Leveraging Artificial Intelligence for Optimization in Computer Supply Chain Management

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Abstract. As information technology continues to advance and evolve, the landscape of global competition has become increasingly fierce. Numerous organizations anticipate a significant transformation in the realm of operations and supply chain management (SCM), encompassing aspects such as planning, scheduling, optimization, and transportation, all under the influence of artificial intelligence (AI). There is a growing interest in leveraging machine learning, AI, and other smart technologies within SCM frameworks. Against this backdrop, the present study offers a comprehensive examination of AI and SCM concepts. It delves into a timely and critical evaluation of AI-powered supply chain research and practical implementations. Through this exploratory investigation, the study scrutinizes the emerging AI-centric business models of various case studies. It assesses their pertinent AI solutions and the consequent value these bring to the organizations. Consequently, this research highlights multiple domains where AI application can generate value within the supply chain. Furthermore, it suggests a methodology for crafting business models tailored to AI applications in supply chain settings.

Keywords: Information Technology (IT), Global Competition, Operations and Supply Chain Management (SCM), Planning, Scheduling.

1 Introduction

The concept of the supply chain, integral to commerce and production, connects suppliers, manufacturers, distributors, and consumers. Historically, supply chain management (SCM) aimed to meet customer demands and enhance stakeholder networks. Recently, supply chains have become more distributed, diversified, and transparent due to changes in business structures and tasks. A major challenge is the lack of visibility and information flow within companies. SCM now focuses on digitizing processes, integrating stakeholders, and aligning products with customer needs to gain competitive advantages [1].

K. Zhang et al. (eds.), *Proceedings of the 2024 3rd International Conference on Economics, Smart Finance and Contemporary Trade (ESFCT 2024)*, Advances in Economics, Business and Management Research 305,
https://doi.org/10.2991/978-94-6463-548-5_12

Traditional IT systems like ERP, MES, PPC, and SCADA have supported logistics and SCM, but operational control remains fragmented and lacks adaptive intelligence. This requires more advanced IT solutions for digital industrial operations.

AI technologies have significant potential to transform industries. AI, capable of learning and decision-making like humans, is advancing through deep learning and optimization techniques. AI aims to create agents that optimize specific objectives, including machine vision, natural language processing, and learning systems [2].

The Association for the Advancement of Artificial Intelligence (AAAI) defines AI as understanding thought and intelligent behavior in machines, highlighting its adaptability (Figure 1). AI offers new functionalities for operations and logistics systems, such as adaptive learning, situation-aware systems, autonomous decision-making, and processing diverse data types [3].

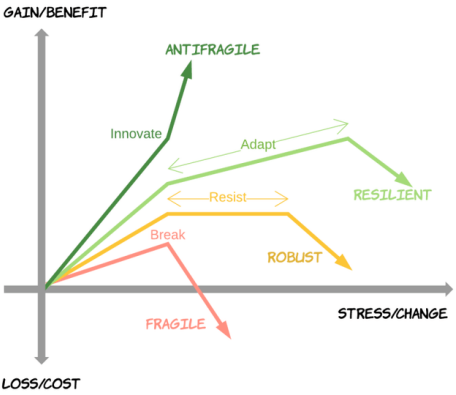

Fig. 1. Artificial Intelligence Antifragile concept.

AI's integration into SCM and operations management has been evolving since the 1960s, significantly impacting SCM. The motivation for incorporating AI into SCM stems from its potential to enhance supply chain visibility, improve product/service quality, and customer satisfaction. Major technology firms like Amazon, Walmart, and eBay have pioneered AI applications in SCM. However, comprehensive studies on AI's role in SCM are limited. This paper aims to explore AI's applications in operations and supply chain management and their business impacts. It examines AI's integration into SCM, showcasing how various AI techniques can streamline operations, optimize processes, and enhance decision-making visibility. Through the analysis of four leading companies, this study provides insights into leveraging AI in supply chains, contributing to a deeper understanding of AI's evolving role in SCM [4].

2 Methodology

To demonstrate the potential of AI in enhancing supply chain management (SCM) performance, this study embarks on an exploratory research journey. The significance of

exploratory case studies grounded in literature review is underscored by scholars such as Childe (2011) and Choi, Cheng, and Zhao (2016), who advocate for its importance within the research community. Case study methodologies are particularly prevalent in supply chain research, offering rich insights into the field (Skender and Zaninović 2020; Ramanathan et al. 2017). Embracing the exploratory nature of this research, a qualitative approach through multiple case studies is selected for its suitability in capturing the complexities of SCM (Yin 2003).

2.1 Research Design

This study follows a structured exploratory research process, as depicted in Figure 2. The initial phase necessitates a thorough literature review to establish a solid foundation of AI and SCM concepts, guided by established literature review protocols.

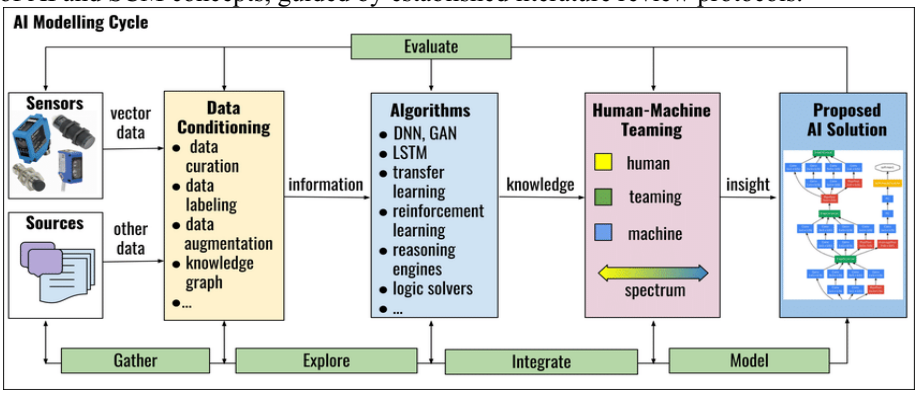

Fig. 2. Process for developing and deploying AI models.

2.2 Data Collection and Analysis

Data from the case companies were gathered using a semi-structured interview process with open-ended questions. Four case studies were chosen to assess the impact of AI in operations and SCM. An IT consulting firm, aiding companies in transitioning to AI, provided access to the case study data. Each case company represented a different sector of the process and utilized distinct implementation technologies.

3 Results and Discussion

To elucidate the integration of Artificial Intelligence (AI) in Supply Chain Management (SCM) and its impact on enhancing overall SCM performance, this study undertook exploratory research across various case scenarios. Each case focused on examining the goals behind AI adoption, the technologies employed, the anticipated and actual effects on key performance indicators, and the individuals involved, particularly those working closely with the company's project manager responsible for the initiative.

3.1 Case 1: Enhancing Sales Processes

The first case study delves into an industrial entity specializing in custom-sized distribution transformers. The sales process involves intricate interactions with customers to ensure specifications align with production capabilities before issuing a quotation. This process, known as sales configuration or CPQ (Configure, Price, Quote), aims to streamline communication between the customer-facing and engineering/production teams. Initially, rule-based systems were employed for this purpose, evolving to incorporate technologies like constraint satisfaction engines for resolving rule conflicts and interfacing with ERP and Production Planning systems. This enables sales staff and informed customers to access the most current product information via a web interface. AI's role in this context was to expedite the quotation process, enhance document quality, and reduce manual intervention, with the sales configurator system continually refined throughout the product lifecycle [5].

3.2 Case 2: Optimizing Production Planning

The second case involves a company manufacturing sheet metal processing equipment. The complexity of production planning at customer sites necessitated AI investment to provide automated decision support for production planners. A cloud-based AI system, utilizing genetic algorithm-based optimization, suggests alterations to production schedules and material/tool changes in response to system or order list modifications. The primary goals were to maximize machinery utilization, adopt a more systematic and adaptable production planning approach, and differentiate control domains from physical assets [6].

3.3 Case 3: Advancing Quality Control

The third case study focuses on a food production plant where quality control, traditionally reliant on visual inspections, is critical (Figure 3). AI-powered camera stream analysis on the production line facilitates defect detection and packaging error analysis, employing deep neural networks (DNN) for rapid training on new product features. The objectives here were to transition to 100% inspection without increasing staff, establish a systematic QA learning loop, and minimize waste [7].

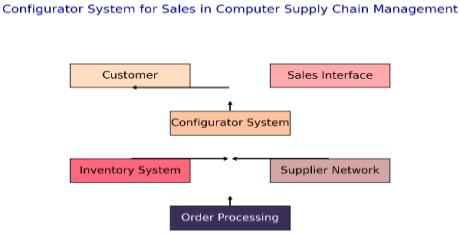

Fig. 3. Configurator system for sales.

3.4 Case 4: Streamlining Spare Parts and Maintenance

The fourth case examines a construction machinery manufacturer, where IoT technology has been leveraged to transition from calendar-based to condition-based maintenance (Figure 4). IoT devices monitor machine usage, identifying early wear or potential breakdowns, with AI analyzing these data to predict failure modes and automatically schedule maintenance services. The goals were to enhance asset lifecycle, adopt condition-based maintenance, and reduce operational and lifecycle costs [8].

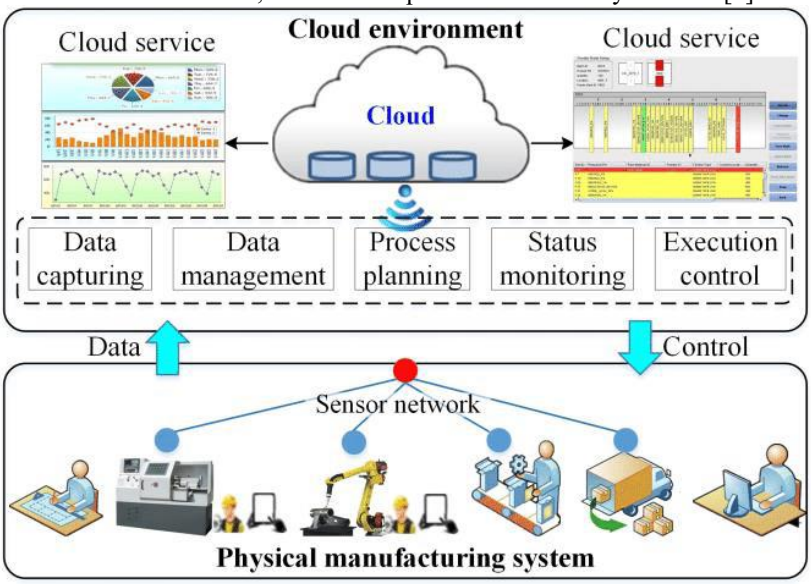

Fig. 4. Centralised cloud-based AI servers in several factories to deliver better production plans as a service.

3.5 Analysis

Across these cases, AI's implementation impacted various organizational aspects, from sales and production planning to quality control and spare parts management. While AI technologies assumed some tasks, they primarily served to assist human operators in repetitive functions, enhancing process efficiency without fully replacing human intervention.

Discussion:

This research, combining a systematic literature review with exploratory case studies, highlights AI's potential to streamline SCM processes, making supply chains more efficient and less wasteful (Figure 5). The study reveals common objectives across cases, such as reducing decision-making time, minimizing manual labor in repetitive tasks, and improving resource utilization rates. Despite the promising outcomes, this research acknowledges its limitations, including a qualitative approach that may not comprehensively cover all sectors or specific implementation patterns, suggesting the need for further investigation [9-10].

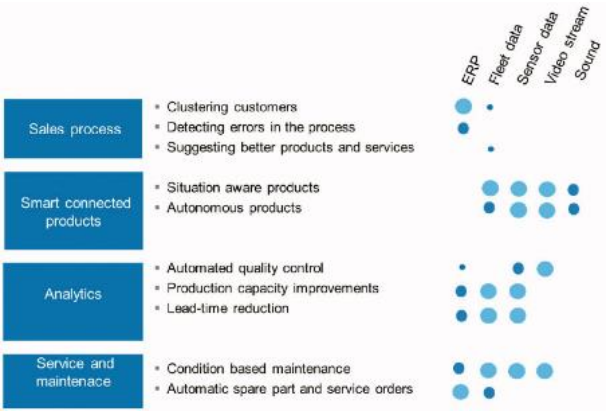

Fig. 5. Matching business processes, potential use cases and data sources connected for AI implementations.

4 Conclusions

The supply chain is essential for connecting various stakeholders—suppliers, manufacturers, retailers, and consumers—efficiently and cost-effectively. Key to its success is the integration of digital technologies like IoT and real-time data analytics. Our study focuses on the significant role of Artificial Intelligence (AI) in enhancing supply chain operations, particularly in manufacturing.

We investigate how AI can revolutionize supply chain management by making it more autonomous, characterized by self-awareness and self-optimization. This research not only reviews recent literature but also analyzes four real-world cases across different SCM aspects: customer, production, quality, and service management. The findings offer insights into AI's practical applications in dynamic supply chain environments, contributing to both academic theory and managerial practice.

This study serves as a foundation for understanding AI's growing impact on supply chain performance and suggests directions for future research, such as the critical factors for successful AI implementation in SCM. Despite AI's vast potential, its full value in SCM is yet to be fully realized.

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