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The emergent role of digital technologies in the Circular Economy: A review

Aris Pagoropoulos[a]*, Daniela C. A. Pigosso[a], Tim C. McAloone[a]

[a]*Technical University of Denmark, Department of Mechanical Engineering, Anker Engelunds Vej 1, Kgs. Lyngby, 2800, Denmark*
* Corresponding author. Tel.: +0045 2764 2264;. *E-mail address:* arispa@mek.dtu.dk

Abstract

Digital technologies have enabled the formulation of multiple Product Service-Systems (PSS) with considerable economic, environmental and societal benefits. One of the most promising paradigms, which is inspired by business models and value propositions that have already been described in the PSS literature, is the concept of Circular Economy. Circular Economy is characterized as an economy that is restorative and regenerative by design and is attracting significant attention from researchers and policy makers alike. In light of the recent proliferation of digital technologies such as Big Data and the Internet of Things, this article attempts to identify how can digital technologies support the transition to Circular Economy. This article conducted a systematic review of the literature based on a review protocol, in an effort to evaluate the application of key digital technologies in Circular Economy. The study concludes by identifying research gaps, reflecting on the application of digital technologies in the field of PSS and proposing suggestions for future research.

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Keywords: Circular Economy; digital technologies; digitization; Product/Service-Systems

1. Introduction

Currently, manufacturing companies are driven by a search for enhanced revenue based on sales volume and cost reduction in supply chains, factories and operations. In the current linear economy, based on a “take-make-dispose” philosophy, products are increasingly becoming commodities, and resource scarcity is becoming a reality for a large variety of materials. In order to remain competitive in this economic context, companies are increasingly looking for alternative ways to achieve sustainable growth and enhanced resource efficiency. Over the last years, various consumption practices that challenge the established growth paradigm, based on a linear economy, have been proposed.

One of the most promising paradigms to appear in recent years is the Circular Economy. According to the Ellen MacArthur Foundation, the Circular Economy is characterized as an economy that is restorative and regenerative by design and which aims to keep products, components and materials at their highest utility and value at all times, distinguishing between technical and biological cycles [1]. In a Circular Economy, companies concentrate on rethinking products and services from the bottom up to “future proof” their operations and prepare for inevitable resource constraints – all the way through to the customer value proposition [2].

In many cases, the implementation of Circular Economy in manufacturing companies requires changes in their business models, which can be achieved by means of Product/Service-Systems (PSS). PSS is one particular value proposition that has attracted considerable attention over the past few decades as a way to decouple economic growth from resource consumption. PSS promote a focus shift from selling just products to selling the utility, through a mix of products and services while fulfilling the same client demands with less environmental impact [3].

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One can draw multiple similarities between PSS and Circular Economy. Both advocate the focus on fulfilling the needs of the users in an effort to radically lower environmental impacts [4], [5]. Moreover, they are characterized by a high degree of overlap as, according to [4], many of the most promising PSS business models are circular in nature. At the same time though, PSS might lead to inefficient practices and less circular models, most notably through rebound effects [6].

While not entirely the same, the commonalities between Circular Economy and PSS invite a deeper investigation into Circular Economy from a PSS perspective. In both PSS and Circular Economy, information technologies play a critical role [4], [7], [8]. The Ellen McArthur Foundation acknowledges the role of intelligent assets and connectivity in the proliferation of Circular Economy [1]. Despite their promise though, there is a limited knowledge as to how new digital technologies and capabilities such as the Internet of Things (IoT) and Big Data can be leveraged to support the transition to Circular Economy. This study attempts to close this gap by conducting a systematic literature review, in order to evaluate the application of digital technologies to support the transition to Circular Economy. Therefore, it poses the following research question:

RQ: How can digital technologies support the transition to a Circular Economy?

The next section presents the research methodology, and is followed by the presentation of the obtained results. Conclusions and future work are discussed in Section 4.

2. Research methodology

2.1 Data collection

A systematic literature review was conducted to examine the intersection between digital technologies and digital capabilities and Circular Economy. The research methodology was based on [9] in an effort to provide a replicable process, and limit the bias of the research.

In order to identify the relevant studies that lie at the intersection between Circular Economy and digital technologies, we used keywords –shown in Appendix A- to query online databases, namely Scopus and Web of Science. The review was carried out in a three-step process, as shown in Fig. 1 consisting of three steps: Collection, Evaluation, and Analysis. During A total of 135 studies were identified, which were reduced to 33 articles after checking the abstract and its contents for relevance. After reading the articles and including articles from the secondary analysis of citations, only 12 were retained.

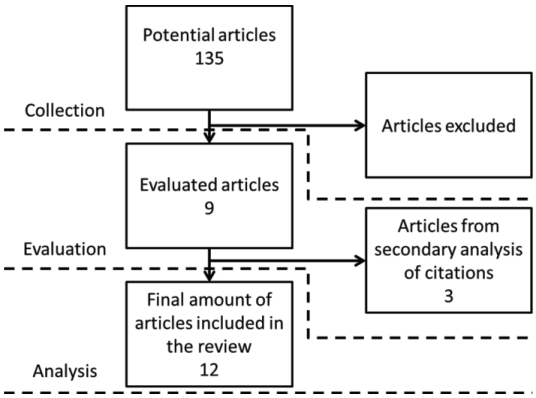

Fig. 1. Systematic review process

2.2 Data analysis

To systematically analyze the identified studies, a review protocol was used (see Appendix A). The review protocol specifies the central research question, and helps evaluate the studies based on predefined data extraction forms. The use of data extraction forms helps standardize the way information is collected and analyzed by the researchers [9]. The coding scheme consists of four categories as shown in Fig. 2.

- Study type: Evaluate whether the study is a review summarizing the literature on a specific topic, a case study illustrating the application of digital technologies in Circular Economy, or a conceptual study proposing a framework.
- Life cycle stages: Identify the life cycle phases that the study attempts to cover.
- Digital technologies: Identify the technologies that are associated to the Circular Economy.
- Digital architecture perspective: includes three data architectural layers [10], as shown in Fig. 2.
    - Data collection: focus on the collection of data from various sources and Systems of Records (SOR).
    - Data integration: covers technologies that assist with the transformation, integration and maintenance of data.
    - Data analysis: focuses on technologies that assist in extracting business value through the analysis of data.

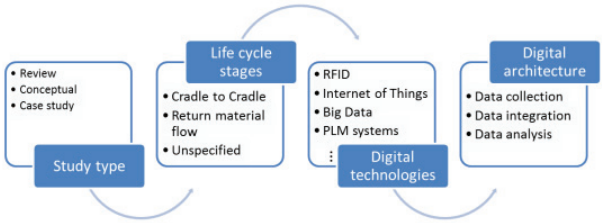

Fig. 2. Coding scheme dimensions and indicative categories