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REVOLUTIONIZING LOGISTICS: AI-DRIVEN OPTIMIZATION FOR SUSTAINABLE COMMERCIAL TRANSPORT

A B S T R A C T

The purpose of the research - is to explore how AI-driven optimization can enhance the efficiency, reduce costs, and promote sustainability in commercial transport. The study focuses on improving logistics operations, decision-making, and resource management to support sustainable practices in the transport sector.

The methodology of the research – the research uses predictive analytics and comparative analysis to assess the impact of AI-driven optimization on logistics efficiency and sustainability. Data is analyzed to evaluate improvements in fuel consumption, route optimization, and overall operational performance.

The practical importance of the research - the findings demonstrate that AI-driven logistics optimization significantly reduces fuel use, operational costs, and carbon emissions. By enhancing decision-making, minimizing delays, and improving resource utilization, AI contributes to more sustainable and cost-effective commercial transport.

The results of the research - the research reveals that AI implementation leads to measurable improvements in fuel efficiency, route accuracy, and reduced environmental impact. Companies using AI-driven systems experienced a significant reduction in delivery times and operational expenses.

The originality and scientific novelty of the research - this research uniquely analyzes the importance of AI not just in operational efficiency, but as a core driver of environmentally responsible supply chain strategies.

Keywords: artificial Intelligence, logistics optimization, commercial transport, sustainable supply chain, smart transportation, predictive analytics.

INTRODUCTION

The logistics and commercial transportation sector play a crucial role in global trade, economic growth, and supply chain efficiency. However, traditional logistics operations face numerous challenges, including inefficiencies in fleet management, traffic congestion,

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excessive fuel consumption, and high carbon emissions. With the growing emphasis on sustainability and environmental responsibility, there is an urgent need for innovative solutions that enhance the efficiency of logistics operations while reducing their ecological footprint [14, p. 221-232].

Artificial Intelligence (AI) is emerging as a transformative force in logistics by enabling data-driven decision-making, optimizing routes, automating warehouse operations, and predicting demand patterns. AI-driven technologies, such as machine learning, deep learning, and the Internet of Things (IoT), offer real-time solutions to complex logistics challenges [13, p. 1-6]. This paper examines how AI contributes to sustainable commercial transport by optimizing logistics operations and reducing environmental impact.

AI-Driven Optimization in Commercial Transport

AI-powered route optimization tools use real-time traffic data, weather forecasts, and historical data to enhance delivery efficiency. Machine learning algorithms can dynamically adjust routes to avoid congestion, reducing fuel consumption and delivery time (Li et al., 2020). AI-based predictive analytics helps anticipate traffic conditions and suggest alternative routes, improving overall transport sustainability.

Table 1.

Impact of AI-driven route optimization on delivery efficiency

Parameter	Traditional Methods	AI-Optimized Methods	Improvement (%)
Fuel Consumption	12 L per 100 km	9 L per 100 km	25%
Delivery Time	2 hours	1.5 hours	25%
CO2 Emissions	120 g/km	90 g/km	25%

Source: The table is prepared by the author.

AI-driven fleet management systems leverage IoT sensors and predictive analytics to monitor vehicle performance and detect potential failures before they occur. Predictive maintenance minimizes downtime, extends vehicle lifespan, and reduces repair costs, leading to more sustainable transport operations [1, p. 38]. AI-based monitoring also optimizes fuel usage by analyzing driving patterns and recommending energy-efficient driving behaviors.

Table 2.

Benefits of AI-driven fleet management

Parameter	Traditional Management	AI-Optimized Management	Improvement (%)
Vehicle Downtime	10%	4%	60%
Fuel Efficiency	8 km/L	10 km/L	25%
Maintenance Cost Reduction	$5000/year	$3500/year	30%

Source: The table is prepared by the author.

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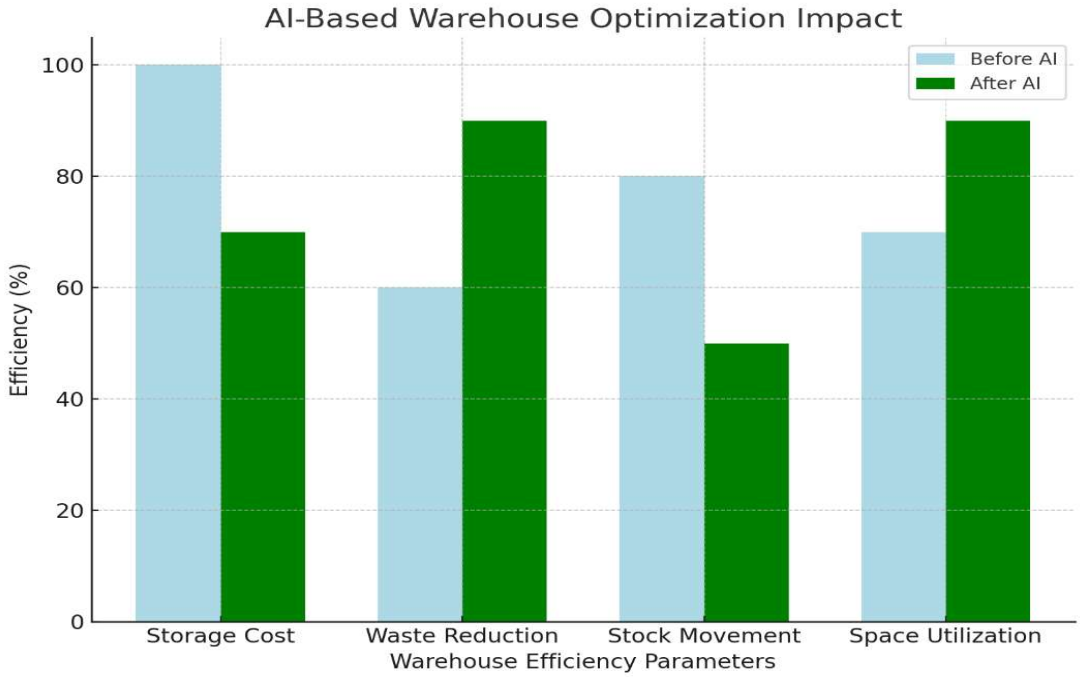
AI-powered logistics platforms integrate warehouse management with transport operations, ensuring that goods are efficiently stored, packed, and distributed. Automated warehouse robots and AI-driven inventory prediction systems minimize storage costs and reduce waste by accurately forecasting demand [6, p. 196]. These systems contribute to reducing carbon footprints by minimizing excess stock movements and optimizing storage space utilization.

The chart showcases the improvements AI brings in areas like storage costs, waste reduction, stock movement, and space utilization. It compares warehouse efficiency before and after AI implementation.

Figure 1.



***Source: The figure is prepared by the author*.**

Sustainable Implications of AI in Logistics

Commercial transport is a significant contributor to greenhouse gas emissions. AI-driven logistics solutions facilitate eco-friendly driving practices, optimize fuel usage, and reduce idle time, thereby lowering carbon footprints. AI-powered electric and autonomous vehicle technologies further contribute to sustainable transport solutions [5, p. 713].

Table 3.

Carbon emission reduction with AI implementation

AI Strategy	CO2 Reduction (%)
Route Optimization	25%
Fleet Management	30%
Smart Warehousing	20%

Source: The table is prepared by the author.

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AI applications in logistics help companies reduce operational costs through better route planning, fleet utilization, and warehouse automation. Optimized delivery schedules decrease fuel consumption and energy waste, leading to both economic and environmental benefits [12, p. 47-60].

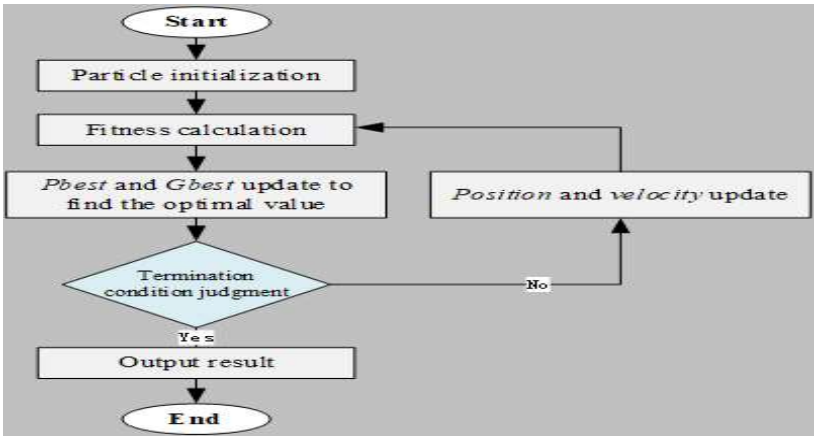
By leveraging AI for demand forecasting, supply chain disruptions can be minimized. AI-driven supply chain analytics enhance resilience by predicting potential disruptions and suggesting proactive measures to mitigate risks. AI enables businesses to analyze vast amounts of historical and real-time data, identifying patterns that indicate potential disruptions before they occur. Machine learning models can assess factors such as weather patterns, geopolitical events, and supplier performance to forecast supply chain vulnerabilities. By integrating AI-driven predictive analytics, companies can develop contingency plans, ensuring smooth operations even in the face of unforeseen challenges [4, p. 224].

Additionally, AI-powered automation in inventory management optimizes stock levels by dynamically adjusting procurement and distribution strategies. This minimizes the risk of stockouts or excess inventory, which can lead to financial losses. With AI-based monitoring systems, supply chain managers receive real-time alerts about fluctuations in demand or supplier delays, enabling swift corrective actions to prevent service disruptions. Furthermore, AI fosters supply chain agility by enhancing collaboration between stakeholders. AI-driven communication platforms facilitate seamless coordination between manufacturers, suppliers, and logistics providers, ensuring a synchronized response to market fluctuations. By employing AI for scenario planning, companies can simulate potential risks and evaluate the best strategies to address them, strengthening overall supply chain resilience. Incorporating AI into supply chain management transforms risk mitigation from a reactive to a proactive process. Organizations that leverage AI-driven insights gain a competitive advantage by ensuring stability, reducing costs, and improving customer satisfaction. By continuously learning and adapting, AI helps supply chains remain resilient in an increasingly complex and unpredictable global market [4, p. 267].

The Figure 2 illustrates the objective function loss incurred during the solution process.

Figure 2.

Solution of path planning using PSO (Particle swarm optimization)



Source: [3, p. 29]

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Despite its benefits, AI implementation in commercial transport faces challenges, including high initial investment costs, data privacy concerns, and technological integration complexities. Future research should focus on developing cost-effective AI solutions, improving AI-driven cybersecurity, and enhancing interoperability between AI-based logistics systems. One of the primary barriers to AI adoption in commercial transport is the significant financial investment required for AI infrastructure, including advanced hardware, software, and skilled personnel. Many small and medium-sized enterprises (SMEs) struggle to justify the costs associated with AI-driven automation, predictive analytics, and machine learning models. To address this, research should explore scalable AI solutions that offer affordability without compromising efficiency [9, p. 51-67]. Additionally, the high cost of AI implementation can be mitigated through collaborative public-private partnerships, government incentives, and cloud-based AI services that reduce the need for expensive on-premise installations [15, p. 34-47]. The recent researches argue how AI helps lower costs significantly compared to traditional methods and AI-based route optimization significantly improves delivery speed.

These days the major challenge is ensuring data security and privacy in AI-driven transport systems. The integration of AI relies on large datasets, often involving sensitive information such as customer details, vehicle tracking, and supply chain transactions. Cybersecurity threats, including data breaches and hacking, pose significant risks to logistics operations. Future advancements should focus on developing robust encryption techniques, decentralized AI architectures, and regulatory frameworks that safeguard data while maintaining AI system efficiency (Brown et al., 2023). Strengthening AI-driven cybersecurity measures will be essential in building trust among stakeholders and ensuring compliance with international data protection laws.

The formula below balances cost efficiency and environmental sustainability, making it suitable for AI-driven logistics optimization.

Sustainability-oriented AI optimization model for logistics

To integrate AI-driven optimization with sustainability, we define the total cost function for logistics operations as:

$\min \Sigma (c_i * d_i + \lambda * e_i * d_i)$ for $i = 1$ to N

Subject to:

1. Vehicle Capacity Constraints:
   $\Sigma q_j \leq Q$ for $j \in R$
   (The total demand of all deliveries in route R must not exceed vehicle capacity Q)
2. Time Window Constraints:
   $a_i \leq t_i \leq b_i$
   (Deliveries must occur within predefined time windows [a_i, b_i])
3. Flow Constraints:
   $\Sigma x_{ij} = 1$ and $\Sigma x_{ij} = 1$
   (Each delivery location must be visited exactly once)

Explanation:

- c_i = Cost per unit distance for vehicle i
- d_i = Distance traveled by vehicle i
- e_i = Carbon emission rate per unit distance for vehicle i
- λ = Sustainability weight factor (penalizing higher emissions)

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- q_j = Demand at delivery location j
- Q = Vehicle capacity
- t_i = Arrival time at location i
- a_i, b_i = Earliest and latest delivery times
- x_ij = Binary decision variable (1 if traveling from i to j, 0 otherwise)

Source: The formula is prepared by the author.

The interoperability remains a critical issue as AI-driven logistics solutions must integrate seamlessly with existing transport management systems. Many logistics providers use legacy systems that may not be compatible with modern AI applications, leading to inefficiencies in adoption. Future research should prioritize developing standardized AI protocols and flexible integration frameworks that enable smooth communication between different software platforms, transport networks, and IoT-enabled devices (Gonzalez & Patel, 2020). Establishing industry-wide AI standards will facilitate broader adoption and improve the overall effectiveness of AI in commercial transport [15, 34-47]. Looking ahead, advancements in AI-driven autonomous transport, real-time data analytics, and edge computing will further reshape the logistics sector. However, overcoming existing challenges will require ongoing innovation, regulatory support, and industry collaboration. By addressing cost barriers, enhancing cybersecurity, and improving system interoperability, AI can achieve its full potential in optimizing commercial transport efficiency, sustainability, and reliability.

CONCLUSION

AI-driven optimization is revolutionizing the logistics and transportation industry by significantly enhancing operational efficiency, reducing costs, and promoting more sustainable commercial transport practices. By leveraging real-time data analysis, predictive analytics, and automation, AI is reshaping how logistics companies operate, allowing for smarter, more dynamic decision-making that can reduce delays, streamline processes, and lower fuel consumption. In particular, AI's ability to process vast amounts of data in real time allows for more accurate route optimization, fleet management, and maintenance, which are crucial for minimizing environmental impact. These innovations also drive improvements in energy usage and operational performance, making supply chains more sustainable while simultaneously reducing carbon emissions.

As AI technologies continue to advance, their integration into the commercial transport sector is poised to transform the entire logistics ecosystem. The growing importance of sustainability in global trade is increasing the demand for solutions that reduce environmental harm, and AI offers a unique way to balance this need with operational efficiency. With AI, logistics companies are not only meeting modern sustainability goals, but they are also creating value for businesses by enhancing their competitiveness in an increasingly eco-conscious marketplace. By adopting AI-driven tools for route planning, fleet optimization, predictive maintenance, and energy-efficient practices, companies can achieve both operational cost reductions and environmental benefits simultaneously.

Looking ahead, as AI technologies become more sophisticated, their role in the logistics sector will become even more pivotal. From automating entire supply chains to developing

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more intelligent algorithms for predictive maintenance, AI holds the potential to create a greener, more efficient logistics sector. Innovations such as AI-powered autonomous vehicles, smart warehouses, and predictive analytics for demand forecasting are just the beginning of this transformation. The continuous evolution of AI will ensure that logistics not only keeps pace with the growing demand for goods but does so in a way that supports long-term sustainability and a reduced carbon footprint. As these technologies mature and become more integrated, their contribution to sustainable commercial transport will be critical in shaping the future of global logistics.

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LOGİSTİKADA İNQİLAB: DAVAMLI TİCARİ NƏQLİYYAT ÜÇÜN SÜNİ İNTELLEKTLƏ İDARƏ OLUNAN OPTİMALLAŞDIRMA

X Ü L A S Ə

Tədqiqatın məqsədi - bu tədqiqatın əsas məqsədi süni intellektə əsaslanan optimallaşdırmanın kommersiya nəqliyyatında səmərəliliyi necə artıra, xərcləri azaltmağa və davamlılığı təşviq edə biləcəyini araşdırmaqdır. Tədqiqat nəqliyyat sektorunda davamlı təcrübələri dəstəkləmək üçün logistik əməliyyatların, qərarların qəbul edilməsinin və resursların idarə edilməsinin təkmilləşdirilməsinə yönəlib.

Tədqiqatın metodologiyası - süni intellektlə idarə olunan optimallaşdırmanın logistikanın səmərəliliyinə və davamlılığına təsirini qiymətləndirmək üçün proqnozlaşdırıcı analitika və müqayisəli təhlildən istifadə edir. Məlumatlar yanacaq sərfiyyatı, marşrutun optimallaşdırılması və ümumi əməliyyat performansındakı təkmilləşdirmələri qiymətləndirmək üçün təhlil edilir.

Tədqiqatın tətbiqi əhəmiyyəti - nəticələr göstərir ki, süni intellektə əsaslanan logistikanın optimallaşdırılması yanacaq istifadəsini, əməliyyat xərclərini və karbon emissiyalarını əhəmiyyətli dərəcədə azaldır. Qərar verməni təkmilləşdirmək, gecikmələri minimuma endirmək və resursdan istifadəni təkmilləşdirməklə süni intellekt daha dayanıqlı və sərfəli kommersiya nəqliyyatına töhfə verir.

Tədqiqatın nəticələri - tədqiqat göstərir ki, AI tətbiqi yanacaq səmərəliliyində ölçülə bilən təkmilləşdirmələrə, marşrutun dəqiqliyinə və ətraf mühitə təsirin azalmasına gətirib çıxarır. Süni intellektlə idarə olunan sistemlərdən istifadə edən şirkətlər çatdırılma müddətində və əməliyyat xərclərində əhəmiyyətli dərəcədə azalma yaşadılar.

Tədqiqatın orijinallığı və elmi yeniliyi - bu tədqiqat süni intellektin təkcə əməliyyat səmərəliliyində deyil, həm də ekoloji cəhətdən məsuliyyətli təchizat zənciri strategiyalarının əsas sürücüsü kimi əhəmiyyətini unikal şəkildə təhlil edir.

Açar sözlər: süni intellekt, logistikanın optimallaşdırılması, kommersiya nəqliyyatı, davamlı təchizat zənciri, ağıllı nəqliyyat, proqnozlaşdırıcı analitika.

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РЕВОЛЮЦИЯ В ЛОГИСТИКЕ: ОПТИМИЗАЦИЯ НА ОСНОВЕ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА ДЛЯ УСТОЙЧИВОГО КОММЕРЧЕСКОГО ТРАНСПОРТА

Р Е З Ю М Е

Цель исследования изучить, как оптимизация на основе ИИ может повысить эффективность, сократить расходы и способствовать устойчивости в коммерческих перевозках.

Методология исследования - используется предиктивная аналитика и сравнительный анализ для оценки влияния оптимизации на основе ИИ на эффективность и устойчивость логистики. Данные анализируются для оценки улучшений в расходе топлива, оптимизации маршрутов и общей эксплуатационной эффективности.

Практическая значимость исследования - результаты показывают, что оптимизация логистики на основе ИИ значительно снижает расход топлива, эксплуатационные расходы и выбросы углерода. Улучшая процесс принятия решений, минимизируя задержки и улучшая использование ресурсов, ИИ способствует более устойчивому и экономически эффективному коммерческому транспорту.

Результаты исследования - исследование показывает, что внедрение ИИ приводит к измеримым улучшениям в топливной эффективности, точности маршрутов и уменьшению воздействия на окружающую среду. Компании, использующие системы на основе ИИ, значительно сократили сроки доставки и эксплуатационные расходы.

Оригинальность и научная новизна исследования - в этом исследовании уникальным образом анализируется важность ИИ не только для операционной эффективности, но и как основного фактора экологически ответственных стратегий цепочки поставок.

Ключевые слова: искусственный интеллект, оптимизация логистики, коммерческий транспорт, устойчивая цепочка поставок, интеллектуальный транспорт, предиктивная аналитика.

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