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Facilitating circular innovation processes across industries: a case study of blockchain technology

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Abstract: This study addresses how digital technologies facilitate circular innovation processes. The empirical setting is an ongoing collaboration project including industrial partners from different parts of the value chain, as well as an industrial cluster, an environmental NGO, and two research organizations. The overall ambition of the project is to solve the sustainability challenges related to the production and consumption of post-consumer plastics (PCP) waste from the Norwegian aquaculture industry and develop new knowledge on how circular economy principles can be applied. By following industrial actors in the project, we explore collaboration mechanisms through a case study of blockchain technology. Preliminary findings indicate two main aspects of how blockchain solutions may facilitate circular innovation processes. First, it provides the infrastructure needed through gaining control of plastics, documentation of material quality, and limiting waste. Second, verified material data builds trust through traceability and transparency and, thus, may enable circular value chains across industries.

Keywords: innovation processes; circular economy; collaborative innovation; enabling technologies; intermediaries; process studies; innovation management

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1 Introduction

The transition to a circular economy (CE) is seen as a solution to pressing societal issues, such as resource scarcity, waste generation, and climate change (Geissdoerfer et.al., 2018). While the CE concept has gained traction in industry, research, and among policymakers, the adoption of circular principles in the industry is still low (Guldmann & Huulgaard, 2020). At the same time, digital technologies are seen as key enablers of green transitions, and the EU calls to accelerate the 'Twin transition', highlighting the need for green and digital solutions through a zero waste and zero carbon economy.

The present study draws upon a collaboration project investigating sustainable use of post-consumer plastics (PCP) from aquaculture. In Norway, this industry generates more than 14000 tonnes of PCP yearly, e.g., due to technological upgrading or the harsh ocean environment. To date, less than 6 % of the plastics are recycled, while the rest is sent to incineration or landfill. The plastic is of high quality and the raw material may be a resource in other loops after use. If handled properly, recycled plastic may also be a resource in new value creation in other industries, such as furniture manufacturing, the construction industry, or the automotive industry. Collaboration across industries is, thus, a core issue to tackle the issue of plastic waste.

Despite possible solutions, value chains providing recycled plastics are nascent which makes the supply unstable. Moreover, the quality implications of recycled plastics are found to differ, and the price of virgin materials is currently lower. Thus, the overall ambition of this study is to explore how the plastic waste problem may be solved through circular innovation processes that may be facilitated through digital technology. More specifically, we are interested in the *collaboration mechanisms* in these processes, and how blockchain technology may contribute to the upscaling of circular value chains.

2 Current understanding

Innovation processes are dependent on e.g., resources and capabilities of the firm, involving a range of actors evolving over time, where the results of the process are not known beforehand (Van de Ven, 2017). Circular innovation processes can be understood in a similar manner with an emphasis on inter-organizational collaboration, i.e., *"how firms can interact with other organizations in their ecosystem to innovate towards circularity"* (Konietzko et.al., 2020, p.5).

By adopting an ecosystem perspective on innovation processes, it is possible to advance scientific understanding of circular economy practices, e.g, recycling of materials or products as service. Relationships between actors, and related developments over time, are central units of analysis. Previous studies point to relevant phenomena, for example, partner selection processes, alignment of actors' interests, and governance structure of ecosystems (e.g., Konietzko et.al., 2020) In other words, mechanisms of collaboration are central to understanding circular innovation processes.

Hansen and Schmitt (2021) identify eight collaboration mechanisms, one of them being the importance of intermediaries facilitating circular innovation processes. Intermediaries, here understood as organizations and industry groups, are creating trust and relationship

building promoting knowledge exchange (Hansen and Schmitt, 2021). We elaborate further on these mechanisms and the role of intermediaries in circular innovation processes through a case study of blockchain solutions. The role of blockchain technology in facilitating interaction between firms through data sharing, tracking, and trustful communication is found particularly relevant in accelerating the transition. Of interest to this study is that blockchain technology can provide both a solution for track and change through protected and shared information in complex networks, as well as stimulate knowledge sharing and collaboration needed in the transition to a circular economy (Upadhyay et.al., 2021).

Collaboration is a well-known success factor for circular innovation. The underlying processes of collaboration are, however, underexplored (Brown et.al., 2021). Previous studies have identified factors but lack empirical investigation of collaborative processes. Therefore, Brown et.al (2021) calls for both researchers' and practitioners' contributions which investigate collaborative processes towards a circular economy.

To address this lack in the existing literature, we provide insights from following an ongoing process where tracking solutions and blockchain technology are applied in a collaborative project. The research question guiding our research is, thus, how blockchain technology contribute to facilitating circular innovation processes. Our aim is to use empirical cases to provide insights into how collaboration in circular innovation processes may be accelerated by technology.

3 Research design

The overall ambition of the study is to explore how a case of using technology to stimulate circular innovation involving a range of actors across industries, can be framed. Our point of departure is that the development of circular innovation develops as a process, emphasizing how organizations and structures evolve over time (Langley et.al. 2013). The time aspect in process research is seen through understanding activities as evolving phenomena, e.g., the development of circular value chains. Process research, therefore, tends to use longitudinal data from studying dynamics of change. Researchers may also be part of these processes, studying with others embedded in the process (Langley, 2021). Hence, interaction is needed both in the role of the researchers, through taking both an insider and an outsider perspective to activities, as well as knowledge sharing amongst actors involved (Langley et.al., 2013).

During the first phase of the study, semi-structured interviews with partners (7 in total) and other stakeholders (17) related to the aquaculture industry and plastics in Norway were carried out. Two physical workshops have been carried out in the project so far. In addition, the project consortium has met at Teams monthly to share information about ongoing activities within each partner organization. Topics in these meetings are ranging from new investments, the establishment of partnerships, technological challenges, or research results. Although topics may be outside the expertise of a single practitioner or researcher, our research approach has focused on building a shared understanding of the problem (Van de Ven, 2007). In this way, the project draws upon an interdisciplinary and applied approach, where researchers from various disciplines, such as polymer chemistry and social science, are addressing the problem from different angles.

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4 Empirical setting

The collaboration project started in March 2020, gathering a consortium of partners from different parts of the value chain. The problem of plastic waste from aquaculture was approached by viewing the challenge as both a grand sustainability challenge and an opportunity for new value creation. Taking this as a point of departure, tracking solutions for plastic material was identified as one of four areas of shared interest in the project. We were interested in understanding the interests and needs of the firms or such solutions. One of the partners is providing a blockchain technology platform, which is previously used to tackle the sustainability challenges of plastic waste in the ocean. The know-how this partner possesses plays an important role, both through providing the technology and in facilitating the ecosystem for collaboration.

In fall 2021, a 100 % recycled and recyclable walkway for fish pens was implemented representing a milestone of the collaboration project so far. This was due to experimentation and collaboration over the past years, involving both the plastic component producer, the fish pen supplier, the fish farmer, and the plastic recycling company. Starting in November 2021, a blockchain tracking solution pilot was established. This solution is explored in close collaboration between the partners producing and using the recyclable walkway in 2022.

5 Preliminary findings

Previous mapping of drivers and barriers to the uptake of circular principles provided a background for further exploration of firm's innovation processes. While the sustainability challenge of plastic waste is identified, and possible solutions (circular business models and value chains) are outlined, the infrastructure needed to enable such solutions are still missing. Tracking solutions was found to be of common interest to partners in the project to gain control of material streams, but also increase transparency for other firms in the value chain, or due to expected regulations. The specific interest of each partner, however, is depending on the perceived value of data provided by blockchain technology.

In our case, we observe that the utilization of blockchain technology first and foremost enables trust between the different actors in the value chain. The blockchain solution represents a systematic way of gathering information and making use of material data, which is perceived as challenging for the fish farmer. More specifically, this relates to trust in the material qualities and characteristics of the recycled plastic materials, which is the core of the studied circular value chain. As blockchain technology presupposes a verification process where the information that is entered into the software concerning the amounts, source, and quality of the plastics that move through the value chain (both in the form of waste, recycled granulate, and finished products/components) is verified first by the actor that registers the plastic, then by the receiving actor. In the value chain studied here, the first step in the process entails that the fish farmers who are disposing of their hard plastic net pens enter data (material quality documentation, source, amounts, etc.) into

the software, and verifies this data entry. We find that data from this process is also found of importance in sustainability reporting. Then, the recycling company that handles the disposed of net pens verifies the plastics they have received, sort, and recycles them into plastic granulate. The output (with documentation of quality) from the recycler sent to a plastic manufacturer who in turn verifies the quality of the materials received from the recycler and produces new components in 100% recycled plastics for aquaculture. The recycled components are in turn entered into the software and verified by the receiving customer, in our case system supplier who assemble net pens and deliver them to fish farmers. The system supplier delivers the net pens (including the components made from 100% recycled plastics) to fish farmers who validates the receival of the component and enters this into the software. When the fish farmers (after 8-10 years) dispose the net pens, including the components made from recycled plastics, the recycling company has full traceability through so-called product passport of the components and their material qualities (including age, usage, location etc.) which provides them with verified data on the material and enables them to recycle the material again.

The above description of the plastic material's journey through the value chain, demonstrates how blockchain technology can be utilized to verify and trace material qualities. Closing the loop of post-consumer plastic through verified data about technical is of importance to the plastic waste problem. Moreover, we find the verified data on previous locations to be of interest to the partners, as the quality implications differ. In our opinion, the application of blockchain technology thus systematizes trust (which may or may not already be there) amongst the actors within the value chain and enables the recycling of plastic material from the aquaculture industry, back to aquaculture or to other industries, such as furniture manufacturing. We find that data generated through the application of the technology can in turn become valuable, as it also constitutes a verified source of certain types of plastics that can be utilized in other value chains across industries. Collaboration in circular innovation processes may take different forms, depending on the purpose and actors involved in collaborations. Blockchain technology may facilitate circular innovation processes actors across industries. Not only by enabling control and transparency in circular value chains, but also creating trust through the intermediary role of such technologies in transition processes.

6. Contributions

We aim to contribute to a better understanding of *collaboration mechanisms* in circular innovation processes, thereby providing an industry case of how collaboration in circular innovation processes may be facilitated through blockchain technology. Findings from this study enlighten our understanding of how digital technologies can contribute to circular innovation and the upscaling of circular value chains.

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Areas for feedback and development

Are there potential approaches or frameworks that could enlighten our study on collaboration mechanisms, or the intermediary role of digital technologies?