Bölüm 7

Tedarik Zincirinde Yapay Zeka Tabanlı Uygulamalar İle Tahminleme ⌘

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Özet

Yapay zeka (AI) tabanlı tahminler, tedarik zincirini daha çevik, veri odaklı ve dirençli bir ekosisteme dönüştürmede çok önemli bir rol oynamaktadır. Doğru tahminler yapma, operasyonları optimize etme ve riskleri proaktif bir şekilde yönetme yeteneği, günümüzün dinamik ve karmaşık tedarik zincirlerinde işletmelerin genel verimliliğine ve rekabet gücüne katkıda bulunmaktadır.

Buradan hareketle bu bölümde lojistik operasyonların verimliliği ve tedarik zincirinin etkin yönetimi için yapay zeka tabanlı uygulamalarda tahminlemeler üzerinde durulmuştur. AI tabanlı uygulamalarda en sık kullanılan ve en çok fayda sağlanan rota belirleme, talep ve envanter yönetimi alanlarında tahminlemenin tedarik zinciri yönetimine katkıları konusuna ışık tutmak amaçlanmıştır.

1. Introduction

Artificial Intelligence (AI) has a significant impact on the logistics industry by optimizing and automating various processes, improving efficiency, reducing costs, and enhancing decision-making.

When we look at the industry, it is seen that it is very difficult for global supply chains consisting of different geographical locations to become sustainable, efficient and fluid(Fig 1). Businesses and their stakeholders that adopt agile strategies in this challenge have a healthier supply chain. Their competitive power, which is the key to the survival of these businesses, is also higher(17). One of the biggest supporters of creating an agile supply chain is AI technology. AI leads to increased productivity and customer satisfaction in the supply chain management with its agile processes.(8)

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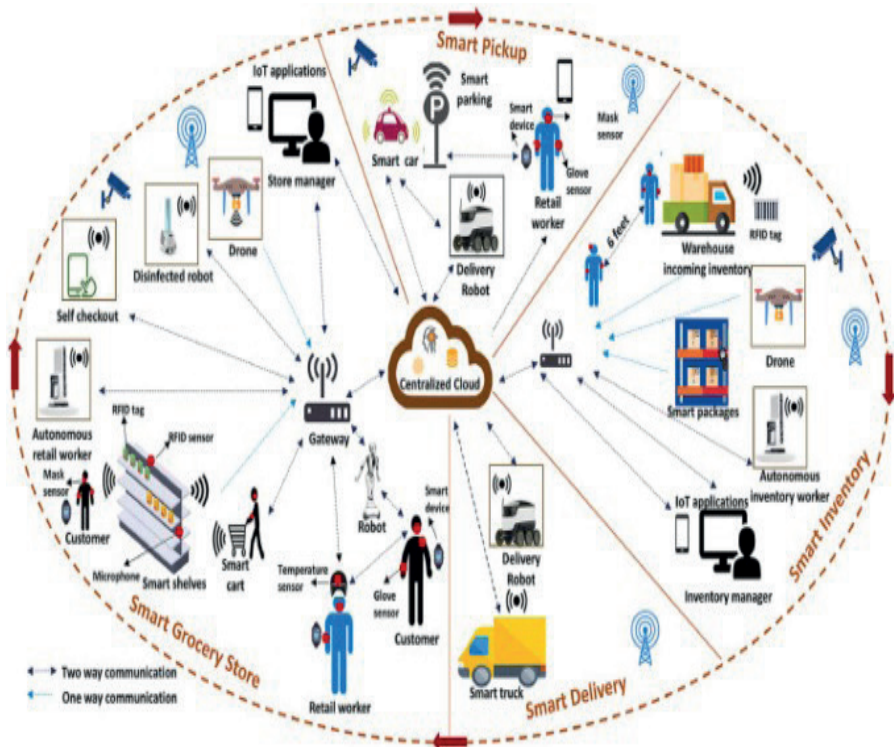
Figure 1 Smart Supply Chain Management (15)

Artificial Intelligence in supply chain management can be beneficial in addressing the complexities and challenges of today's dynamic and unpredictable business environment. The best future of AI is its ability to analyze huge amount of data. Thanks to this analyse, relationships can be understood, decision-making helps prductivity of supply chain management, flows of goods can be tracked that it makes process visible and innovate processes can be modeled (16). AI becomes instrumental in enabling the modern digital supply chain. Day by day supply chains are becoming more complex, impacting everything from design to sourcing, production, distribution, and maintenance. Unpredictability brought about by unexpected events, such as natural disasters, pandemics, and political instability adds to the challenge with far-reaching implications on the availability of labor, equipment, and materials. Plus, with a lack of transparency across the supply chain, companies become more vulnerable to phenomena such as demand distortion and risk having their costs spiraling out of control. Despite substantial digitalization investments over the past several years, companies still struggle to deliver the capabilities different business functions need to

manage the supply chain. The many functional teams involved in supply chain-centric processes continue acting in silos, with misaligned objectives and limited visibility outside their core responsibilities(22).

2. Predictive Anaytics with AI-based logistics applications

Predictive analysis points the use of data, statistical algorithms, and machine learning techniques to identify the likelihood of future outcomes based on historical data patterns. This function of the AI application means predictive analyse(12). The analyse helps in determining the most efficient routes as mentioned in the Route Optimizaton topic. With that prediction, AI can suggest alternative short routes. Real time based short routes support companies to reduce fuel consumption and CO_2 emissions(13), increase customer satisfaction and sustainability, save money and time. Secondly, based on historical customer and sales data which involves records of past purchase details such as product, quantity, and time of purchase, future buying behavior of customers and their demand for products can be predicted(14)(Fig 2). With sales and customer behavior data is used by AI for prediction, we can get an analyse for product affinity, understand different customer segments for marketing, forecast potential impact of future marketing campaigns. Thirdly, with demand forecasting, it is possible to ensure inventory levels optimum. This reduce the cost assosciated with overstocks and stockouts. So by aligning inventory levels with actual demand, both overstock operations (transportation, handling, warehousing etc.) costs decrease and stockouts based lost sales are minimized. Allowing businesses to adjust prices in real-time, AI not only helps in efficient inventory management by aligning prices with demand but also maximixe revenue potential.

Supplier behavior, potential risks, return rate and sustainability performances are other areas where AI-based forecasting helps.
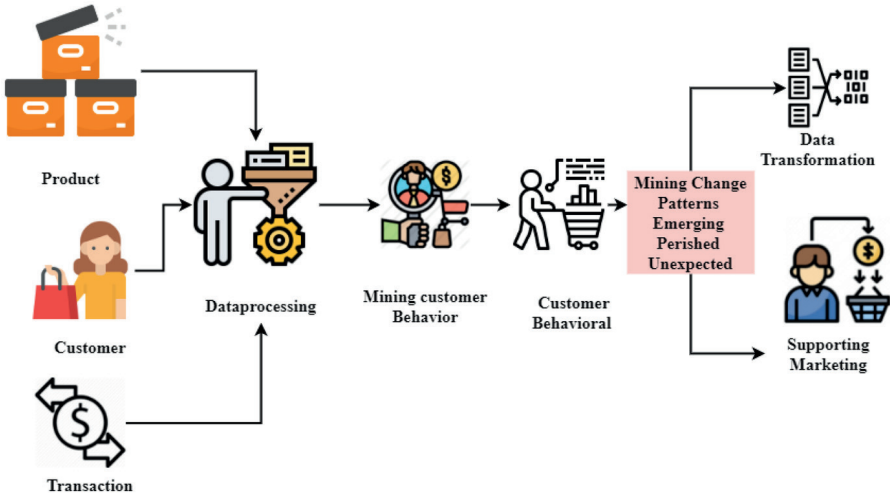
Figure 2 Flowchart for change mining for customer behavior analysis (23)

2.1. Route Optimization

AI plays an impressive role in optimizing vehicle routes within supply chains, solving to the route problem with more agile and efficient operations. In practise, Predictive Analytics, Real-time Monitoring, Machine Learning for Continuous Improvement, Geospatial Analysis, Dynamic Scheduling, Cost Optimization, Integration with IoT Devices, environmental Considerations are AI integrated technologies in this field. And these technologies contribute companies to be more competitive for customer satisfaction.

To minimize logistics cost and to manage time efficiently companies need to create optimize routes based on their logistics operations. With the optimization, companies minimize fuel consumption, reduce vehicle wear and and tear, maximize resource usage on transportation and handling processes. This directly contributes to main aims of logistics; minimizing costs and customer satisfaction. Cost savings are essential for companies to make profit and competition in relevant sector and managing time efficiently in logistics operations makes customer satisfaction.(5)(6)

Besides as mentioned before optimizing routes helps in better utilizing the available resources. So this allows logistics companies using fewer resources for handling in higher volumes. Also using less resources impact on carbon reductions. This aligns with sustainability goals and supports environmentally conscious practices.

AI based route optimization systems often provide enhanced visibility into the entire logistics process. This visibility allows logistics managers to monitor the movement of goods, track deliveries, and identify potential issues in real time. Also customers can monitor their orders too. Timely deliveries and efficient routes contribute to a positive customer experience. Customers appreciate when their orders are delivered promptly, and route optimization plays a key role in achieving this. In case of any disruption in the route plan such as traffic, weather, or unexpected events, this optimization system allow for dynamic adjustments. This points to "dynamic adaptability" that makes managers and customers feel their orders are safe. (6)Adaptability also refers another useful feature, too. Intagrating compliance and regulations such as traffic rules, vehicle size on roads etc and legal other requirements in a route optmization system is possible with that feature. Based on this adaptability and monitorization, the system also can predict and warn about risks such as traffic fines, delays, accidents etc.(5) Operational efficiency increases with effective route planning that provides better coordination different stages of the supply chain.

2.2. Demand forecasting

By leveraging AI-based demand prediction, businesses can enhance their forecasting capabilities, improve inventory management, reduce stockouts, and adapt more effectively to the challenges posed by volatile demand in the real world. The continuous learning capabilities of AI models contribute to a more adaptive and responsive supply chain. (10)

There are many external factors effect on customer demand such as economic conditions, weather patterns, holidays, promotions, or even social factors. Incorporating these external factors into AI algorithms helps improve the accuracy of demand forecasts. By analyzing large amounts of historical data and incorporating external factors, AI algorithms can provide more accurate and reliable demand forecasts, leading to better inventory management and improved operational efficiency(10)(11). Therefore inventory management can do ıts plan for future term and ensure that products are available when customers need.

AI-based demand prediction is an essential tool in supply chain management because it enhances forecasting accuracy, allows for real-time adjustments, supports scenario planning, enables personalized forecasting, improves inventory management, enhances supply chain resilience, leads to cost savings, and contributes to overall customer satisfaction. The continuous learning and adaptability of AI models make them invaluable in navigating the complexities and uncertainties of the modern business landscape(19).

2.3. Inventory management

By maintaining an adequate level of safety stock, businesses can better absorb and navigate uncertainties within the supply chain, ensuring a more resilient and responsive operation. Striking the right balance between safety stock levels and cost considerations is essential for effective supply chain management. Advanced analytics and AI-driven forecasting models can contribute to optimizing safety stock levels based on historical data and predictive insights.

By using artificial intelligence to predict inventory needs, companies can avoid ordering excessive amounts of stock, thereby minimizing wastage and reducing the occurrence of expired or obsolete inventory. For tracking inventory, companies use some devices such as RFID (Radio Frequency Identification readers, barcode scanners and smart shelves are integrated with AI (15). These devices' tags are attached to goods. This provides remote but real-time visibility and efficient inventory management with AI algorithm based on real data. Such a RFID integrated with artificial intelligence is called smart retail system. In summary this system uses RFID data to analyze customer buying patterns and optimize inventory levels, ensuring products are readily available when customers need them(15).

Therefore optimizing inventory levels avoid of companies excessive capital in inventory and reduce the costs associated with overstocking and understocking. And AI helps companies optimize their inventory levels by predicting when and how much stock needs to be reordered. This improves customer satisfaction(18).

2.4. Other Predictions

AI-driven forecasting can provide valuable insights into "supplier behavior" by analyzing historical data. This data encompasses key metrics such as order fulfillment times, lead times, on-time delivery performance, quality of goods, and overall reliability. By scrutinizing this wealth of historical information, AI can uncover hidden patterns, correlations, and trends that may not be apparent through traditional methods. Machine learning algorithms can identify patterns and trends in supplier behavior, helping businesses anticipate potential delays, assess supplier reliability, and optimize procurement strategies. This proactive approach enables organizations to build stronger relationships with reliable suppliers and minimize the impact of uncertainties in the supply chain(24).

AI's predictive capabilities are instrumental in identifying "potential risks" within the supply chain. By analyzing historical data and external factors,

AI models can assess the likelihood of various risks such as transportation disruptions, geopolitical events, or supplier issues. This allows businesses to develop risk mitigation strategies, implement contingency plans, and make informed decisions to minimize the impact of unforeseen events. AI's ability to continuously learn and adapt enhances the resilience of the supply chain against potential risks.

AI-based forecasting can also analyze historical data about returns. Theses are customer feedback, and other relevant factors. After that analyse, AI can present future predicted return rates. This forecast is essential for optimizing inventory management, understanding product quality issues, and implementing measures to reduce return rates. By addressing return challenges proactively, businesses can improve overall efficiency and customer satisfaction(25).

Recently attached another prediction with AI in supply chain is "sustainability". AI-based applications can contribute to forecasting and optimizing sustainability performances within the supply chain. By analyzing data related to energy consumption, water usage, carbon emissions etc. and ethical sourcing practices(like gender equavelence, child labor etc.), AI models can predict the environmental and social impact of supply chain operations. This information empowers businesses to make environmentally and socialy conscious decisions, optimize their supply chain for sustainability, and meet the growing demand for eco-friendly practices(26).

Some other AI-based predictions are used in supply chain are given Figure 3.

Contract Consumption
Proactively renew contracts by predicting their expiration and consumption

Sourcing and Procurement

Stock in Transit
Mitigate production risks by forecasting stock in transit delays

Material Management

Sales Quotation Conversion
Improve Sales Forecasts

Sales Analytics

Payment Block – Cash Discount at Risk
Avoid loss of cash discounts

Procure-to-Pay

Smart Alerts for Profit & Loss Analysis
Get informed of hidden unusual costs and revenue opportunities

Finance

Project Cost Forecast
Mitigate project budget overruns

Idea

Sales Forecast Prediction
Forecast sales based on predictive analytics

Sales Analytics

Dynamic buffer level adjustment
Optimizes inventory buffers based on replenishment leads time

Material Management

Delivery Performance
Forecast sales based on predictive analytics

Sales Analytics

Supplier Delivery Delay
Forecast sales based on predictive analytics

Sourcing and Procurement

Figure 3 SAP AI Based Prediction Fields in Supply Chain (9)

3. Example : E-Commerce Company

It would be enlightening to summarize the use of AI-based applications with an example. A common known e-commerce company's supply chain generally covers nationwide. The company ships products to customers with a complex supply chain network. This network consists of multiple distribution centers, warehouses and fleets of delivery vehicles. Optimizing delivery routes are real challenge for the company that must face. Because environmental factors such as traffic conditions, **delivery** time windows, and varying demand in different regions makes system harder to ensure timely and cost-effective deliveries. But the company can reach desired solution with AI that collects historical data on delivery routes, traffic patterns, delivery times, and customer preferences. Also that AI system can take into account **cost** factors, such as fuel efficiency and vehicle maintenance, to optimize routes in a way that minimizes operational expenses. Besides historical datas in the system can be analysed thanks to machine learning

algorithms to present specific traffic conditions or certain routes etc. One of the best part is that real-time data is analyzed and instantly supports the company to make a decision and promise the customer. The company can make the logistics process of product visible with sharing customer screen that is a part of the AI system for customer. This has a direct impact on customer satisfaction by ensuring that products are delivered within specified time frames (Figure 4).

On the other hand this e-company needs to predict future demand for quick response to customers. This also makes its supply chain **flexible** in the competitive environment. With analysing historical data, a close prediction of demand is possible for the company. Thus, AI aligns the company's supply chain with its customer expectations for timely and reliable service, ultimately enhancing its overall customer experience. If the company not only focus on **customer satisfaction** but also reducing cost in its AI integrated supply chain, then we can talk about system quality of supply chain. The company probably assess, monitor and proactively manage its quality as a competitive factor. Lastly in that supply chain there would be an only need to understand which **quality** level the company has for continuous development. So AI-based applications generaly provide a feedback loop where the outcomes of logistics processes are continuously evaluated. This information is used by that e-commerce company to improve the accuracy and effectiveness of future logistics planning.
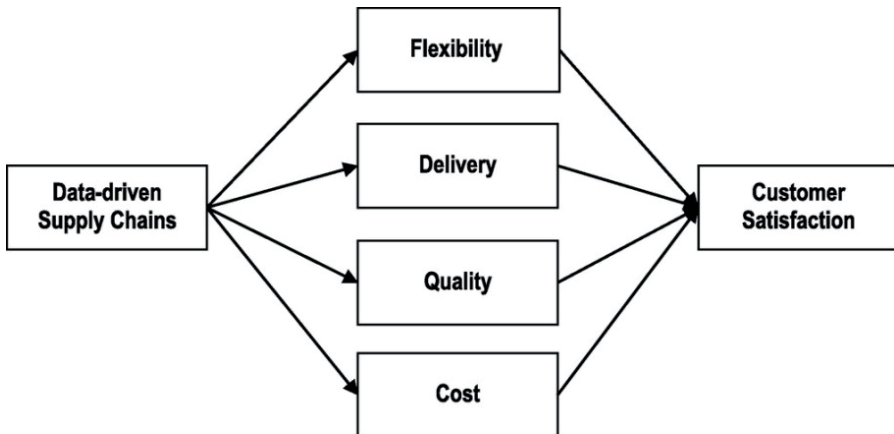

Figure 4. AI-based application effects customer satisfaction (2)

4. References

1. Rameshwar Dubey, David J. Bryde, Yogesh K. Dwivedi, Gary Graham, Cyril Foropon, Impact of artificial intelligence-driven big data analytics culture on agility and resilience in humanitarian supply chain: A practice-based view, International Journal of Production Economics, Volume 250, 2022,108618, ISSN 0925-5273, https://doi.org/10.1016/j.ijpe.2022.108618.

2. Roberto Chavez, Wantao Yu, Mark A. Jacobs & Mengying Feng (2017) Data-driven supply chains, manufacturing capability and customer satisfaction, Production Planning & Control, 28:11-12, 906-918, DOI: 10.1080/09537287.2017.1336788

3. Waller, M. A., and S. E. Fawcett. 2013. "Data Science, Predictive Analytics, and Big Data: A Revolution that Will Transform Supply Chain Design and Management." Journal of Business Logistics 34 (2): 77–84.10.1111/jbl.12010

4. Dubey, R., A. Gunasekaran, S. Childe, S. Fosso Wamba, and T. Papadopoulos. 2016. "The Impact of Big Data on World-class Sustainable Manufacturing." The International Journal of Advanced Manufacturing Technology 84 (1-4): 631–645.10.1007/s00170-015-7674-1

5. Chairote Yaiprasert, Achmad Nizar Hidayanto, AI-powered ensemble machine learning to optimize cost strategies in logistics business, International Journal of Information Management Data Insights, Volume 4, Issue 1, 2024, 100209, ISSN 2667-0968, https://doi.org/10.1016/j.jjimei.2023.100209

6. Paolo, Toth., Daniele, Vigo. (2001). The vehicle routing problem.   doi: 10.1137/1.9780898718515

7. https://optimoroute.com/route-optimization-techniques/#what-is

8. Reza Toorajipour, Vahid Sohrabpour, Ali Nazarpour, Pejvak Oghazi, Maria Fischl, Artificial intelligence in supply chain management: A systematic literature review, Journal of Business Research, Volume 122, 2021, Pages 502-517, ISSN 0148-2963, https://doi.org/10.1016/j.jbusres.2020.09.009.

9. https://blogs.sap.com/2019/02/07/pai-series-blog-3-training-and-activating-the-out-of-the-box-predictive-content-shipped-by-s4hana/

10. Aylak, B. L, Oral, O., Yazıcı, K. "Using Artificial Intelligence and Machine Learning Applications in Logistics, " El-Cezerî Journal of Science and Engineering, 2021, 8 (1); 74-93.

11. Ertemel, A. V., Alış, G. ve Pirtini, S., "The Effect Of Industry 4.0 Applications On Operational Efficiency In The Logistics Sector", Business and Management Studies An International Journal. 2020, 8 (1), 371-395

12. https://studyonline.unsw.edu.au/blog/descriptive-predictive-prescriptive-analytics

13. Jayol, A.; Lejri, D.; Leclercq, L. Routes Alternatives with Reduced Emissions: Large-Scale Statistical Analysis of Probe Vehicle Data in Lyon. Atmosphere 2022, 13, 1681. https://doi.org/10.3390/atmos13101681

14. Abid Haleem, Mohd Javaid, Mohd Asim Qadri, Ravi Pratap Singh, Rajiv Suman, Artificial intelligence (AI) applications for marketing: A literature-based study, International Journal of Intelligent Networks, Volume 3, 2022, Pages 119-132, ISSN 2666-6030, https://doi.org/10.1016/j.ijin.2022.08.005.

15. Gupta et al., 2021D. Gupta, S. Bhatt, M. Gupta, A.S. TosunFuture smart connected communities to fight covid-19 outbreakInternet Things, 13 (2021), Article 100342

16. Richey, R.G., Jr., Chowdhury, S., Davis-Sramek, B., Giannakis, M. and Dwivedi, Y.K. (2023), Artificial intelligence in logistics and supply chain management: A primer and roadmap for research. J Bus Logist, 44: 532-549. https://doi.org/10.1111/jbl.12364

17. Korucuk, S., Tirkolaee, E.B., Aytekin, A. et al. Agile supply chain management based on critical success factors and most ideal risk reduction strategy in the era of industry 4.0: application to plastic industry. Oper Manag Res 16, 1698–1719 (2023). https://doi.org/10.1007/s12063-023-00360-5

18. Liang, Y., Xiao, J., Wang, Y., Pang, Z., Li, Y., Jin, X., Liu, G.A method to make accurate inventory of smart meters in multi-tags group-reading environment(2016) 2016 IEEE International Conference on RFID Technology and Applications, RFID-TA 2016, art. no. 7750743, pp. 123-128. Cited 4 times. ISBN: 978-150901408-8 doi: 10.1109/RFID-TA.2016.7750743

19. https://ttpsc.com/en/blog/how-will-ai-change-demand-forecasting-in-the-supply-chain/

20. Boone et al., 2019 T. Boone, R. Ganeshan, A. Jain, N.R. Sanders Forecasting sales in the supply chain: consumer analytics in the big data era Int. J. Forecast., 35 (2019), pp. 170-180

21. Richey, R. G., & Davis-Sramek, B. (2022a). A research agenda to reflect reality: On being responsive. Journal of Business Logistics, 43(1), 4–8. https://doi.org/10.1111/jbl.12297

22. https://www.mckinsey.com/industries/metals-and-mining/our-insights/succeeding-in-the-ai-supply-chain-revolution

23. Wang, C., Liu, Y. & Zhou, H. Consumer Consumption Behavioral Model for Business Intelligence Using Artificial Intelligence. J Knowl Econ (2023). https://doi.org/10.1007/s13132-023-01391-w

24. Allgurin, A., & Karlsson, F. (2018). Exploring Machine Learning for Supplier Selection : A case study at Bufab Sweden AB.

25. Mohsen, F., Al-Absi, H.R.H., Yousri, N.A. et al. A scoping review of artificial intelligence-based methods for diabetes risk prediction. npj Digit. Med. 6, 197 (2023). https://doi.org/10.1038/s41746-023-00933-5

26. Javid Ghahremani Nahr & Hamed Nozari & Mohammad Ebrahim Sadeghi, 2021. "Green supply chain based on artificial intelligence of things (AIoT)," International Journal of Innovation in Management, Economics and Social Sciences, International Scientific Network (ISNet), vol. 1(2), pages 56-63.