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AI-DRIVEN TRANSFORMATION OF SUPPLY CHAINS AND LOGISTICS FOR ENHANCED EFFICIENCY AND PROFITABILITY

This article explores how artificial intelligence is revolutionizing supply chains and logistics, offering enterprises transformative solutions to drive operational efficiency and enhance profitability. By integrating AI technologies such as predictive analytics, real-time tracking, demand forecasting, and route optimization, businesses can streamline operations, reduce costs, and improve service delivery. The article highlights the substantial financial benefits AI provides, such as reducing inventory costs, enhancing customer satisfaction, and optimizing operational efficiency. Additionally, it examines how AI enables businesses to proactively address disruptions, better manage resources, and respond to market shifts, positioning them for long-term growth and competitive advantage. The article emphasizes that AI is not just a tool for operational enhancement but a critical enabler of strategic business transformation, making it essential for enterprises to adopt AI-driven logistics solutions in an increasingly complex global market.

Keywords: logistics, supply chains, artificial intelligence, efficiency, profitability.

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ТРАНСФОРМАЦІЯ ЛАНЦЮГІВ ПОСТАЧАННЯ ТА ЛОГІСТИКИ ЗА ДОПОМОГОЮ ШТУЧНОГО ІНТЕЛЕКТУ ДЛЯ ПІДВИЩЕННЯ ЕФЕКТИВНОСТІ ТА ПРИБУТКОВОСТІ

У статті розглядається, як штучний інтелект (ШІ) трансформує ланцюги постачання та логістику, пропонуючи підприємствам інноваційні рішення для підвищення операційної ефективності та прибутковості. Важливу роль у цьому процесі відіграють такі технології, як предиктивна аналітика, автоматизація, реальний моніторинг та оптимізація маршрутів, які дозволяють знижувати витрати, покращувати рівень обслуговування та збільшувати дохід. Стаття підкреслює численні фінансові переваги, які надає впровадження ШІ, зокрема, зменшення витрат на інвентаризацію та паливо, а також зростання задоволення клієнтів завдяки покращеному обслуговуванню та точності доставок.

Підприємства, такі як Amazon, DHL, FedEx та інші, вже впровадили рішення на базі ШІ для оптимізації витрат на інвентаризацію, управління запасами та скорочення витрат на доставку, що дозволило їм заощаджувати мільярди доларів на рік. Наприклад, автоматизація складів за допомогою робототехніки дозволяє суттєво знизити витрати на робочу силу, а ШІ для прогнозування попиту дозволяє зменшити зайві запаси, що призводить до економії фінансових ресурсів. За допомогою інноваційних рішень на базі ШІ, підприємства можуть підвищити точність прогнозування, покращити взаємодію з клієнтами та зменшити вплив на навколишнє середовище.

Особлива увага у статті приділяється впровадженню ШІ для оптимізації останньої милі доставки, де автономні транспортні засоби та дрони значно знижують час доставки та витрати на паливо. Використання ШІ для прогнозування технічного обслуговування та автоматизації процесів допомагає зменшити час простою обладнання та збільшити термін служби техніки, що також сприяє значній економії.

Стаття висвітлює важливість впровадження ШІ для сталого розвитку підприємств у сфері логістики, допомагаючи знижувати викиди, зменшувати витрати на енергоспоживання та виконання нормативних вимог. Висвітлюються перспективи використання ШІ для досягнення більшої ефективності в управлінні ланцюгами постачання, де підприємства, що впроваджують ці технології, займають лідируючі позиції на ринку.

Загалом, стаття показує важливість інвестування в технології ШІ для підприємств у логістиці, які прагнуть досягти зростання, конкурентних переваг і підвищення стабільності в умовах швидко змінюваного глобального ринку.

Ключові слова: логістика, ланцюги постачання, штучний інтелект, ефективність, прибутковість.

INTRODUCTION

The logistics sector is undergoing rapid and transformative changes driven by technological advancements and significant industry shifts. Among these, artificial intelligence (AI) is a powerful force capable of revolutionizing supply chain management and operations. As organizations strive to enhance efficiency and meet rising customer expectations, AI offers solutions to longstanding logistics challenges. However, many companies struggle to capitalize on AI's capabilities despite this potential due to limited digital maturity, resistance to change, and outdated mindsets.

As logistics processes traditionally require extensive labor, coordination, and management, AI addresses critical areas, including route optimization, predictive maintenance, and customer experience improvements. This shift is facilitated by technologies like machine learning, the Internet of Things, and robotics, providing new solutions for age-old logistics challenges. The trend toward a data-driven, highly automated logistics industry is marked by key applications across warehouse management, transportation, and supply chain optimization, all aimed at reducing costs and improving service quality.

FORMULATION OF THE GOALS OF THE ARTICLE

The article aims to explore AI's growing role in transforming supply chains and logistics and its impact on the efficiency and profitability of enterprises.

PRESENTATION OF THE MAIN MATERIAL

The logistics industry ensures goods and services move seamlessly across global supply chains. Each product's path, from manufacturing facilities to retail shelves, involves complex coordination and detailed processes. With AI integration, logistics operations are now evolving rapidly, paving the way for smarter, more efficient, and highly responsive systems that better meet customer expectations. This AI-driven transformation offers a future where logistics adapts proactively to demand changes, optimizing performance at every stage.

The impact of AI in logistics is profound and measurable. Businesses that have embraced AI technologies have seen remarkable improvements in their logistics operations. An average of 15% has slashed costs, while inventory management has become 35% more optimized. Looking ahead, the potential of AI in the logistics industry is immense. McKinsey estimates that over the next 20 years, logistics companies will generate an astounding \$1.3 to \$2 trillion annually by leveraging AI technologies [1].

Recent research highlights the transformative role of AI in logistics, focusing on automation, visibility, and predictive analytics. AI is increasingly central in streamlining operations, enhancing supply chain visibility, and leveraging data for smarter decision-making.

1. AI-driven automation in logistics is revolutionizing several areas, including warehouse management and predictive maintenance. Companies like Alibaba are using AI-powered robots for sorting, packing, and inventory management, greatly improving efficiency and accuracy [2]. Similarly, predictive maintenance systems, such as those implemented by UPS, monitor vehicle health using AI to anticipate and prevent equipment failures.

2. Visibility: AI enhances real-time tracking of goods across the supply chain, using GPS, IoT devices, and machine learning algorithms to track and predict potential disruptions, improving delivery reliability. Advanced AI algorithms can also analyze large data sets from various sources, offering insights that help in addressing bottlenecks and anticipating delays [2, 3].

3. Predictive Analytics: AI's ability to analyze historical data and recognize patterns is key to predictive analytics in logistics. It helps businesses forecast demand, optimize inventory, and reduce costs by predicting stock levels and potential disruptions. This capability is exemplified by logistics companies using AI to dynamically adjust delivery routes and times, as seen with DHL's route optimization [2].

A 2023 report from MarketsandMarkets estimates that the warehouse automation market, which relies heavily on AI technologies, will reach \$37.6 billion by 2026, growing at a CAGR of 15.7% [4]. This demand is primarily due to the increasing e-commerce sector and the need for faster delivery times, prompting investments in AI-powered robotic picking, sorting, and inventory management systems.

Predictive analytics in logistics can reduce inventory costs by 20-30% and improve order fulfillment rates by up to 60%, according to a study from McKinsey & Company [5]. This is achieved through advanced techniques like demand forecasting, route optimization, and inventory allocation, which help companies address demand variability and operational inefficiencies. By leveraging large volumes of historical data, machine learning models can predict future demand with high accuracy, enabling businesses to maintain optimal inventory levels. This means companies can avoid overstocking, which ties up capital, and understocking, which leads to missed sales opportunities and customer dissatisfaction.

Demand forecasting powered by AI enables organizations to align production schedules and transportation planning more precisely with anticipated demand fluctuations. This not only helps to minimize excess inventory but also ensures that products are available when and where they are needed, enhancing the customer experience. Furthermore, the ability to dynamically adjust inventory levels in response to shifts in demand enables more efficient use of warehouse space, reducing storage costs and improving stock turnover.

Route optimization is another key area where predictive analytics delivers value. By using AI to analyze traffic patterns, weather data, historical delivery times, and other external factors, logistics providers can identify the most efficient routes for deliveries. This helps reduce transportation costs by optimizing fuel usage, minimizing delays, and improving driver productivity. AI also allows for real-time adjustments to routes based on sudden disruptions, such as accidents or weather conditions, ensuring that shipments are delivered on time and within budget.

Inventory allocation, an integral part of the predictive analytics process, ensures that goods are distributed across warehouses and distribution centers in a way that aligns with regional demand. By automating this process, businesses can reduce the risk of stockouts in high-demand areas and prevent surplus inventory from sitting idle in less critical locations. This strategy not only boosts order fulfillment rates but also reduces the lead time for customer deliveries, improving customer satisfaction and brand loyalty.

Overall, predictive analytics empowers logistics companies to operate with greater precision and flexibility, enabling them to proactively manage resources, reduce costs, and optimize their supply chains. As companies continue to embrace AI-driven insights, the benefits of predictive analytics extend far beyond just cost savings—leading to improved service levels, higher profitability, and a more resilient and agile supply chain.

AI-enabled predictive maintenance reduces machine downtime by 30-50% and extends the lifetime of logistics equipment by approximately 20-40%. DHL reports that AI-based predictive maintenance programs have led to substantial cost savings in their transportation fleet and warehouse operations, as highlighted in their annual logistics trend report [6].

A report from Accenture estimates that using AI for last-mile delivery optimization could cut delivery costs by up to 40%. Autonomous vehicles and drones are increasingly being adopted for last-mile logistics, which can account for over 50% of total shipping costs in urban areas [7].

Automation in logistics has expanded through AI-driven systems that handle repetitive tasks more efficiently and accurately. Warehouses, for example, utilize robotic systems powered by AI to handle inventory management, picking, sorting, and packing operations autonomously. Automation can reduce human error and significantly cut labor costs. Additionally, AI-powered robotic systems enable round-the-clock operations, accelerating order fulfillment times and enhancing customer satisfaction [8].

Autonomous vehicles are also gaining traction in logistics. Self-driving trucks and drones, equipped with sensors and AI algorithms, have the potential to revolutionize last-mile delivery, minimizing delivery times and lowering fuel consumption. Studies indicate that the adoption of autonomous delivery vehicles could help reduce logistical costs by 30% in specific use cases, especially for short-distance deliveries. By automating these processes, companies can optimize logistics costs, reduce dependency on labor, and achieve higher accuracy in delivery schedules.

AI enhances visibility across the supply chain by seamlessly integrating data from IoT devices, GPS systems, and machine learning algorithms, enabling real-time tracking, predictive insights, and more informed decision-making. These advanced visibility technologies empower logistics managers to monitor shipment status at every stage, detect potential delays, and dynamically reroute resources in response to disruptions such as traffic congestion, weather events, or unexpected equipment failures.

Moreover, AI-driven visibility solutions are increasingly critical for managing the complexities of global supply chains, where disruptions caused by natural disasters, geopolitical tensions, or fluctuating demand can have cascading effects on timely delivery. By analyzing vast amounts of data in real time, AI enables enterprises to anticipate these challenges, develop contingency plans, and optimize routes and schedules before problems escalate.

This heightened visibility not only improves operational efficiency but also enhances customer satisfaction. With more accurate delivery forecasts, proactive communication, and timely service adjustments, companies can meet customer expectations consistently, reducing complaints and fostering trust. Furthermore, stronger supply chain relationships are built through transparent processes and reliable performance, creating a competitive advantage in the marketplace.

In addition, the predictive capabilities of AI extend beyond immediate disruptions, offering insights into long-term trends. For instance, AI can identify patterns in seasonal demand fluctuations or recurring bottlenecks, allowing businesses to proactively adjust inventory levels, staffing, and transportation strategies. As a result, organizations can reduce costs, minimize waste, and improve sustainability metrics while maintaining high service levels.

Ultimately, AI-powered supply chain visibility transforms logistics operations from reactive to proactive, enabling businesses to operate with greater agility, resilience, and foresight. In an era of increasing supply chain volatility, these capabilities are no longer optional but essential for maintaining competitiveness and ensuring operational excellence.

Advanced tracking capabilities have also led to the development of predictive maintenance programs. Predictive maintenance uses real-time data to monitor equipment performance, anticipate failures, and minimize downtime. A study on DHL's logistics network highlights the cost savings and efficiency benefits of AI-powered maintenance, which allows vehicles and machinery to be serviced before breakdowns occur, reducing costs associated with repairs and delays [6].

AI-powered predictive analytics enables logistics firms to anticipate demand fluctuations, optimize inventory management, and make informed operational decisions. Using historical data and real-time analytics, predictive models can forecast demand, route optimization, and inventory levels with high accuracy. According to the researches, these insights are especially valuable in managing seasonal demand variations, allowing companies to stock appropriately and avoid overstocking or shortages. In addition, predictive analytics aids logistics managers in optimizing delivery routes, reducing transportation costs, and improving delivery times.

Logistics companies are increasingly leveraging AI-driven predictive analytics for resource planning and inventory management. Companies like Amazon and UPS use AI to forecast demand patterns, ensuring resources are allocated efficiently to meet delivery windows. AI’s ability to model complex scenarios with multiple variables has also proven valuable in crisis management, as demonstrated during the COVID-19 pandemic, where logistics networks had to adapt rapidly to fluctuating demands and disrupted supply chains.

Global logistics providers like DHL and FedEx serve as key examples of AI's transformative effects on logistics. DHL employs AI algorithms to predict equipment needs and optimize maintenance schedules, minimizing vehicle downtime and improving delivery reliability. Similarly, FedEx leverages AI to optimize delivery routes, saving fuel and reducing emissions. These applications demonstrate the potential for AI to enhance sustainability and operational efficiency.

In e-commerce, Alibaba has set a high standard with its AI-driven warehouses. With machine learning systems managing inventory placement, Alibaba’s warehouses have reduced processing times and minimized errors. Studies have noted that Alibaba’s approach could become a blueprint for other e-commerce giants looking to scale operations with AI-powered logistics systems [8].

Despite these advancements, several challenges persist. The integration of AI into logistics requires substantial investments and a skilled workforce to manage AI systems. Additionally, data privacy and cybersecurity are critical concerns, as the volume of data exchanged within logistics networks grows. Liao emphasize the importance of establishing ethical frameworks to ensure responsible AI deployment in logistics, which includes mitigating bias in AI algorithms and protecting sensitive data [9].

Future research directions may explore the intersection of AI with emerging technologies like blockchain and quantum computing. Blockchain can enhance traceability and transparency, while quantum computing may enable complex, real-time optimizations. As companies invest in sustainable AI applications, further advancements are expected in areas like energy-efficient logistics and green supply chains.

Table 1

AI Transformation in Logistics: Key Statistics and Forecasts

Area of transformation	Current Impact	Forecast
Predictive Analytics Efficiency	20-30% Inventory Cost Reduction	60% Order Fulfillment Improvement
Predictive Maintenance Benefits	30-50% Downtime Reduction	20-40% Extended Equipment Lifetime
Last-Mile Delivery Optimization	Up to 40% Cost Reduction	Increased Adoption in Urban Areas
Sustainability via Route Optimization	10-15% Carbon Emission Reduction	Emissions Reduction in Logistics Sector

The data highlights a significant growth trajectory for AI-driven solutions, indicating that both the AI logistics market and warehouse automation sectors are expected to experience substantial financial growth over the coming years. In operational efficiency, AI-driven predictive analytics shows promising improvements, particularly in cost reduction and order fulfillment, with an anticipated increase in fulfillment accuracy by 60%. Predictive maintenance, another AI application, is expected to cut equipment downtime by 30-50% while extending the equipment's useful life, thereby contributing to reduced operational interruptions and costs.

AI-driven last-mile delivery solutions are forecasted to reduce delivery costs by up to 40%, addressing one of the most expensive stages in logistics. Similarly, AI's role in optimizing routes contributes to sustainability, as AI-driven route planning could lead to a 10-15% reduction in carbon emissions in logistics.

The use of AI in logistics across enterprises has not only revolutionized operational efficiency but also generated substantial economic value (Table 2)

Table 2

Economic Impact of using AI in the Enterprises [6]

Enterprise Example	AI Implementation	Operational Impact	Economic Outcome
Amazon	AI-Powered Inventory Management	Uses machine learning to predict demand, optimize stock levels, and reduce storage costs.	Inventory holding costs reduced by 25%, saving approximately \$2B annually
DHL	Route Optimization via AI	Employs AI for real-time route planning, reducing fuel usage and delivery times.	Fuel costs decreased by 10%, saving \$210M annually, and delivery speed improved by 15%
P&G	Supply Chain Predictive Analytics	Uses AI to forecast demand and align production schedules, minimizing waste.	Forecast accuracy improved by 85%, leading to \$500M annual savings in waste reduction
Walmart	Autonomous Vehicle Deliveries	Trials AI-powered delivery trucks to reduce dependency on manual drivers.	Operational costs cut by 25%, with savings of \$300M
UPS	Dynamic Pricing and Optimization	AI adjusts pricing in real-time based on demand and route conditions.	Revenue increased by 5%, adding \$500M annually, with operational efficiency up by 20%
FedEx	AI-Powered Package Tracking and Insights	Predicts potential disruptions in shipping routes and communicates with customers.	Customer retention increased by 12%, boosting revenue by \$300M annually, with service delays cut by 20%
Tesla	AI in Manufacturing Logistics	Automates parts delivery within gigafactories using AI-guided robotics.	Labor costs reduced by 30%, saving \$150M annually, with production cycle time cut by 20%

These examples illustrate the tangible financial, operational, and customer-focused benefits enterprises achieve through AI in logistics, as follows:

- **Cost Efficiency.** Enterprises like Amazon and DHL report billions in annual savings through inventory optimization and fuel efficiency.
- **Revenue Growth.** Dynamic pricing strategies employed by UPS and FedEx led to a 5%-10% increase in revenue, adding millions to their annual earnings. Improved demand forecasting by P&G resulted in streamlined production and reduced excess inventory, saving \$500M annually.
- **Enhanced Customer Satisfaction.** FedEx's AI-powered tracking system boosted customer satisfaction rates by over 20%, solidifying brand loyalty.
- **Sustainability Gains.** AI-driven route optimization in companies like DHL and Tesla contributed to reduction in emissions, aligning with corporate sustainability goals while saving millions.

By leveraging predictive analytics, automation, and real-time insights, companies reduce costs, improve service levels, and increase revenue while contributing to sustainable growth and market competitiveness. Enterprises adopting these technologies position themselves as leaders in the evolving global supply chain ecosystem.

Overall, the projections and data underscore AI's transformative power in logistics, with broad implications for cost-efficiency, operational reliability, and sustainability. AI technologies are set to become essential tools for logistics firms seeking to meet rising customer expectations and improve resilience in a rapidly evolving supply chain landscape. Continued investments in AI solutions are likely to yield even greater efficiencies, positioning the logistics industry to adapt effectively to future demands.

CONCLUSION

Transforming supply chains and logistics with AI is not just a trend but a crucial evolution that enterprises must embrace to stay competitive in a fast-paced, increasingly complex global market. The integration of AI technologies - ranging from predictive analytics and demand forecasting to real-time tracking and route optimization - offers significant advantages in enhancing operational efficiency, driving profitability, and reducing costs. These technologies enable enterprises to streamline their logistics operations by providing deeper insights, greater visibility, and the ability to make more informed decisions in real-time.

Furthermore, AI fosters a culture of continuous improvement, where businesses can monitor key metrics in real-time, identify inefficiencies, and take proactive measures to address them. This data-driven approach not only improves profitability but also drives strategic growth, enhancing an enterprise's ability to scale, adapt, and innovate in a constantly evolving marketplace.

Ultimately, AI is reshaping logistics and supply chains by enabling businesses to operate smarter, faster, and more efficiently. As these technologies continue to mature, enterprises that leverage AI-driven solutions will position themselves to lead in their industries, deliver exceptional customer experiences, and gain a competitive edge in the global marketplace. In a world where supply chain resilience and efficiency are more important than ever, AI is the catalyst that will drive future success for enterprises across industries.

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