Chapter 4
Integrating Circular Economy Concerns Into the Industry 4.0 Roadmaps of Companies:
A Literature Review

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ABSTRACT

The concept of circular economy (CE) aims to promote sustainable resource utilization, minimize environmental impacts, and create societal, economic, and business value. Simultaneously, the fourth industrial revolution or Industry 4.0 (I4.0) offers companies the opportunity to enhance their operational efficiency. Various process models have been proposed to assist companies in developing a digitalisation strategy roadmap. This chapter presents a thorough analysis of how CE utilizes I4.0 technologies to transition from a conventional linear economy to a circular one. The authors have then first proposed a generic three-stage process to establish a I 4.0 strategy roadmap, then conducted an exhaustive review of the latest literature on CE and I4.0 theory to explore the interrelation between these concepts and ascertain the extent to which I4.0 technologies facilitate progress towards a more sustainable industry.

INTRODUCTION

Industry 4.0 (I4.0) and Circular Economy (CE) have emerged as prominent and extensively discussed subjects in recent decades. The Circular Economy (CE) entails a production and consumption model focused on the reuse, repair, and recycling of materials and products to minimize environmental impacts. Embracing a circular economy involves waste elimination, prolonging product lifespans, and fostering the regeneration of natural systems. On the other hand, Industry 4.0 (I4.0), often referred to as the fourth industrial revolution, signifies a manufacturing revolution propelled by technological advancements, such as big data and connectivity, analytics, human-machine interaction, and robotics. The integration of technologies like IoT, Big Data, and augmented reality can empower manufacturing companies to enhance process performance. To effectively implement Industry 4.0, companies need to establish a strategic vision, develop a roadmap, and translate this vision into practical projects.

This chapter undertakes a Literature review to explore the correlation between the concepts of Circular Economy and Industry 4.0. The question we want to address is whether there is a relationship between the concept of CE and I4.0 technologies. We therefore want to know how I4.0 technologies are being used to influence the CE approach on the one hand, and on the other, how CE-related domains can be covered by I4.0 technologies. We will therefore begin by proposing a generic three-stage process to establish a I 4.0 strategy roadmap, then we will review the most recent literature on CE and I4.0 theory to determine the extent to which I4.0 technologies are facilitating progress towards a more sustainable industry and to develop an innovative framework that enable companies to create an I4.0 Roadmap that adequately incorporates ecological concerns.

The chapter is structured as follows: Section 2 provides a brief theoretical background on the Circular Economy Concept. Section 3 introduces the fourth industrial revolution technologies. Section 4 presents a generic process model for developing an Industry 4.0 strategy roadmap. Section 5 conducts a literature review of the Circular Economy and Industry 4.0 concepts, aiming to identify the interrelation between them and assess the extent to which I4.0 technologies contribute to building a more sustainable industry. Finally, the last section presents conclusions drawn from the study and outlines potential goals for future research.

THE TWO LIFE CYCLES OF CIRCULAR ECONOMY

The Circular Economy (CE) presents a production and consumption model centered on reusing, repairing, and recycling existing materials and products to minimize environmental impact, making it a pivotal strategy for achieving sustainable development. Sustainable development, a United Nations principle, seeks to balance economic growth, environmental protection, and social well-being. Transitioning to a circular economy entails waste elimination, prolonging product lifespans, and regenerating natural systems. This shift expands the conventional linear economy into a closed-loop system, aligning the product life cycle with the natural life cycle (Zbicinski, Stavenuite, Kozlowska, & van de Coevering, 2006). This section provides a concise theoretical background of the CE concept.

The concept of sustainable development today emphasizes economic and social progress, as well as safeguarding the environment for future generations. The Brundtland Report in 1987 (Brundtland, et al., 1987) defined sustainable development as development that meets present needs without compromising future generations' ability to meet their own needs. The CE model is instrumental in achieving sustainable

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