

Research Article

AI-Driven Optimization of Order Procurement and Inventory Management in Supply Chains

Gökçe Yılmaz^{1*}, Gökhan Kayatürk², Gizem Yeldan²

¹ KOÇTAŞ R&D Center, Orcid ID: <https://orcid.org/0009-0004-6506-5451>, E-mail: kelesgokce@gmail.com

² KOÇTAŞ R&D Center, Orcid ID: <https://orcid.org/0009-0005-8750-0554>, E-mail: gokhan.kayaturk@koctas.com.tr

²KOÇTAŞ R&D Center, Orcid ID: <https://orcid.org/0009-0005-4689-8738>, E-mail: gizem.yeldan@koctas.com.tr

* Correspondence: kelesgokce@gmail.com

Received 05 September 2024

Received in revised form 17 October 2024

In final form 26 October 2024

Reference: Yılmaz, G., Kayatürk, G., & Yeldan, G. (2024). AI-driven optimization of order procurement and inventory management in supply chains. *The European Journal of Research and Development*, 4(4), 46-56

Abstract

This project focuses on the development of an advanced artificial intelligence-based system for optimizing order procurement and inventory management in supply chains. The system utilizes machine learning algorithms to analyze historical sales data, customer behavior, and market trends, enabling it to predict optimal procurement times and quantities for imported products. The primary objective is to reduce excess stock, prevent stockouts, and improve overall inventory turnover. By integrating features such as substitute product tracking, import forecasting, and truckload optimization, the system enhances decision-making processes and ensures efficient supply chain operations. Furthermore, the inclusion of real-time data for demand forecasting aims to improve the accuracy of predictions and adapt to dynamic market conditions. The project also envisions future advancements, including the incorporation of external factors like seasonal variations and promotional campaigns, as well as the automation of supply chain processes. Ultimately, the system aims to provide more accurate, data-driven insights for decision-making, leading to enhanced operational efficiency and a more responsive and resilient supply chain.

Keywords: Artificial Intelligence, Inventory Management, Supply Chain Optimization, Machine Learning, Procurement Forecasting

1. Introduction

The retail industry has changed quickly in recent years due to shifts in customer needs and market conditions. In today's competitive environment, businesses need to adjust swiftly to fulfill customer needs while improving their operational procedures (Shekhawat, 2023). Product procurement is a vital part of retail operations, especially when it comes to imported goods. Managing product supply chains effectively, particularly for imported goods, is crucial for lowering costs and making sure products are available to customers when and where they need them. Yet, accurately predicting demand and matching supply with changing customer preferences can be a major challenge for retailers (Cox, 2001; Wieland, 2021).

The project seeks to tackle this issue by creating an advanced decision support software system that utilizes artificial intelligence (AI). This system will use machine learning algorithms to examine past sales data, customer buying habits, and product demand patterns to accurately predict future demands. The main goal of the project is to improve how inventory is managed and how products are procured, especially for imported items. This will help increase customer satisfaction and lower costs related to stock. The system will use supervised machine learning algorithms to create automated recommendations for product procurement based on insights from data. The algorithms will analyze large datasets that consist of past sales data, customer information, and current market trends, allowing the system to predict the demand for various products. This method will help improve inventory levels while reducing the chances of running out of stock or having too much inventory, both of which can result in extra operational costs. The project includes an important part focused on creating predictive models that will indicate which imported products should be stocked and in what amounts. By analyzing sales trends and changes in demand, the system will help retail companies make better and quicker purchasing decisions, minimizing the chances of running out of products or having too much stock. The addition of the AI-driven procurement system will help manage supplier relationships and improve supply chain visibility, leading to better operational efficiency.

The project aims to create significant effects. In addition to improving inventory management, it will assist businesses in staying competitive by quickly adapting to market changes, lowering costs linked to supply chain issues, and enhancing customer loyalty by ensuring better product availability. The project aims to provide a solution that is scalable and flexible by using various machine learning techniques. This includes

predicting product demand and automating reporting, allowing it to adapt to different market conditions and changing business needs.

The system serves as more than just a tool for better supply chain management. It represents a significant change for the retail industry, providing clear advantages like lower costs, improved customer satisfaction, and a more flexible method for procurement. At the conclusion of the project, the aim is to provide a strong, AI-driven system that can transform how retail businesses handle their purchasing processes and inventory management in response to constantly evolving consumer needs.

2. Literature Survey

The literature review for the project examines how artificial intelligence (AI) techniques can improve order procurement processes in the retail industry (Pournader, Ghaderi, Hassanzadegan, & Fahimnia, 2021). The retail market is becoming more complex and dynamic, leading to a growing interest in AI-based solutions that can enhance decision-making processes. These systems use machine learning algorithms to examine past sales data, customer behavior, and market trends to predict demand more accurately. Recently, AI has been utilized to create realistic talking head avatars, which can improve customer engagement and experience. These avatars enable a more personal interaction with customers by answering questions and suggesting products, which can enhance the AI-driven order procurement system and boost customer satisfaction (Adamashvili, Zhizhilashvili, & Tricase, 2024; Shoushtari, Ghafourian, & Talebi, 2021).

There has been a lot of research on how AI can help predict demand, especially in retail and supply chain management. A number of studies have examined how supervised machine learning algorithms, including regression models, decision trees, and neural networks, can be used to forecast future product demand by analyzing historical data. These methods have been shown to greatly enhance the accuracy of demand forecasts, which helps to minimize stockouts and surplus inventory. The creation of talking head avatars, driven by AI, has demonstrated promise in enhancing communication between consumers and automated systems. These avatars utilize natural language processing and computer vision methods to create engaging, human-like interactions, improving the customer experience in online settings (Harikrishnakumar, Dand, Nannapaneni, & Krishnan, 2019; Rafiei Oskooei, Yahsi, Sungur, & Aktas, 2024; Gustafson-Pearce & Grant, 2017).

Dynamic stock management is an area where AI has significantly influenced operations. Retailers are using AI systems to manage inventory more effectively. These systems automatically change stock levels according to expected demand, which helps lower costs and increase profits (Lingam, 2018). Combining AI with procurement systems helps ensure that the correct products are available when needed and enables retailers to quickly adapt to shifts in consumer behavior (Cui, Li, & Zhang, 2022).

The study of AI applications in logistics and transportation is essential for the success of the project. Improving delivery routes and cargo loading, referred to as "truck optimization," is now a crucial aspect of making supply chains more efficient. AI models that forecast the best loading and transportation methods can assist in lowering costs and enhancing delivery speed. By using AI-powered systems, logistics managers can get real-time updates through interactive systems that present complex logistics data in a simple and clear way. This combination has the potential to change the way logistics teams engage with and oversee their supply chains (Loske & Klumpp, 2021; Chang & Lee, 2018). AI systems have shown great effectiveness in improving supply chain management and customer engagement in the retail industry. The integration of demand forecasting, inventory optimization, logistics enhancements, and advanced AI interfaces shows great potential for future research and development. Using AI-driven technology in these systems could make them more engaging and efficient for retailers, leading to better customer satisfaction and improved operational efficiency.

Ensuring software quality and prioritizing user satisfaction have become critical objectives in the development of systems that aim to enhance operational efficiency and decision-making processes. The literature underscores the systematic evaluation of the human factor in software quality, emphasizing how users influence the software development lifecycle (Güveyi, Aktas, & Kalipsiz, 2020). Furthermore, methodologies such as the detection of code clones are shown to significantly reduce maintenance costs and allow for early error detection (Aktas & Kapdan, 2016). Deep learning-based approaches have also demonstrated their ability to automate test scenario generation and optimize software testing processes, contributing to the robustness of quality assurance frameworks (Oz, Kaya, Olmezogullari, & Aktas, 2021), (Oguz, Oz, Olmezogullari, & Aktas, 2022). Additionally, user-centric methods, such as employing hidden Markov models to learn from user behaviors, have proven effective in tailoring test scenarios to optimize user-centric testing approaches (Erdem, Oguz, Olmezogullari, & Aktas, 2021). These techniques have accelerated testing processes in large-scale projects, thereby enhancing overall software quality. The integration of big data analytics and

recommendation systems further strengthens testing and evaluation frameworks. For instance, recommendation systems facilitate more user-centric solutions during software development by predicting and addressing user needs (Düzen & Aktas, 2016). In domains like e-commerce and e-science, scalable big data testing frameworks have been instrumental in enhancing the precision of recommendation systems, as demonstrated in prior research (Uzun-Per, Can, Gurel, & Aktas, 2022). The current project builds upon this foundation by integrating advanced software testing and user-centric optimization techniques to create an AI-powered solution tailored for supply chain operations. Unlike prior work that primarily focuses on standalone methodologies, this project emphasizes the development of a comprehensive platform that merges classification, fault management, and operational process optimization. Recent studies have utilized machine learning techniques to address various challenges across domains such as image resolution enhancement (Yildiz, 2022a), efficient text classification on imbalanced datasets (Yıldız, 2022b), and abstractive summarization evaluation metrics (Briman & Yıldiz, 2024). Moreover, the application of reinforcement learning has shown promising results in both intrusion detection (Saad & Yıldiz, 2022) and optimizing click-through rates in online advertising (Haider & Yıldiz, 2023). In addition to these advancements, bitmap index encoding optimization for query performance (Yildiz, 2021) and hyperparameter assessment for improving word embedding quality (Yildiz & Tezgider, 2020) have contributed significantly to computational efficiency and accuracy in data processing tasks. In contrast, the AI-driven optimization system for order procurement and inventory management proposed in this study diverges from these works by specifically focusing on the retail supply chain context, integrating predictive modeling with operational features such as substitute product tracking and real-time decision support to enhance inventory turnover and reduce operational costs. The project's AI-driven system is uniquely designed to address the specific challenges of inventory and procurement management in supply chains, ensuring a user-friendly interface and robust software quality for the logistics sector. By doing so, it bridges the gap between theoretical advancements and practical applications, offering a transformative approach to supply chain optimization.

3. Methodology

The methodology for this project, aimed at developing an AI-based order procurement system for a retail company, revolves around advanced machine learning techniques to enhance product supply processes. The methodology incorporates data collection, model

development, system integration, and optimization, all aimed at improving inventory management, minimizing stockouts, and optimizing procurement strategies.

Initially, the project focuses on data collection, ensuring comprehensive and accurate inputs for the predictive models. This involves gathering historical sales data, customer purchasing behaviors, market trends, and product demand patterns. To facilitate this, a robust data preprocessing phase is employed to clean and prepare the data. Steps like anomaly detection, normalization, and handling missing values ensure data reliability and readiness for analysis. These datasets are then split into training and testing sets to allow for effective model training and validation.

The core of the methodology involves the application of supervised machine learning algorithms to forecast demand for products, particularly focusing on imported goods. Techniques like Long Short-Term Memory (LSTM) networks and Gradient Boosting Machines (GBM) are selected for their ability to handle time-series forecasting and their adaptability to retail-specific needs. The LSTM model will be particularly beneficial for predicting demand based on sequential data such as historical sales and market seasonality, while GBM is ideal for capturing non-linear relationships in diverse product categories.

For the model development phase, the algorithms are trained using the prepared datasets, with independent variables such as product codes, categories, prices, sales history, promotions, and customer demographics. The dependent variable is the future sales quantity. The project's goal is to develop a highly accurate model that predicts future demand with minimal error. Key performance metrics like Mean Absolute Percentage Error (MAPE) will be used to evaluate the prediction accuracy. The expected target is to maintain an error rate of less than 10% to ensure reliable predictions.

Once the models are trained and evaluated, the next step involves integrating these predictions into the company's existing procurement and inventory management systems. This is accomplished by developing a series of software modules that automate the procurement process. These modules incorporate features like vendor-specific order optimization and vehicle load capacity constraints, ensuring that the recommended order quantities match the supply chain's logistical capabilities.

In parallel, a user-friendly interface will be developed to facilitate real-time monitoring and reporting. This interface includes customizable filters and KPIs to track inventory levels, order fulfillment rates, and sales performance. Additionally, the system will

support dynamic reporting, enabling users to adjust procurement strategies based on up-to-date market trends and customer demand.

The system also addresses the challenge of product substitution by integrating an algorithm for identifying substitute products. This allows the system to automatically consider alternative products when the primary item is unavailable or when demand fluctuates unexpectedly. The system's flexibility ensures that new and similar products can be incorporated into the model without the need for manual updates, providing a scalable solution for evolving market conditions.

Testing and optimization are critical stages in this methodology. After initial development, the system undergoes rigorous testing to ensure it performs as expected under real-world conditions. This includes testing the algorithm's response to varying data inputs and stress-testing the software's integration with existing IT systems. Performance optimization techniques are applied to enhance processing speed and ensure the system operates efficiently even as data volume grows.

Ultimately, the methodology is designed to deliver an AI-powered procurement system that minimizes stockouts, reduces excess inventory, and optimizes the supply chain for imported goods. By leveraging advanced machine learning models, the project aims to create a dynamic and scalable system that improves decision-making, enhances customer satisfaction, and drives operational efficiency within the retail company.

4. Expected Outputs and Benefits

The project's expected outputs and benefits center around the development of an AI-based order supply decision support system, designed to optimize inventory management and enhance supply chain efficiency for retail companies, specifically focusing on the management of imported goods. This system will leverage machine learning algorithms to predict demand for imported products and automatically generate procurement suggestions based on past sales data, market trends, and customer behavior.

The system's primary benefit will be the optimization of stock levels, reducing excess inventory and minimizing the risks of stockouts, which will significantly lower operational costs. By using predictive analytics, the project will enable more accurate demand forecasts, leading to better inventory turnover and enhanced financial efficiency. This will contribute to a reduction in storage and handling costs, as the company will be able to keep only the necessary stock and avoid over-purchasing.

From the perspective of customer satisfaction, the system will ensure that high-demand products are always available, leading to improved customer experiences and increased customer loyalty. The ability to predict and meet customer needs with precision will differentiate the company from competitors, providing a competitive advantage in a dynamic retail market.

On a broader scale, the project will also contribute to the national economy by creating new job opportunities in the fields of AI, data science, and supply chain management. By enhancing supply chain operations, the project will improve the efficiency of the broader retail sector, benefiting both businesses and consumers. Additionally, the project's success could serve as a model for other industries seeking to implement AI in their operations, enhancing the country's technological capabilities in AI-driven supply chain management.

Thus, the project promises substantial financial, operational, and societal benefits, positioning the company for improved profitability, customer satisfaction, and sustainable growth.

5. Results and Future Work

This project will result in the creation of an artificial intelligence-based order procurement system that enhances inventory management and boosts supply chain efficiency. The system will use machine learning algorithms to examine previous sales data, customer behavior, and market trends to forecast which imported products should be purchased and the optimal timing for procurement. This ability to predict will help lower excess inventory and avoid stock shortages, which will enhance inventory turnover and cut operational expenses. Incorporating features such as tracking substitute products, forecasting imports, optimizing truckloads, and reporting on user interfaces will improve decision-making and further streamline the supply chain.

For future work, we will focus on enhancing the accuracy of demand forecasting models. The system will be improved using real-time data to enhance predictions and adjust to changes in the market. Furthermore, the system will be expanded to manage more complex situations, including the integration of external factors such as seasonal changes or promotional activities. As technology develops, there will be an emphasis on automating various parts of the supply chain and incorporating advanced analytics to offer better insights for strategic decision-making. This will ultimately result in improved operational efficiency and a more adaptable supply chain system.

Acknowledgment: We extend our gratitude to the KOÇTAŞ R&D Center for providing the computational platform and working environment that facilitated the activities carried out within the scope of this research.

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