options.
- **Green AI Algorithms:** Logistics companies will increasingly use AI to reduce the environmental impact of their operations. For example, AI could optimize supply chains for energy efficiency, help choose suppliers with lower carbon footprints, or identify opportunities to reduce waste and emissions in warehouses and transport.

Human-Robot Collaboration in Warehouses

- **Collaborative Robotics:** In the future, robots and humans will work side by side in warehouses. AI-driven robots will assist human workers in tasks like picking, packing, and sorting, reducing physical strain and improving productivity. These robots will be designed to learn from human actions and adapt to working alongside them, enhancing efficiency.
- **Advanced Robotic Sorting Systems:** AI will allow robots to make smarter decisions in sorting goods in warehouses. These systems could distinguish between fragile and non-fragile items, categorize packages based on delivery time, and dynamically adapt to changes in workflow.

Autonomous Smart Ports

- **Port Automation:** Ports will become more automated, with AI-driven systems managing container loading/unloading, vessel traffic, and supply chain coordination. Autonomous ships and AI systems will streamline operations, reducing human labor and operational costs while increasing throughput.
- **AI for Real-Time Monitoring and Security:** AI will enhance port security by monitoring vessel arrivals, cargo integrity, and tracking potential threats. Advanced AI cameras and sensors could analyze vast amounts of data for signs of tampering, accidents, or risks in real-time.

Advanced Customer Experience through AI

- **Personalized Delivery Services:** AI will enable highly personalized customer experiences. Customers could choose delivery windows, real-time tracking, and even interact with AI chatbots for faster issue resolution. AI could also optimize product delivery options based on individual preferences or historical behaviors.
- **Voice-Activated Logistics:** Integration with virtual assistants (like Alexa or Google Assistant) will allow customers to track shipments, change delivery preferences, or re-route packages simply by using



voice commands. Logistics companies could further automate customer support, making it available 24/7.

AI-Powered Optimization of Multi-Modal Transport

- **Seamless Multi-Modal Logistics:** Future AI systems will seamlessly optimize multi-modal transportation (combining road, rail, air, and sea) for the best cost-to-time ratio. AI will analyse factors like cargo size, destination, delivery time, and costs to automatically choose the best combination of transport methods, making logistics more flexible and efficient.
- **Cross-Border Optimization:** AI will handle the complexities of international logistics, including compliance with customs regulations, cross-border routing, and tariff management. This will improve the speed and efficiency of global supply chains.

AI for Dynamic Pricing and Cost Optimization

- **Real-Time Dynamic Pricing:** AI will enable dynamic pricing in real time, adjusting logistics and delivery costs based on factors like demand, traffic conditions, and competitor pricing. This can optimize revenue and help logistics companies stay competitive.
- **Optimizing Resource Allocation:** AI will help logistics companies more efficiently allocate resources (e.g., labor, fleet, warehouse space) by analyzing real-time data and predicting demand. This leads to reduced operational costs and more effective decision-making.

AI for Cognitive Automation

- **Smart Decision-Making:** Cognitive AI will enhance decision-making in logistics by analyzing massive datasets from all parts of the supply chain. These systems will learn from past experiences to make informed decisions about routing, staffing, inventory management, and more.
- **Automated Negotiation Systems:** AI-powered systems could handle negotiations with suppliers, customers, or service providers, optimizing deals based on cost, performance metrics, and historical data, helping companies secure the best prices and terms.

The future of AI in logistics is filled with opportunities to enhance efficiency, reduce costs, and provide better services to customers. As AI technologies continue to evolve, the logistics industry will see even more automation, intelligent decision-making, and data-driven solutions. At the same time, the ethical and societal impacts of these technologies will need to be carefully managed to ensure that the benefits of AI in logistics are realized responsibly and sustainably.

4. Discussion

4.1 Extract and Findings from Literature Review

From capacity planning and forecasting to network optimization, the predictive capabilities of AI are helping logistics operators make precise decisions to proactively streamline operations. For instance, with double-digit e-commerce growth increasing last-mile diversity and complexity, this final segment of delivery is still the most expensive link of supply chains. The challenges of balancing delivery time windows, fuel consumption, travel distance, traffic patterns, load capacity, and ad hoc pickups while simultaneously communicating accurate arrival times and updates to customers make the last mile difficult and costly for operators. Across the industry, however, AI is making strides in dynamic route optimization, managing all these variables in an efficient manner and generating time-window predictions for customers. As AI becomes more intelligent, predictive technology could take logistics players a step further into the territory of anticipatory delivery models. Instead of waiting for customers to order, AI will go beyond same-day or same-hour delivery, supplying goods to customers before they even realize what is needed (McKinsey & Company, 2020).



Early adopters and early case studies demonstrate AI's potential to transform business processes, shake up entire sectors, increase profits, and create new sources of value. AI applications are starting to reach maturity, and companies with serious, proactive adoption strategies stand to gain significant competitive advantages. There are many industry- and sector-specific use cases to inform companies when they define a focused strategy. Also, while machine learning and deep learning underpin most opportunities, industries will need to identify the AI technologies that will bring the most benefits to them, and then start to develop their infrastructure, talent, and knowledge as early as possible to catch up on the learning and adoption curves. AI is more than the sum of its parts: for truly impressive gains, companies are building their AI capability across the value chain, integrating it into core processes, and using it to enable their employees to be more productive (McKinsey & Company, 2017)

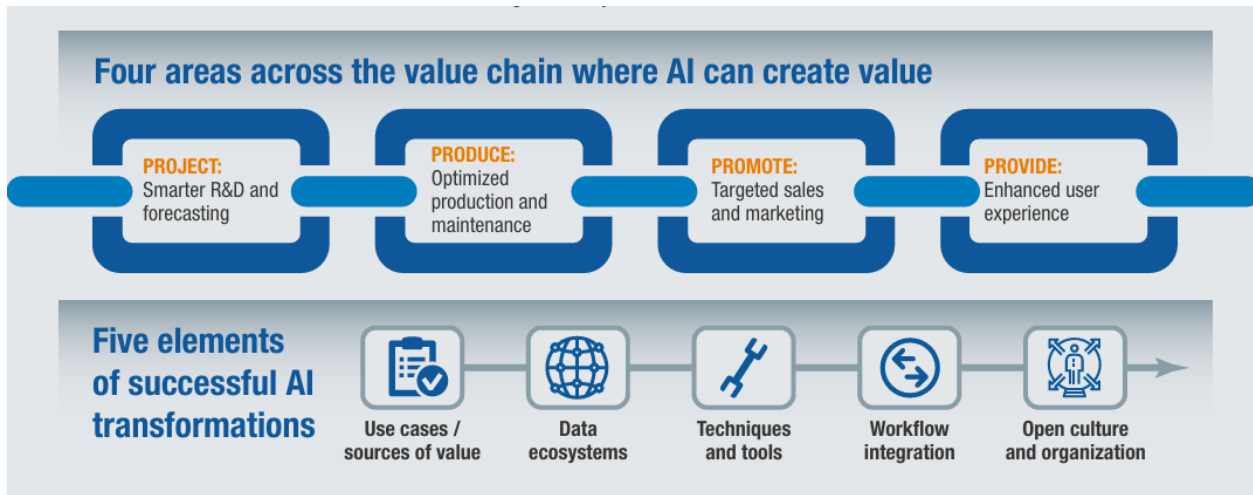


Figure 1: AI Transformation in Logistics (McKinsey & Company, 2017)

In today's fast-paced business world, staying ahead means consistently analysing business processes and taking swift actions. How and to which extent AI can impact business process management is a fairly new topic when going beyond the process automation aspect only (Signavio, 2024).

As far as concerning future developments, a new generation of language models is upcoming. GPT-4 continues the trend of increasing the number of parameters in the model as well as the window size (the ability to process more text as input). Additionally, GPT-4 is capable of processing images as well as text inputs, which increases the range of potential applications, including ones related to logistics and supply chain management (OpenAI Citation, 2023). Additionally, the latest developments in the field, including RETRO Transformer by DeepMind (Rea et al., 2021) and WebGPT by OpenAI (Nakano et al. Citation2021). Adapting the proposed framework to the new generation of language models can be considered a promising direction for future research (Ilya et al., 2024).

New intelligent technologies are allowing companies to achieve what used to be three competing outcomes: relevance, resilience and responsibility. Accenture research identified a small group of companies that are using these technologies to improve performance and outperform competitors. Three important use cases—scenario modelling, unified demand planning and supplier risk monitoring and resolution—are good entry points (Accenture, 2021).

Combined with rising geopolitical tensions, this process is increasingly driving companies to look at strategies to make supply chains more resilient by moving production closer to home.

Thanks to technological advances like AI and robotics, the era of chasing the lowest wage rates possible has become a thing of the past, eschewed for a more sustainable business approach. Nowadays, what matters more is to secure sustainable, highly flexible production located as close as possible to demand while maintaining a reliable supply chain. (World Economic Forum, 2024).



The following areas are highly affected from digital technologies in the logistics sector are Communication Systems, Decision Making, Environmental Monitoring and Compliance, Smart Ports and Logistics, Automation, Remote Control, Maintenance Monitoring, Cyber Security, IoT (Internet of Things), Digitalization of Administrative and Financial Application. To achieve an effective logistics activity, the logistician with the skills to prevent accidents and incidents, respond to emergencies, and ensure the safety of personal, and cargo handling.

The application of AI in the transport field is aimed at overcoming the challenges of an increasing travel demand, CO2 emissions, safety concerns, and environmental degradation. In light of the availability of a huge amount of quantitative and qualitative data and AI in this digital age, addressing these concerns in a more efficient and effective fashion has become more plausible. The successful application of AI requires a good understanding of the relationships between AI and data on one hand, and transportation system characteristics and variables on the other hand. Moreover, it is promising for transport authorities to determine the way to use these technologies to create a rapid improvement in relieving congestion, making travel time more reliable to their customers and improve the economics and productivity of their operations (Adiguzel, 2021).

It was considered that the most difficult part of the challenge of implementing comprehensive intelligent logistics is as follows. The lack of information technology to improve the information platform, the lack of facilities and security system, and the imperfection of the regulatory system. (He 2017, 10-12). The reason is that the people's views, attitudes and behaviours on intelligent logistics will have a great effect on the feasibility of its development in China's current national conditions. To promote the development of China's intelligent logistics, the most important thing is to make the country, and enterprises have an accurate understanding of it. (Jia et al. 2019, 44). To understand the importance of the development of intelligent logistics, such as reducing the logistics cost of enterprises, improving the competitiveness of the logistics enterprises, building a smart city and improving the level of urban services.

In April 2021, the European Commission proposed the first EU regulatory framework for AI. It says that AI systems that can be used in different applications are analysed and classified according to the risk they pose to users. The different risk levels will mean regulation (Topics European Council, 2020). As part of its digital strategy, the EU wants to regulate artificial intelligence (AI) to ensure better conditions for the development and use of this innovative technology. AI can create many benefits, such as better healthcare; safer and cleaner transport; more efficient manufacturing; and cheaper and more sustainable energy. Anneke et al, (2021) published an article on "Implications of the use of artificial intelligence in public governance". Sousa et al, (2019) states that Value can be created in multiple government functional areas, such as decision support, transportation, public health, and law enforcement.

A significant proportion of logistics transactions are non-transparent and therefore information gathering on these activities is limited. There is a need for artificial intelligence and especially machine learning applications by utilizing the available data to make a near-accurate prediction in areas where healthy information collection is limited. AI is required to make a healthy prediction or estimation, especially in related planning for port operations.

4.2. Recommendations to The Logisticians on Using AI Effectively

For logistics professionals, adopting and utilizing AI effectively is essential to remain competitive in a rapidly evolving industry. AI can drive efficiencies, reduce costs, improve customer satisfaction, and enhance operational performance. However, to leverage AI effectively, logisticians should consider several best practices and strategies:



Start with Clear Objectives and Use Cases

Identify Key Areas for AI Implementation: Before adopting AI, it's essential to pinpoint specific areas where AI can deliver the most value. These could include route optimization, demand forecasting, predictive maintenance, inventory management, or improving customer service.

Define Clear KPIs (Key Performance Indicators): Set measurable goals (e.g., reducing delivery times by 10%, cutting costs by 15%, improving customer satisfaction scores). AI should be implemented with clear objectives in mind to assess its effectiveness and return on investment (ROI).

Invest in Data Quality and Management

Data Collection and Integration: AI thrives on data. Ensure that data from various sources (e.g., vehicles, warehouses, inventory systems, customer orders) is collected, integrated, and made accessible to AI systems. This might require upgrading legacy systems or investing in new technologies to ensure data flows seamlessly across platforms.

Data Accuracy and Cleaning: AI systems are only as good as the data fed into them. Implement data cleaning processes to eliminate inconsistencies and ensure data accuracy, as bad data can lead to inaccurate predictions and suboptimal decision-making.

Collaborate with IT and AI Experts

Work with Data Scientists and AI Specialists: Logistics teams should collaborate with IT professionals and AI experts to implement the most effective algorithms and tools for their specific needs. AI is complex, and working with experts can ensure that the technology is correctly tailored to your operations.

Continuous Training: Ensure that logistics teams receive training in AI tools, data management, and interpreting AI outputs. This will help them make informed decisions and troubleshoot issues that arise during implementation.

Focus on Scalability and Flexibility

Scalable AI Solutions: Choose AI solutions that can scale as your business grows. As your company expands, the amount of data and the complexity of operations will increase, and your AI systems should be able to handle these changes without needing a complete overhaul.

Flexibility and Adaptation: AI systems should be adaptable to changes in the supply chain, customer needs, or market conditions. Choose AI tools that can learn and evolve over time based on new data, market trends, and changing operational needs.

Invest in Automation, But Retain Human Oversight

Automation with Oversight: While AI can automate many tasks (such as inventory management, route planning, and customer service), human oversight is essential to monitor system performance, handle exceptions, and make strategic decisions. Ensure AI complements human expertise rather than completely replacing it.

Human-AI Collaboration: AI should be used to augment human decision-making. For example, AI can handle routine tasks like analysing large datasets, while human employees focus on higher-level decision-making and solving complex issues that require critical thinking.



Focus on Improving Customer Experience

Personalized Service: Use AI to better understand customer behavior and preferences. AI can analyse purchase patterns, shipping preferences, and other data to offer personalized recommendations and optimize delivery schedules.

AI-Powered Chatbots and Virtual Assistants: Implement AI-powered chatbots for real-time customer support. These tools can answer routine questions, track shipments, and resolve simple issues, improving customer satisfaction and freeing up human agents to handle more complex inquiries.

Predictive Analytics for Proactive Decision-Making

Demand Forecasting: AI can help predict customer demand and adjust supply chain operations accordingly. Using AI for demand forecasting can help logistics professionals avoid stockouts and reduce inventory costs by making more accurate predictions.

Predictive Maintenance: Use AI to monitor the condition of vehicles and machinery in real-time. Predictive maintenance allows logistics companies to identify potential issues before they become major problems, reducing downtime and repair costs.

Enhance Security and Fraud Prevention

Data Security and Privacy: With AI systems handling large volumes of data, security is paramount. Ensure compliance with data privacy regulations like GDPR and implement robust cybersecurity measures to protect sensitive customer and operational data.

Fraud Detection: Use AI for monitoring transactions, deliveries, and other aspects of logistics to detect unusual patterns and prevent fraudulent activity. Machine learning algorithms can spot anomalies in shipping behaviour, payment systems, and inventory levels.

Foster a Culture of Continuous Improvement

Monitor and Optimize AI Performance: Continuously monitor the performance of AI systems and adjust as needed. AI models improve over time, but it is essential to track performance and fine-tune algorithms to achieve the best results.

Feedback Loop: Set up feedback loops between AI systems and human operators. Gather feedback from employees who interact with AI tools regularly and use their input to improve the algorithms and make the system more effective.

Leverage AI for Sustainability

Sustainable Routing: Use AI to reduce environmental impact by optimizing delivery routes for fuel efficiency and reducing carbon emissions. AI can account for factors such as traffic patterns, vehicle type, and weather to determine the most sustainable routes.

Electric and Autonomous Vehicles: Consider integrating AI-driven electric vehicles (EVs) and autonomous vehicles into your fleet to reduce fuel consumption and emissions. This aligns with global sustainability trends and can provide long-term cost savings.

Embrace Multi-Modal Logistics Optimization



Seamless Transport Integration: AI can help optimize multi-modal logistics by seamlessly integrating road, rail, air, and sea transport. AI systems will dynamically adjust transport modes based on factors like cost, delivery time, and environmental impact.

Cross-Border Logistics: AI can manage the complexities of international logistics, such as customs regulations and tariff management. This helps streamline global supply chains and reduces delays in cross-border transport.

Regularly Assess ROI and Impact

Track ROI: Measure the impact of AI investments regularly to ensure the technology is delivering expected returns. Assess key performance indicators (KPIs) such as reduced delivery times, cost savings, and improvements in customer satisfaction.

Cost vs. Benefit Analysis: Conduct a cost-benefit analysis of AI implementation to ensure that the initial investment in AI systems, software, and training is justified by the improvements in operational efficiency and service quality.

For logisticsicians to effectively use AI, they must be strategic and proactive in its adoption. AI can be a game-changer for logistics operations, but success depends on thoughtful implementation, data-driven decision-making, and continuous learning. By integrating AI with human expertise, maintaining flexibility, focusing on customer-centric solutions, and monitoring performance, logistics companies can unlock the full potential of AI while mitigating risks and optimizing their operations.

5. Conclusion

Any part of the economic sector cannot refrain the use of AI today. The use of Artificial Intelligence (AI) in logistics is transforming the industry by improving efficiency, reducing costs, and enabling more intelligent, data-driven decision-making. Here is an overall assessment of how AI is being applied in logistics, along with its benefits and challenges:

a. Key Applications of AI in Logistics

Route Optimization
Warehouse Automation:
Demand Forecasting:
Supply Chain Management:
Last-Mile Delivery:
Predictive Maintenance:

b. Benefits of AI in Logistics

Cost Reduction
Efficiency and Speed:
Better Decision-Making
Improved Customer Experience
Sustainability

c. Challenges of AI in Logistics

High Initial Investment:
Data Quality and Availability
Complex Integration



Skill Shortage
Security and Privacy Concerns

d. Future Outlook of AI in Logistics

The future of AI in logistics is bright, with advancements in areas like autonomous vehicles, 5G connectivity, edge computing, and AI-powered decision support systems. The continued evolution of AI technology will lead to even more sophisticated and integrated logistics networks. In the coming years, we may see AI-driven systems managing entire logistics chains end-to-end, minimizing human intervention and maximizing automation.

Autonomous Delivery
Collaborative AI and Humans
AI and Blockchain Integration

Resume

AI is revolutionizing logistics by improving efficiency, reducing costs, and enhancing decision-making capabilities. While challenges like high costs, data quality, and integration issues persist, the long-term potential of AI in logistics remains substantial. As technology continues to mature, we can expect even greater advancements in automation, predictive analytics, and supply chain optimization, further transforming the logistics landscape.

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