

From Data to Decisions: Leveraging Digital Twins, AI, and IoT for Smarter Supply Chain Management

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Abstract

This research explores how Digital Twins and the Internet of Things (IoT) can be integrated to transform supply chain management at scale. Modern supply chains often face persistent challenges such as limited real-time visibility, low forecasting accuracy, rising operational costs, and heightened exposure to both local and global disruptions. Traditional systems frequently provide delayed or incomplete insights, leading to bottlenecks, inefficiencies, and reduced competitiveness. Advances in technology now make it possible to overcome these limitations and reshape the way supply chains are designed and managed. The study has three primary objectives: (a) to conduct a systematic review of the literature on the combined use of IoT and Digital Twins in supply chains; (b) to propose a conceptual framework that unifies these technologies into a coherent model; and (c) to design and implement a simulation prototype that demonstrates how this integration can enhance responsiveness, efficiency, and resilience. In this context, IoT devices will be assessed for their role in transmitting continuous, sensor-based data streams, while Digital Twins will be examined as real-time virtual models capable of simulating, monitoring, and optimizing supply chain activities. By addressing current gaps in research, this study seeks to contribute both theoretical insights and practical applications, supporting the development of supply chain systems that are more adaptable, sustainable, and resistant to disruption.

Keywords

Digital Twins, Internet of Thing, Supply chain management, Artificial Intelligent

Biographies

Maryam Alawlaqi is a junior undergraduate student pursuing a Bachelor of Science in Operations and Supply Chain Management at Effat University, Jeddah, Saudi Arabia. She is a motivated and detail-oriented student with strong communication and public speaking skills, actively seeking opportunities to gain practical experience through internships, research, and collaborative projects. Fluent in Arabic and English, with conversational proficiency in German, she brings a multicultural perspective to her academic and professional endeavors. Her research interests include supply chain automation, digital transformation, and sustainable operations, with a particular focus on the Saudi fashion industry and culturally significant supply chains. Maryam is passionate about bridging theory and practice by engaging in applied research and contributing to the growing discourse on innovation in supply chain management within the context of Saudi Arabia's Vision 2030.

Dr. Sarah Y. Osailan is an Assistant Professor and Chair of the Operations and Supply Chain Management Department at Effat College of Business, Effat University. She holds a Ph.D. and a master's in information systems & technology with a concentration in Geographic Information Systems (GIS) from Claremont Graduate University.

Her research and teaching focus on digital transformation, data analytics, and business model innovation, with a particular interest in how emerging technologies are reshaping supply chains and operations. Building on her foundation in GIS, she explores how spatial data, intelligent systems, and automation can support areas such as AI-driven logistics, digital supply chains, and autonomous mobility. Dr. Osailan is passionate about bridging academia and industry, designing engaging, technology-enabled learning experiences, and preparing future leaders to navigate an increasingly data-driven and digitally connected world.

Malak Ali is a senior undergraduate student pursuing a Bachelor of Science in Operations and Supply Chain Management at Effat University, Jeddah, Saudi Arabia. She is passionate about diverse areas within her field, including procurement, logistics, supply chain strategy, quality management, sustainability, and digital transformation. As an active member of the IEOM (Industrial Engineering and Operations Management) Student Chapter, she has strengthened her leadership, teamwork, and organizational skills while connecting with peers and industry professionals. Her academic and professional interests focus on how artificial intelligence, data analytics, and emerging technologies can improve supply chain resilience, enhance supplier reliability, and support Saudi Arabia's Vision 2030 goals. Fluent in Arabic and English, Malak brings strong communication, problem-solving, analytical thinking, adaptability, and project management skills to her work. She is dedicated to bridging theory and practice by contributing innovative solutions that drive efficiency, sustainability, and competitiveness in business operations.

Noor Yousef is a junior undergraduate student in Operations and Supply Chain Management at Effat University, Jeddah, Saudi Arabia. She is a proactive and dedicated learner with strong abilities in teamwork, leadership, and organization. Noor demonstrates excellence in research, public speaking, and adaptability, with advanced proficiency in both Arabic and English. She has led innovative collaborations with L'Oréal and is actively working on a research project to enhance blockchain technology in supply chains. Noor holds certifications in supply chain management, as well as courses in small business project management, business problem-solving, and business networking. Noor played an important role in operations management and served as the Head of Public Relations for the IEOM Club. She is also the head of Hajj pilgrim dispatch management at Nasser Nassar Al Hazmi Company, contributing significantly to operational excellence. Noor is passionate about integrating innovation into supply chain practices and continually seeks collaboration and research opportunities aligned with Saudi Arabia's Vision 2030.

Noura Babakor is a senior undergraduate student at Effat University, specializing in Supply Chain Management. She is a motivated and versatile student with strong communication, public speaking, and design skills. Alongside her academic studies, Noura has gained professional experience in sales, marketing, and public relations through roles at Beautiva, Shanz Studio, and Travel Zone, where she managed social media accounts, designed promotional materials, coordinated events, and supported e-commerce operations. Her research and career interests include supply chain optimization, digital transformation, and sustainable operations, particularly within the context of Saudi Arabia's Vision 2030. She has further strengthened her profile by completing certifications in leadership, global procurement, business forecasting, and digital literacy. In addition, she actively engages in university initiatives, including facilitating innovation and entrepreneurship workshops at Effat University Career Day. Noura is passionate about bridging theory and practice by contributing to innovative supply chain strategies and effective communication practices that drive organizational growth and sustainability.