


Chapter 13

Unleashing the Potential of Artificial Intelligence for Dynamic Supply Chain Optimization and Sustainability

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ABSTRACT

Green supply chain management (GSCM) integrates environmental considerations into supply chain functions from product design to end-of-life management. This chapter examines the emerging applications of artificial intelligence (AI) for advancing sustainability across supply chain operations and decision-making. Specifically, it reviews the use of AI-powered analytics, optimization algorithms, machine learning systems, and distributed ledgers for enabling circular resource flows across global value chains. The chapter also critically evaluates the successes, limitations, risks, and ethical considerations of current AI applications in GSCM. Challenges related to data quality, algorithmic bias, job automation risks, and operational integration complexities are discussed, along with mitigation strategies. Case studies demonstrating AI's impact on solving real-world supply chain sustainability issues are incorporated. The chapter broadens the discussion to encompass economic, social, and environmental dimensions of sustainability, as well as AI's role in enhancing supply chain resilience.

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INTRODUCTION

With climate change threats and resource depletion intensifying, corporations are facing growing stakeholder pressures to improve environmental performance (Pinto, 2020). GSCM offers a systems-based strategy incorporating green considerations across supply chain (SC) activities, from sourcing sustainable materials to manufacturing energy-efficient products and managing post-use recycling (Sarkis, 2003). However, barriers related to investible funds, technological capabilities, coordination complexities, and information gaps constrain the adoption of GSCM principles (Raut et al., 2019). This is where emerging digital infrastructures like artificial intelligence (AI) offer new possibilities.

AI refers to intelligent software and algorithms that can learn patterns from SC data to automate analysis, planning, and control functions with increasing accuracy over time (Zhong et al., 2017). As GSCM generates vast sustainability-related data across product lifecycles, AI can drive rapid insights for eco-innovation and impact reduction (Centobelli et al., 2020). However, research on AI applications for greening SCs remains relatively nascent. AI allows computers to demonstrate intelligent capabilities by mechanizing, materializing, and extending human cognition. It has broad use cases in expert systems, natural language processing, robotics, computer perception, machine learning, and more that aim to simulate human-like thinking and problem-solving (Lee et al., 2015). Intelligent supply chain management (SCM) leverages emerging technologies like the Internet of Things (IoT) and cloud computing to achieve rapid coordination, tight integration, and risk management across SC activities (Wang, 2019). This builds smart systems with enhanced visibility, traceability, and responsiveness beyond traditional industrial limitations (Ivanov et al., 2016).

Sustainable supply chain management (SSCM) integrates environmental and social goals with economic performance through coordinated efforts among stakeholders (Hu et al., 2019). It encapsulates the product life cycle from raw material extraction to end delivery and associated impacts on sustainability. Construction materials require factoring long-term resource constraints into procurement planning (Liu & Lin, 2021). Sustainable performance measures using the triple bottom line of ecology, society, and economy are crucial (Liu et al., 2019). AI has demonstrated positive effects on financial outcomes and overall enterprise performance from increased efficiencies and automated decision-making (Choi et al., 2010). Hence, its applications in SCM hold tremendous potential for sustainability. Environmental sustainability has become an urgent priority as climate change and resource depletion threaten long-term socioeconomic development (Kleindorfer et al., 2009). Businesses are under increasing pressure from governments, communities, and consumers to reduce their environmental footprints across product life cycles from design to

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