UNLEASHING THE POTENTIAL OF DIGITAL TWIN IN OFFERING GREEN SERVICES

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Abstract

Decarbonisation and the transition towards a sustainable economy are current challenges faced by many organisations belonging to industries that have zero carbon emission on their horizon. In this backdrop, orientation to services is playing a role in the creation of more sustainable business models. Nonetheless, definition, design, and effective development of green services are still an ongoing debate in the literature. On the other hand, new cross-field technologies are emerging as drivers in the transformation process for sustainability. In this vein, digital twin is already showing their potential on optimising processes and increase operational efficiency. Despite the growing number of articles in digital twin, research on how this technology can underpin services and enable sustainable practices is still scarce and fragmented. This extended abstract contextualises and describes an ongoing research project aiming to shed light on the role of digital twin in enabling green services. The research work in progress, by means of systematic literature review combined with benchmarking analysis, is portraying the state of art and current cross-sector best practices for the development of green services facilitated by digital twin. In a second step, building on the insights deduced from the systematic review, a panel of experts will be interviewed with the object to identify current and future perspectives on the use of digital twin in the service context and define a framework of the key socio-technical factors to be considered in digital twin-enabled green services to succeed. This expected framework could guide both practitioners and researchers in the better design and development of green services by using digital twin.

1 Introduction

Advanced economies have already set ambitious targets to reduce greenhouse emissions and decarbonise economy by 2050 (i.e. UK Climate Change Act, EU Green Deal) [1,2]. These objectives lead to the promotion across all productive sectors of models of growth decoupled of resource consumption [2]; notwithstanding, recent reports on the monitoring of the fulfilment of these objectives are flagging the need of introducing more and more challenging measures and legal obligations to meet the net zero targets [3]. In such context, organisations face this major challenge while still struggling with measuring CO2 footprint in their production processes and supply chains and attempt to redefine their business model to be better aligned with these green objectives. One of these business model transformations, particularly prevalent in manufacturers, is the integration of services and product [4], which also lead to the development of Product Service Systems (PSS) [5]. However, to date, even though services represent around 65-85 percent in developed economies, they are not being sufficiently researched as part of the green transition. More research around what a green service is and the creation of standards for the design and development of green services is demanded to contribute to addressing the challenge of creating a sustainable economy [6].

Achieving the abovementioned green targets require investment and innovation in cross-field technologies with the potential to change our economy and drive the transformation for sustainability [7]. Among these technologies, digital twin (DT) is being proved beneficial to production planning, control and maintenance management [8], predictive maintenance [9] and different lifecycle-based applications [10,11]. Likewise, digital twin is beginning to be seen as service enabler [12], being of particular interest in the development of PSS [13]. Nonetheless, there is still an important gap on understanding the role of DTs in service design and developments beyond operational efficiency [14]. And even more specifically, there is no research to date on investigating the role of DT as an enabler for the development of green services.

Given all of the above, it is notable that on the one hand, an improved understanding of the concept of green service and the role of services in the green transition, and on the other, more guidance on the application of digital twins in green service propositions, can be seen as current and significant matters where more research is required. Therefore, the research in progress aims to achieve a treble objective. Firstly, to characterise green services in this technological context and identify features of green services that can be already found in services enabled by DT. Secondly, to understand the current cross-sector best practices on the design and development of DT-driven green services. Thirdly, to identify key socio-technical factors and propose a framework that facilitate the design and development of green services by using DT.

In this extended abstract, a theoretical contextualisation that spots and justifies the relevance of the research work in progress is presented. Likewise, the research method that is being applied in the ongoing research project is meticulously explained.

The rest of the paper is organised as follows. An initial theoretical background is provided to contextualise the research topic in the areas of green services and resource integration processes, sustainable PSS, and digital twin as service enabler. Afterwards, the different steps that are being followed in the methodology are detailed and justified. In the final sections, some intended preliminary findings are presented, and a brief conclusion is drawn.

2. Theoretical Background

Green Services and resource integration processes

There is scarce research addressing how the orientation towards services can reduce the impact of excessive consumption in the environment, being the study of this link between services and sustainability a recognised research niche [15, 16, 17]. At present, it is difficult to find a well-established definition of green services in the published literature. Cocca and Ganz [18] define green services by analogy with the Triple Bottom Line model [19]. This definition includes three main areas of action: economic, social and ecological and consider as "green" any offering whose key target is ecological sustainability. A different way to understand green services is by conceptualising them as services connected with cleaner production methods [20] or with the minimisation of negative environmental impact throughout a product life cycle [21]. A different approach considers green services as those which are part of eco-efficiency (use of fewer resources and generating less waste) [22]. In a more recent study, green services are defined in a generic approach as those aiming to improve the well-being of the natural ecosystem [23]. From this perspective, green services are oriented to meet a double objective: customer satisfaction and environmental improvements [23].

Resources play an important role in processes of value creation [24,25]. The integration of resources consists of a series of processes of collaboration, interaction, cooperation between different actors involved in value-creation activities [26]. In service research, the study of resource integration from a sustainable perspective was initiated as part of the study of environmental resource efficiency processes in services [27]. From a resource integration perspective, green services are created through resource integration processes that provide environmental benefits. The traditional resource integration processes related to the three Rs from waste management literature: reducing, reusing and recycling [27]. These three classical processes have been recently complemented with three new resource integration processes in the offering of green services: redistributing, reframing, and renewing [23].

Sustainable PSS

The relationship between PSS and sustainability has received a lot of attention in the literature. PSS were intrinsically considered as sustainable because they imply to offer solution to the clients without requiring physical ownership [28]. However, Tukker [29] rejected this claim by considering a misconception that PSS equals sustainability. According to his view, a PSS is not "per se" sustainable, and that environmental benefits must be analysed in a case-by-case basis [30,31], in fact, providers must actively seek out the category of sustainable in a PSS [32]. As a result, sustainable PSS can be seen as a PSS category endorsed to those PSS that are "sustainable in terms of environmental burden and resource use" [33]

DT as a service enabler

To understand the potential of DT as a service enabler is important to contextualise the concept of Service-Dominant Logic (SDL) [34]. According to SDL, the value is co-created, being value ultimately determined by the customer's perception [34]. Driven by servitization phenomenon, companies' business models are evolving towards the offering of 'advanced services' that focus on performance-based services [35]. These advanced services reflect the process by which products become the mean to offer value through services. In this shift, production costs and risks are assumed by the provider who is owner of the physical asset. This fact makes product assessing and operations particularly sensitive for the service provider [12]. In this context, DT technology allows service providers to achieve two important objectives; first DT can be used to enhance and optimise operations and performance of physical assets used to offer advanced services. Second, the analysis and operation of DT by service providers allow them to understand better the needs of actors in the service ecosystem and refine value propositions [12,36]. Consequently, DT can be understood as data-driven operant resources for service provision [12].

Therefore, the research context described above motivates this ongoing research that is aiming to recognise characteristics of sustainable services in offerings already facilitated by DT, and identify factors that may play a prominent role for the design and development of DT-enabled green services.

3 Methodology

In order to explore the identified research niche, a three-steps methodology has been tailored as the most suitable method to address the proposed objectives. This methodology, that is being applied in the research in progress, is explained in detail hereunder. First step is to perform a systematic literature review (SLR) to better understand what the state of art in the offering of services enabled by DT is, and what services offerings can be classified as 'green'. The review is organised in three phases: review planning, review execution and reporting of the review [37]. An initial set of keywords related to green services is defined by reviewing the categorisation and definition of green services in combination with the classification for resource integration processes

proposed by Guyader et al. [23]: reducing, recirculating, recycling, redistributing, reframing, renewing. This initial list of keywords is later combined with a set of keywords able to characterise digital twin technology and a third set of keywords to include the concept of technology-enabled services such as 'advance service' and 'PSS'. As part of the review planning, the criteria for inclusion and exclusion have been defined trying to design a sensitive search able to recall all relevant studies. SCOPUS database is defined as source to perform the literature search. Based on the identified articles and grey literature (industrial reports, with papers, government documents and evaluations) a benchmarking analysis is carried out to understand and compare the current cross-sector practices and uses cases.

In a second step, the initial insights from SLR and benchmarking analysis lead the development of series of open-ended questions to be used in interviews with experts from both academia and industry with the object to refine these initial outputs and assess the sense-making in the offering of green services enabled by DT. A focus of these interviews would be on determining socio-technical factors (people, processes, data) with high impact in the successful development of DT-driven green services. The third step of the method involves the analysis of all the content in order to develop a framework that shed light on the potential of DT to enable green service propositions.

4 Preliminary findings

Throughout the proposed methodology, a clearer understanding on technology-driven green services is expected to be achieved. In particular, by exploring what resource integration processes play a prevalent role in the design and development of green services enabled by DT. Simultaneously, this ongoing research expects to contribute to increase the knowledge on how DT enable services and understand good practices and differences between different industries. Finally, the potential identification and structuration of key socio-technical factors connected with organisations (culture, roles, capabilities, skills), processes (value co-creation, standard practices, operating business models) and data (data management and governance, data sharing, data privacy and security) will provide a novel guidance in the development of green services by using DT.

5 Conclusion

The achievement of the ambitious emissions target by 2050 represents a huge challenge for many organisations. In such background, the role that the design and development of green services play in attaining these *net zero* objectives needs further attention. In addition to that, the potential of DT to offer services is a recent research area that is gaining more and more attention. This research project, by addressing these two gaps from an overlapping perspective, is aiming to create knowledge in these areas and bring as an output a framework that helps to understand better the potential of DT in the generation and development of new and more effective green services that, ultimately, lead to the reduction of carbon emission and collaborate in building a net zero economy.

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