Chapter 7
Big Data-Driven Circularity:
Enhancing Sustainability Through Closed-Loop Supply Chain Models

Mohammad Al Refat Reyel
http://orcid.org/0009-0000-0431-5294
Ulster University, UK

Mehedi Hassan Anik
http://orcid.org/0009-0000-5325-1442
Unitec Institute of Technology, New Zealand

Syed Waqar Ul Hassan Shah
http://orcid.org/0009-0001-6654-5906
Ulster University, UK

ABSTRACT

This chapter explores how big data technologies are transforming circular supply chains, enabling firms to manage end-of-life products more efficiently while promoting sustainability. By integrating predictive analytics, IoT, AI, and digital twins, organizations can anticipate product returns, optimize reverse logistics, automate sorting, and make informed decisions on reuse, refurbishment, and recycling. The discussion highlights applications across electronics, automotive, and consumer goods industries, illustrating how data-driven strategies support circular economy practices, improve resource efficiency, and reduce environmental impact. Challenges such as interoperability, data quality, cost, privacy, and ethical considerations are

DOI: 10.4018/979-8-3373-6896-2.ch007

also examined, alongside recommendations for governance, collaboration, and technology adoption. The chapter underscores the strategic potential of data-driven circularity in achieving long-term operational and environmental resilience.

INTRODUCTION

This chapter takes a closer and somewhat reflective look at how the growing availability of big data, along with the rapid push of digital technologies, is gradually reshaping the way organisations think about circularity and, more specifically, how they manage closed-loop supply chains (CLSCs). Although sustainability discussions often highlight cleaner production or greener sourcing activities, the end-of-life stage of products is still where many firms, even experienced ones, tend to struggle. Decisions around product returns are sometimes delayed or made with incomplete information. The chapter therefore tries to bridge this gap by discussing how big data combined with tools such as artificial intelligence (AI), machine learning (ML), the Internet of Things (IoT), and digital twins can make these return flows more predictable, more transparent, and, in many cases, more valuable for the organisation. The narrative begins by revisiting the basic foundations of CLSCs and pointing out how they differ from the more familiar, linear supply chain structures. Instead of focusing only on outbound flows of products and materials, CLSCs also incorporate reverse streams, meaning that used items must be collected, inspected, possibly disassembled, and then directed toward suitable recovery options like reuse, refurbishment, remanufacturing, or recycling. These recovery practices are widely recognised as key drivers of reduced raw material dependency and lower environmental pressure. Still, they remain difficult to coordinate because reverse flows rarely behave in a stable or predictable manner. The volume, condition, and even the timing of product returns can be highly irregular, which puts additional pressure on planning and coordination. Following this foundation, the chapter turns to product end-of-life (EOL) strategies and their growing importance. Effective EOL decision-making has implications not only for environmental outcomes but also for cost savings and compliance with regulatory frameworks. The chapter reviews the major options reuse, refurbishment, remanufacturing, recycling, and when unavoidable, safe disposal and discusses why firms often struggle to choose the most appropriate pathway. In the absence of reliable, real-time information on product condition or material composition, EOL decisions sometimes become reactive or based on assumptions rather than evidence. To address these challenges, the chapter highlights how big data is gradually becoming a transformative element in supply chain sustainability. Large-scale datasets coming from sensors, manufacturing systems, logistics networks, and even customer interactions allow

Related Content