Integration of Artificial Intelligence in Production Planning: A Systematic Literature Review in Operations Management

Mezhuyev Vitaliy[1], Muaz Barucic[1], Ibraim Didmanidze[2]

[1]FH Joanneum University of Applied Sciences, Kapfenberg, Austria

[2] Batumi Shota Rustaveli State University, Batumi, Georgia

vitaliy.mezhuyev@fh-joanneum.at, ibraim.didmanidze@bsu.edu.ge

Abstract

This study investigates the integration of artificial intelligence (AI) into production planning within operations management, highlighting its growing importance in modern industrial environments. Traditional systems such as ERP and MES increasingly struggle to meet the flexibility, responsiveness, and data-driven requirements of Industry 4.0 and emerging Industry 5.0 systems. To address this gap, a systematic literature review (SLR) was conducted to identify current AI applications, assess their benefits and challenges, and evaluate their impact on organizational performance. Results reveal that machine learning (ML) and deep learning (DL) are the most widely applied AI techniques in production planning, supporting tasks such as demand forecasting, scheduling, real-time monitoring, and resource optimization. These technologies enable more accurate decision-making, improved responsiveness, and greater efficiency in planning processes. Furthermore, AI supports autonomous systems and enhances the resilience and adaptability of production environments. However, effective implementation remains dependent on high-quality data, appropriate algorithm selection, and organizational readiness. Key challenges include data preparation, integration with existing systems, model transparency, and workforce skills. Additionally, the findings emphasize the need for cross-functional collaboration and employee upskilling to achieve successful AI adoption. Overall, AI provides substantial potential to enhance production planning performance, increase productivity, and strengthen competitiveness. At the same time, companies must address technical, organizational, and human-related factors to fully leverage AI-driven planning systems.

1.Introduction.

Artificial intelligence (AI) has evolved from rule-based symbolic systems to data-driven models capable of learning and autonomous decision-making. Modern AI draws on machine learning (ML), deep learning (DL), neural networks, and natural language processing to interpret data, recognize patterns, and optimize decisions, making it increasingly relevant across industrial domains.

In manufacturing, the shift toward Industry 4.0 and the emerging principles of Industry 5.0 have accelerated the need for intelligent and adaptive planning systems. Traditional planning tools such as ERP, MES, and APS, while foundational, often lack the flexibility and real-time responsiveness required to manage complex, interconnected, and dynamic production environments. Competitive pressures demand higher product quality, reliable delivery performance, shorter lead times, and efficient resource utilization. AI-enhanced planning systems offer the potential to meet these requirements by leveraging real-time data, predictive analytics, and autonomous decision support.

This research addresses the integration of AI into production planning and investigates three key questions:

1. Which AI models are currently applied in production planning within operations management?
2. What advantages and disadvantages are associated with AI-based planning?
3. How does AI influence the operational and organizational environment?

To answer these questions, a systematic literature review (SLR) was conducted to identify and evaluate peer-reviewed studies published between 2020 and 2024. The review synthesizes current developments, application areas, limitations, and future challenges in AI-driven production planning.

The findings aim to provide a structured overview of state-of-the-art AI applications in production planning and offer guidance for practitioners and researchers on how AI can strengthen planning performance, competitiveness, and industrial transformation.

The remainder of this paper is structured as follows: Section 2 presents the main body, including background on production planning and AI, the SLR methodology, and key findings on AI models, advantages, and challenges. Section 3 discusses the implications of these findings, addressing integration trade-offs, human factors, and strategic extensions. Finally, Section 4 concludes with a summary of insights, recommendations for implementation, and suggestions for future research.

2. Main Part.

2.1. Background: Production Planning and AI

Production planning and control (PPC) ensures efficient order execution by coordinating tasks, resources, and scheduling. Traditional systems such as ERP, MES, and APS support planning tasks but often lack flexibility in highly dynamic environments driven by Industry 4.0 requirements, including real-time data integration and autonomous decision support. As manufacturing systems evolve into cyber-physical socio-systems (CPSS), AI provides computational capabilities to analyse large data streams, identify complex production patterns, and support autonomous, adaptive decision-making.

2.2. Systematic Literature Review Methodology

A systematic literature review (SLR) approach was adopted to ensure transparency, reproducibility, and conceptual rigor. Peer-reviewed sources published from 2020–2024 in ScienceDirect, SpringerLink, and Emerald Insight were screened. Inclusion criteria included English language, full-text availability, and relevance to AI in production planning. Out of 1,030 initial publications, 28 articles met all criteria following multi-stage screening and PRISMA-based documentation.

2.3. Key Findings

Benefits of AI-Driven Planning

AI improves production planning by enabling:

- Real-time monitoring and rapid response
- Enhanced resource utilization
- Improved reliability and planning precision
- Predictive and prescriptive decision support
- Dynamic scheduling, automated process control, and performance optimization emerged as high-value use cases.

Challenges and Limitations

- Barriers to adoption include:
- High data quality requirements

- Integration complexity with legacy systems
- Need for specialized skills and employee acceptance
- Model transparency and interpretability concerns
- Companies must strengthen workforce competence and foster trust in AI-enabled decision systems.

3. Discussion.

The systematic review indicates that artificial intelligence has significant potential to transform production planning, yet its adoption remains uneven across industries. While AI-driven models-particularly ML-demonstrate superior forecasting accuracy, adaptive scheduling, and real-time response capabilities, practical implementation is influenced by several organizational and technological constraints.

A central insight is the trade-off between AI's advanced predictive capability and the complexity of integrating these systems into existing planning environments. Traditional ERP, MES, and APS systems continue to serve as core planning tools, but they often lack the flexibility and real-time data processing required for Industry 4.0 environments. AI systems, when combined with these platforms, can enhance responsiveness and autonomy; however, this requires seamless data pipelines and robust data governance frameworks to ensure data quality and availability.

Human factors also play a critical role. AI does not act as a replacement for planners but instead augments decision-making by automating calculation-intensive tasks and supporting strategic decisions. The literature highlights the importance of employee acceptance and upskilling to fully leverage AI capabilities and avoid resistance, skill gaps, or misaligned expectations among planning personnel.
Furthermore, while deep learning offers strong performance in complex tasks such as visual inspection and anomaly detection, its interpretability and data requirements remain barriers compared with more transparent machine learning approaches. Organizations must therefore balance advanced model power with explainability and operational reliability.

Finally, the review suggests that AI's value extends beyond efficiency gains. It supports strategic goals such as resilience, adaptability, and sustainability by enabling data-driven resource use, predictive planning, and proactive quality management. However, these advantages will only fully materialize when companies address technical limitations, governance needs, and human-centred implementation strategies.

4. Conclusiones.

This study demonstrates that artificial intelligence is becoming a decisive enabler for modern production planning. Traditional planning systems, while still foundational, lack the flexibility and autonomy required in increasingly dynamic industrial environments. The systematic literature review confirms that AI - particularly machine learning - enhances decision-making by providing advanced forecasting, adaptive scheduling, resource optimization, and real-time process adjustment capabilities.

Machine learning emerged as the most widely applied method due to its ability to extract insights from production data and continuously improve planning performance. Deep learning, although less frequently applied, shows strong potential in specialized domains such as visual inspection, quality control, and anomaly detection. Together, these technologies form the backbone of intelligent production planning aligned with Industry 4.0 and emerging Industry 5.0 paradigms.

Despite these advantages, the review highlights critical challenges. Successful AI deployment depends on data quality, compatible system infrastructure, and appropriate algorithm selection. Equally important are organizational factors - employee acceptance, training, and new forms of collaboration between humans and intelligent systems. Without addressing these prerequisites, companies risk underutilizing or misapplying AI tools.

Overall, AI-driven planning provides substantial opportunities: improving responsiveness, production accuracy, efficiency, and strategic resilience. To fully realize these benefits, industrial organizations must invest not only in technologies, but also in data governance, workforce competencies, and adaptive planning frameworks. When supported by these foundations, AI will serve as a key driver for competitive advantage and sustainable technological development in operations management.

References:

1. Usuga Cadavid, J. P., Lamouri, S., Grabot, B., Pellerin, R., & Fortin, A. (2020). Machine learning applied in production planning and control: A state-of-the-art in the era of industry 4.0. Journal of Intelligent Manufacturing, 31(6), 1531–1558. https://doi.org/10.1007/s10845-019-01531-7
2. Elbasheer, M., Longo, F., Nicoletti, L., Padovano, A., Solina, V., & Vetrano, M. (2022). Applications of ML/AI for Decision-Intensive Tasks in Production Planning and Control. Procedia Computer Science, 200, 1903–1912. https://doi.org/10.1016/j.procs.2022.01.391
3. Büttner, K., Antons, O., & Arlinghaus, J. (2023). Exploring Implementation Barriers of Machine Learning in Production Planning and Control. Procedia CIRP, 120, 1546–1551. https://doi.org/10.1016/j.procir.2023.09.211
4. Dhamija, P., & Bag, S. (2020). Role of artificial intelligence in operations environment: A review and bibliometric analysis. The TQM Journal, 32(4), 869–896. https://doi.org/10.1108/TQM-10-2019-0243
5. Kriouich, M., & Sarir, H. (2024). Artificial Intelligence Application in Production Scheduling Problem Systematic Literature Review: Bibliometric Analysis, Research Trend, and Knowledge Taxonomy. Operations Research Forum, 5(2), 29. https://doi.org/10.1007/s43069-024-00312-0