Chapter 3
AI-Driven Digital Twins and Autonomous Operations for Sustainable Logistics and Procurement

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ABSTRACT

This chapter explores how Artificial Intelligence (AI), digital twins, and autonomous operations are transforming logistics and procurement into intelligent, resilient, and sustainable ecosystems. It examines theoretical foundations, sustainability drivers, and the integration of circular supply chain practices and ESG accountability. AI-driven digital twins enable real-time simulation, predictive analytics, and prescriptive optimization, while autonomous operations streamline warehousing, transport, and procurement with robotics, drones, and AI-based control towers. Case studies from healthcare and oil & gas illustrate practical applications, highlighting benefits and regulatory challenges in the GCC and MENA regions. Ethical, regulatory, and social implications are discussed alongside emerging innovations such as agentic

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AI, blockchain, IoT, and quantum-ready optimization. The chapter concludes with insights into future directions, emphasizing human-AI collaboration, transparency, and sustainability as critical enablers of next-generation global supply chains.

INTRODUCTION

Artificial Intelligence (AI) is quite safe to navigate logistics and procurement to global level, but it is focusing on the digital transformation concerns on the sector. AI along with digital twins, and autonomous technology convergence is prying the seams on the industry. Supply chains have lost their previously physical form and are now chains of autonomous and highly adaptable intelligent systems which exhibit extreme resilience to disturbances. Fragments of disparate data which used to be disparate and singular are now woven into a hyper-complex multi-structured tapestry in consequence of neural networks, digital twins and streamlining AI, and digital glue methods. AI tools such as Generative Adversarial Networks along with new techniques in Augmented Reality are reaching new zeniths in optimization, prediction, and automation at previously unattainable scales (Arab et al, 2023). The global logistics and supply chains real world barriers are represented as digital twins of procurement systems with corresponding intelligent virtual replicas of warehouses and transport networks. These intelligent twin systems permit real-time evaluation and scenario based impactful decision making for the requisite chains. The efficiency of drone delivery and AI controlled automated supply tower handling and robotics has ruggedly improved efficiency on hands-free material handling, last-mile logistics, and supplier control systems Like the measurement and circular policy scope3 carbon washers, these systems lead the industry with full ESG compliance and are the newest waves of innovation (Lintukangas et al., 2023). This chapter is focused on policy with weaving diverse elements on seamless integration of flexible, easily sustainable, and logistics and able to supply worldwide adaptable procurement and procurement policy on devising sustainable adaptable and procurement policy on logistics policy with flexible integration of diverse elements.

BACKGROUND ON LOGISTICS AND PROCUREMENT TRANSFORMATION

The combining of procurement and logistics can be attributed to both the resilient and cost-effective nature of operations strategy. In the past, cost-effective supply chains focused on minimizing the costs of bulk purchasing, storing and labor. The fragmentation of e-commerce and geopolitical changes exposed the vulnerabilities of

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