

ARTIFICIAL INTELLIGENCE IN INDUSTRIAL PROCESSES: OPPORTUNITIES, LIMITATIONS, AND ETHICAL DILEMMAS – A CASE STUDY FROM THE KUJAWSKO-POMORSKIE PROVINCE

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Purpose: The purpose of this article is to analyze the use of artificial intelligence in the packaging ordering process at a confectionery company located in the Kujawsko-Pomorskie Province. The article reflects on the ethical and organizational aspects of implementing intelligent decision support systems in a production environment.

Design/methodology/approach: The article is based on a case study approach, including an analysis of a manufacturing company operating in the food industry. The following methods were used: process analysis, participant observation, interviews with management and procurement staff, analysis of data on order cycles, inventory levels, and delivery timeliness prior to AI implementation.

Findings: The implementation of AI-based solutions in the packaging ordering process brought a number of benefits:

- reduction of order fulfillment time by approx. 18%,
- reduction of packaging inventory by 22%,
- reduction in the number of incorrect deliveries and excess orders,
- improvement in the accuracy of demand forecasts during peak production seasons.

At the same time, barriers and risks were identified, such as: insufficient integration of IT systems, lack of digital skills among employees, and the need to ensure oversight of algorithmic decisions.

Research limitations/implications: The study covers one company and one area of the industrial process (ordering packaging), which limits the possibility of fully generalizing the results.

Practical implications: The article points to practical possibilities for applying AI in the procurement processes of industrial companies. The results can serve as a reference point for production and logistics managers.

Social implications: The implementation of AI requires the development of employees' digital skills, building trust in technology, and taking into account the ethical aspects of decision automation.

Originality/value The article is an example of a rarely analyzed application of artificial intelligence—in the process of ordering packaging in the food industry. It combines technological analysis with ethical and organizational reflection, highlighting the interdisciplinary nature of AI implementations in industry.

Keywords: artificial intelligence, industrial processes, packaging ordering.

Category of the paper: Case studies.

1. Introduction

Contemporary industry is on the verge of a transformation known as Industry 5.0, in which artificial intelligence (AI) plays a key role. Unlike the earlier Industry 4.0 paradigm, which focused on automation and the integration of cyber-physical systems, the new concept emphasizes human-technology collaboration, sustainable development, and corporate social responsibility (Dacko-Pikiewicz, Szczepańska-Woszczyzna, Lis, 2023). AI is thus becoming not only a tool for increasing the efficiency of industrial processes, but also a catalyst for organizational, competency, and ethical change.

As Barbara Siuta-Tokarska (Siuta-Tokarska, 2021) points out, the implementation of artificial intelligence in industry is, on the one hand, a huge opportunity to improve the competitiveness of the economy, but on the other hand, it raises a number of social and economic challenges. Automated decision support systems, process robotization, and predictive data analysis models allow for the optimization of supply chains, shortening of production cycles, and reduction of human error. At the same time, questions arise about the limits of machine autonomy, responsibility for decisions made by algorithms, and the security of sensitive data.

The AI Business (Artificial Intelligence, 2025) report shows that the number of AI implementations in the manufacturing, logistics, and construction sectors will grow rapidly in the coming years. These solutions will include demand forecasting, supply planning, quality management, and maintenance. However, the effectiveness of these technologies depends not only on the sophistication of the algorithms, but also on the organizational and cultural readiness of companies.

Piotr Kosiak (Kosiak, 2023), on the other hand, emphasizes that the ethical use of AI requires the creation of transparent rules for the supervision of learning systems and a balance between automation and human control. In the context of industry, this means that mechanisms for auditing algorithmic decisions must be developed and their compliance with the principles of responsible management must be ensured.

The PARP report (Report, 2024) and Andrzej Gontarz's analysis (Gontarz, 2023) show that Polish companies are increasingly using AI in the areas of procurement and logistics.

This article presents a case study of a company from the Kujawsko-Pomorskie Province, operating in the food industry, which has implemented elements of artificial intelligence in its packaging ordering process. The aim of the study is to identify the opportunities, limitations, and ethical dilemmas associated with the implementation of AI in an industrial environment and to assess the impact of this technology on the efficiency and sustainable development of the organization. Automating the packaging ordering process reduces the risk of excess inventory, optimizes costs, and increases flexibility in responding to changing market needs.

2. Theoretical foundations of artificial intelligence applications in industrial processes

Artificial intelligence (AI) is currently one of the key catalysts of industrial transformation, revolutionizing the way production is organized, resources are managed, and operational decisions are made. The literature on the subject indicates that AI technologies—including machine learning, predictive systems, big data analysis, intelligent sensors, and generative language models—enable significant improvements across the entire value chain of a company, affecting the efficiency, quality, and flexibility of manufacturing processes (Brynjolfsson, McAfee, 2014; Baryannis et al., 2019). Their role is particularly important in the context of contemporary challenges, such as the complexity of global supply chains, market instability, pressure to reduce costs, and the need to maintain high quality and continuity of production, which is also crucial for the food and confectionery industry.

The classic approach to Industry 4.0 focused on automation, digitization, and the integration of cyber-physical systems (CPS) (Nawrat, 2020). Artificial intelligence was treated as a technology supporting automation and process prediction. In the Industry 5.0 approach (Dacko-Pikiewicz, Szczepańska-Woszczyzna, Lis, 2025), the emphasis shifts towards human-centeredness, sustainability, and corporate social responsibility.

AI acts as a tool that works with employees, not replacing them, but increasing their decision-making and operational capabilities. Technological transformation cannot be analyzed solely in technological terms—it also represents a cultural and organizational change, which is particularly important in the food industry, where precision, repeatability, and quality control are central elements of the production process, and at the same time, many activities still require manual verification.

In international literature, artificial intelligence is defined as the ability of computer systems to perform tasks that previously required human intelligence, such as pattern recognition, learning, decision-making, and predicting future states of processes (Russell, Norvig, 2021). In industrial practice, AI is used in four key areas:

- Production process optimization (Hao et al., 2020): using predictive algorithms to predict failures, schedule production, and minimize downtime.
- Supply chain management (Baryannis et al., 2019): AI supports demand forecasting, purchasing planning, intelligent inventory management, and transportation optimization.
- Quality control and image analysis (Lee et al., 2018): algorithms using machine vision enable automatic defect detection.
- Decision support systems (DSS): Generative and predictive tools analyze large volumes of data, streamlining decision-making processes, e.g., ordering packaging in the confectionery industry.

Scientific literature consistently emphasizes that despite its enormous technological potential, the implementation of AI faces numerous technical, organizational, and social barriers (Walicka, Czemieli-Grzybowska, 2023). The most frequently cited limitations include low input data quality resulting from a lack of integration between ERP, MES, and warehouse systems (Hazen et al., 2021). Equally problematic is employee resistance to decision automation, resulting from fears of dehumanization of work or loss of control over the process (Sielska, Olszowy, 2024). Insufficient digital skills are a serious barrier to implementation, especially in traditional industries such as the confectionery industry, where many processes still rely on the tacit knowledge of operators (Walicka, Czemieli-Grzybowska, 2023). Ethical challenges, such as responsibility for algorithmic decisions, model transparency, and data security, are another challenge considered when introducing AI.

AI technologies can increase process stability, reduce variability, and improve production repeatability—which is particularly important in industries with highly standardized requirements (Klinkosz, 2023). In practical terms, this means that predictive systems facilitate quality monitoring and non-compliance identification, intelligent demand forecasting models support packaging demand planning, and AI can reduce human error through automated data analysis.

3. Research methodology

The study was conducted in the form of a case study, which enabled the analysis of the application of artificial intelligence in the real operating conditions of a confectionery company in the Kujawsko-Pomorskie Province. Triangulation of research methods was used, including analysis of logistics and production processes, participant observation, semi-structured interviews with management and procurement and packaging employees, as well as analysis of operational data on order fulfillment times, inventory levels, and delivery timeliness before and after AI implementation.

The analysis of the research material was comparative in nature and focused on assessing the effectiveness of the packaging ordering process and identifying the benefits, limitations, and implementation barriers. The methodology adopted allowed for the consideration of both technological and organizational and social aspects related to the implementation of artificial intelligence in an industrial environment.

4. Implementation of AI solutions in the packaging ordering process at company X

Company X, operating in the food industry, was founded in the 18th century in one of the cities of the Kuyavian-Pomeranian Province. It is a leader on the domestic and foreign markets, thanks primarily to its strong, multi-generational brand. The company's logo has remained unchanged since its inception, making its products easily recognizable to a wide range of customers. The products have become a symbol of the region, shaping its history.

The company employs about 500 people, which is a significant number for traditional machines. It stands out on the Polish market thanks to its exclusively domestic capital. The company participates in exports, expanding its reach every year. Export products are sold on a smaller scale, but the company is intensively entering new retail chains, organizing extensive promotional campaigns. The plant sets ambitious goals for its employees related to brand development and building a year-round product range.

In the context of such a complex and multi-element production environment as that of Company X, the role of the packaging cooperater, responsible for maintaining the fluidity of processes and eliminating errors that could disrupt the rhythm of the plant's operations, takes on particular importance. The scope of their responsibilities - including quality control, production data management, and cooperation with the inventory department and packers - reflects the high operational dynamics characteristic of the confectionery industry, where speed of response and precision are key determinants of economic efficiency. It is in this area that the first signs of the implementation of artificial intelligence tools capable of improving the flow of information, supporting decision-making processes, and reducing the risk of human error are becoming apparent. Understanding the specifics of a cooperater's work is therefore an essential context for analyzing the functioning of Company X- a company with a centuries-old history, a strong market position, and constantly growing requirements for quality and production reliability resulting from domestic and foreign expansion.

The packaging cooperater plays a key role in the production area of company X, supporting both quality control and the efficient flow of information between production, warehouse, and purchasing departments. Their primary tasks include monitoring product quality, quickly detecting production errors, and providing packers with the appropriate tools, such as the correct labels, individual packaging, and bulk packaging. The cooperater is also responsible for verifying the correctness of expiration dates and batch numbers, which is particularly important in conditions of frequent changeovers and machine malfunctions.

The cooperators' cooperation with the inventory department includes ongoing inventory control and reporting critical packaging stock levels, which enables quick purchasing decisions. In addition, the employee checks the conformity of packaging deliveries in terms of quantity and quality. The effectiveness of their actions directly affects the economic efficiency of the plant, minimizing the risk of downtime and production losses.

Due to the dispersion of information, the manual nature of many activities, and the high number of potential human errors, the area of packaging cooperator work is an important starting point for the implementation of artificial intelligence-based solutions. Automating data analysis, decision support, and streamlining the packaging ordering process can significantly increase work efficiency and reduce operational risks throughout the entire production and logistics area.

The packaging ordering process at Company X was initially largely manual and relied on the work of a packaging cooperator who, based on the production plan, prepared the demand for packaging materials for subsequent shifts. The need for frequent replenishment of stocks resulted from limited storage space in the production area and high volatility of short-term plans, taking into account machine breakdowns, downtime, and variable staffing.

The process involved a wide range of packaging and auxiliary materials, and manual calculations based on consumption standards were time-consuming and prone to errors, which in extreme cases led to downtime of packaging machines and economic losses.

In response to these limitations, a Microsoft Excel spreadsheet tool was implemented to standardize the process, reduce order preparation time, and minimize errors. The spreadsheet, based on built-in formulas, enabled automatic calculation of demand based on the production plan, material standards, and current inventory levels imported from the SAP system. This solution was positively evaluated by users and became a stable basis for further automation, even though it still required manual data entry.

The next stage was to expand the existing solution with an artificial intelligence module that acts as a decision support system. In line with the Industry 5.0 concept, AI does not replace the packaging cooperator, but supports them by analyzing data faster, identifying risks, and generating order recommendations. The AI module automates demand analysis, compares it with current inventory levels, and reduces errors resulting from manual calculations. The procedure involves feeding data from Excel and SAP, calculating demand, AI analysis and recommendation, and final verification and approval of the order by a human. This approach ensures process consistency, error reduction, and human oversight of algorithmic decisions, which is important both organizationally and ethically in an industrial environment.

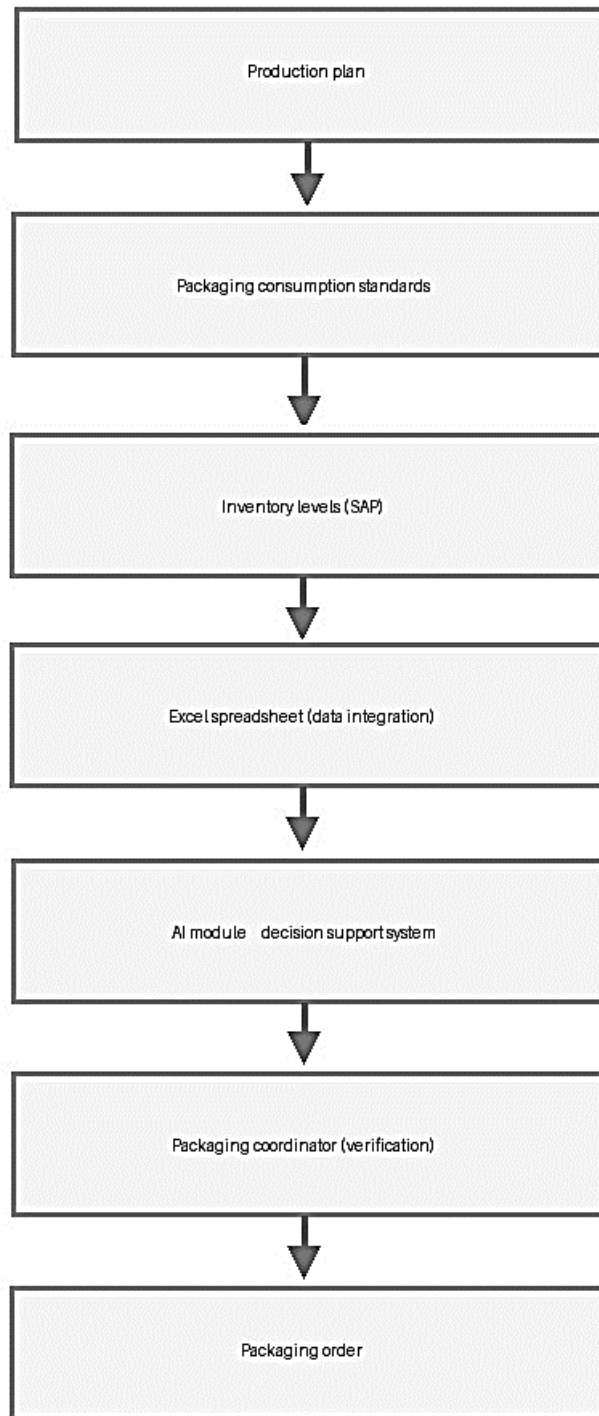


Figure 1. Diagram of the artificial intelligence module of company X.

Source: Own work.

Figure 1 shows a simplified diagram of how the artificial intelligence module works in the packaging ordering process at Company X, a confectionery manufacturer. The input data for the system comes from the production plan, packaging consumption standards, and current inventory levels obtained from the SAP system and integrated into an Excel spreadsheet. The AI module acts as a decision support system, analyzing demand, identifying the risk of stock shortages, and generating order quantity recommendations. A key element of the process

remains the packaging cooperater, who verifies the algorithm's suggestions and makes the final purchasing decision, ensuring that the principle of human supervision over algorithmic decisions is maintained and that the solution is consistent with the idea of Industry 5.0.

5. Summary

The case study showed that the implementation of AI-based solutions in the packaging ordering process at Company X brought measurable organizational and economic benefits. The most significant effects included a reduction in order fulfillment time by approximately 18% and a reduction in packaging inventory by 22%, which directly translated into improved inventory management efficiency. In addition, there was a marked reduction in the number of incorrect deliveries and excess orders, resulting from the automation of analyses and standardization of the decision-making process. AI support also contributed to improving the accuracy of demand forecasts during periods of increased production, which was crucial for ensuring the continuity of packaging processes and operational stability in the confectionery industry.

At the same time, the analysis of company X indicates that technical and competence barriers are a significant limitation to the effective use of artificial intelligence in industrial processes in the confectionery industry. The lack of full integration of IT systems (ERP, warehouse modules, and analytical tools) and the need to manually update key data limit the potential for automation and increase the risk of operational errors, undermining the reliability of AI-generated recommendations. As Hazen (Hazen et al., 2021) points out, outdated input data can lead to significant deviations between planned and actual packaging material consumption, which in an industry with short order fulfillment cycles can result in serious operational disruptions. At the same time, insufficient digital and analytical skills among some employees, as well as an initial lack of trust in algorithmic decisions, slow down the process of technology adaptation and require intensive training and organizational efforts. At company X, this problem manifested itself, among other things, in the need to train packaging operators, warehouse workers, and production managers in interpreting the results generated by the AI module. In the initial phase of implementation, a low level of trust in algorithmic recommendations was also observed. This is confirmed by numerous analyses describing employee resistance to the automation of decision-making processes (cf. Wuest et al., 2020). These results confirm the conclusions of the literature, according to which the effectiveness of AI implementations depends not only on technological maturity, but also on the competence readiness of the organization and the ability to build a data-driven work culture, especially in traditional sectors such as the confectionery industry.

Although the analysis concerns a company in the food industry, the conclusions may also apply to other industrial sectors, such as the automotive, pharmaceutical, and e-commerce industries, where accurate demand forecasting and inventory management play a key role. In sectors with higher automation, the level of system integration tends to be greater, which can accelerate the adoption of AI, but issues of trust in algorithmic decisions and ethical oversight remain universal and cross-sectoral.

Future research should consider quantitative indicators of employee trust in AI systems, measured before and after implementation, e.g., using verified technology acceptance scales (e.g., TAM model extensions). This would allow for a more in-depth analysis of the social implications and a better understanding of the relationship between the level of trust and the effectiveness of algorithmic solutions.

The implementation of AI in a production environment also raises ethical and organizational dilemmas, primarily related to responsibility for algorithmic decisions. In the case analyzed, it was crucial to maintain the principle of human oversight of decisions generated by the AI system, which reduces the risk of errors and strengthens employee trust in the technology. Ensuring the security of production data and the transparency of algorithms also remains a significant challenge.

Based on the research conducted, it can be concluded that artificial intelligence is an effective tool supporting procurement processes in industrial enterprises, provided that it is implemented in a gradual and human-centered manner. Further integration of IT systems, systematic development of employees' digital skills, and formalization of rules for supervising algorithmic decisions are recommended. This approach not only increases operational efficiency but also ensures that AI implementations are consistent with the idea of Industry 5.0 and the principles of responsible and ethical management.

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