



TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics, Mechanics, and Engineering
Vol. 64, Issue Special IV, December, 2021

INDUSTRY 4.0 AND THE CIRCULAR ECONOMY: A SYSTEMATIC REVIEW OF THE LITERATURE

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***Abstract:** Recent studies have highlighted the role of technologies in Industry 4.0 as facilitators of product service-system. About 7 years ago, research on circular economy and I4.0 began to receive more attention from researchers. As such, companies are encouraged to adopt a circular economy to enable advanced opportunities. Through this systematic review we try to understand the relationship between I4.0, product service-system and the circular economy using the 24 identified articles. This research support that the adoption of Industry 4.0 technologies for product service-system facilitate the transition to circular economy through intelligent services. The results of this study aim to provide a clearer perspective and direction for researchers so that they can understand how these 3 concepts relate and how they influence the transition to a circular economy.*

***KEY WORDS:** circular economy, industry 4.0, product service-system, internet of things.*

1. INTRODUCTION

The Industry 4.0 produced a fundamental shift within the manner we tend to live, work and interact with others. What it really represent is the use of smart technology to automate the traditional production and industrial processes we were used to. [1]. There is a big step in automatization because of the integration of machine-to-machine communication that not only improved communication but also helped in developing of intelligent machines that can identify and determine potential problems. In order to achieve better performance and efficacy companies should be continuously transforming the way they work by transforming the nature of their business, from being owners of competencies and resources to becoming integrators of skills, resources and technologies. [2-4].

However, the circular economy is also receiving increasing attention [5] to develop smarter systems that consider waste as excessively valuable while supporting innovative life cycle management [6]. Practitioners are actively adapting to the circular

economy paradigm and adopting essential technologies to improve their operational efficiency [7]. For example, an unprecedented shift has been made by software products to convince companies to adopt digitalization [8].

The circular economy methodology provides environmental, social and economic benefits to businesses as it moves away from the “take-make-dispose” model [9]. Withal, product as a service delivers a service outcome instead of a single sale [10]. Thus, in today's ever-competitive market, there is a growing demand for novel, smart products with better functionality and value-added services [11,12].

There is an extensive literature on I4.0 in the context of the circular economy, especially in the manufacturing industry [13]. However, the main focus of this literature is to explain the benefits of IoT for circular economy initiatives. The main benefit of the SLR methodology is its ability to cut back bias and supply a additional comprehensive understanding of the things studied [14]. I4.0 and the circular economy are two industrial paradigms that enable new strategies for natural resources [15].

The purpose of this review is to clarify the explanation to the further research questions: What are the main findings of earlier researchers (1) I4.0, (2) Product-Service-System and (3) Circular Economy. The systematic review developed in this paper examine the link between the selected variables, namely Industry 4.0, product-service-system, and the circular economy, to see how this rapid global revolution has impacted. [16].

2. METHODOLOGY

We have adopted a systematic review of the literature developed by Okoli and Schabram [17]. The methodology adopted aims to identifies, selects and critically appraises research in order to answer the research questions [18]. The systematic review in order to be able to answer the specific questions formulated is based on the selected criteria and contributes to a well-defined conclusion for the created study [19]. We also ventured into systematic review of the literature (SRL), which has been used in many multidisciplinary reviews to investigate complex research areas with applications in different studies [20,21].



Fig. 1. The stages of the systematic review of the literature

The first stage of any SLR is to establish the purpose of the research and identify the key objectives [23]. In this research, previous studies are analyzed to identify the key characteristics and innovation of the following key variables: I4.0, product-service system and CE and the links between those. The second step in this type of analysis is to check out the selected articles. At this stage, there is a huge risk of systematic error, so we also used Newbert's [24] inclusionary and exclusionary selection criteria [24]. In order to reduce errors, subjective bias and to ensure the validity and reliability of this study, we have included a number of questions in the checklist as follows:

- 1: Are there technologies covered in the selected documents?
- 2: Is the selected work related to Circular Economy, Industry 4.0, and product service system?

- 3: Do the selected articles address the relationships between the variables of interest to us?
- 4: Are the results and conclusions of the chosen studies part of our research area?

2.1 Methodology

To do this systematic review we used the database available on the Web of Science and using keywords we extracted the articles of interest to us. The first step was to search for keywords (I4.0, product service system, and Circular Economy) to select only relevant research papers for this study.

2.2 The analysis process

After selecting the works that meet the criteria imposed by us, we created a database with them and organized them according to the topic approached. Of course, the classification was made according to the year in which it was

published (2014-2021), the name of the magazine, topic (main research objective), the gap in research (for future researchers) and results.

in order to have a more complete picture of them being easier to identify information of interest.

3. THE RESULTS OF THE ANALYSIS

SLR results are characterized by three criteria. First, the way in which the key aspects (I4.0, CE and PSS) were examined in the field of business and management. Another objective was to analyze cross affiliations. The analysis was intended to highlight the impact on the performance of a business depending on the selected key variables.

3.1 The relationship between the three key variables

By analyzing the selected articles, we wanted to see how each variable interacts with each and what role each has in relation to the other. The search returned 41 results, of which only 24 articles were considered particularly representative. The deleted studies did not directly address I4.0, the circular economy and the product service system in quantitative terms, or had a high degree of similarity to other articles already included in the review.

3.2 Impact on company performance

Industry 4.0, CE and product-service-system have a crucial impact on the performance of a company, improving the production model but also the business systems [25,26]. The Internet of Things and other novel technologies help to complement product lifecycle approaches [28] and enable the incorporation of product information, from idea perception to product description, business case evaluation, product design, and resolution. Similarly, with digitalization and product service system, companies are implementing digital technologies for consumer production and management [25]. It is not difficult to understand that Industry 4.0 has a key role to play in facilitating and sustaining long-term global competitiveness, but from another point

of view we must be aware that there are still uncertainties about the implications and real impact of the Internet of Things [28]. After a careful analysis, we found that many papers focus on studying the redesign of a company's operational processes, changes in operational efficiency [29], or differences in operational performance after a company's transformation.

4. CONCLUSIONS

In this study, the different aspects of Industry 4.0, product service system and CE were presented over the presented review. In this review, the analysis of the 24 scientific articles tried to evaluate the links that were studied in the case of Industry 4.0, Circular economy and product service system.

The first part deepened the EC understanding and view of the product-service system and examined how I4.0 technologies affect service systems [30- 32]. The role of Industry 4.0 in the product-service system and Circular Economy, value propositions and financial performance indicators was explored in this review. In the next step, thematic group were integrated to evaluate the relationship between variable. In the last step, we tried to examine the possible impact that this connection can have on the performance of a business. Through this review we wanted to have a broader picture of the business context in order to come up with a deeper perspective of the transition to a circular economy within Industry 4.0 [33-35] and with product-service system. Following our analysis, we noticed that most articles supported the importance of the transition to a circular economy by systematically adopting Industry 4.0 technologies and using the product system as a service to create value-added and sustainable. The results of this study suggest that the relationship between our variables of interest should have a positive impact on firm performance. Therefore, it is recommended that future research examine the impact of a specific Industry 4.0 technology when companies adopt facilitation around an explicit Circular Economy practices. This integration will determine in the following period a change in the market with a high management and production capacity.

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INDUSTRIA 4.0 ȘI ECONOMIA CIRCULARĂ: O RECENZIE SISTEMATICĂ A LITERATURII

Rezumat: Studii recente au evidențiat rolul tehnologiilor în Industria 4.0 ca facilitatori ai sistemului de servicii de produse. În urmă cu aproximativ 7 ani, cercetările privind economia circulară și I4.0 au început să primească mai multă atenție din partea cercetătorilor. Ca atare, companiile sunt încurajate să adopte o economie circulară pentru a oferi oportunități avansate. Prin această revizuire sistematică încercăm să înțelegem relația dintre I4.0, produs-serviciu-sistem și economia circulară folosind cele 24 de articole identificate. Această cercetare susține că adoptarea tehnologiilor Industry 4.0 pentru produse-servicii-sistem facilitează tranziția la economia circulară prin servicii inteligente. Rezultatele acestui studiu urmăresc să ofere cercetătorilor o perspectivă și o direcție mai clară, astfel încât aceștia să poată înțelege cum se leagă aceste 3 concepte și cum influențează tranziția către o economie circulară.

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