

# Information as a Circular Resource

## Facilitating Information Exchange to Extend Product-life

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*Document Version*

Accepted author manuscript

*Published in:*

Measuring Business Excellence

*DOI:*

[10.1108/MBE-09-2023-0131](https://doi.org/10.1108/MBE-09-2023-0131)

*Publication date:*

2023

*License*

Unspecified

*Citation for published version (APA):*

Jørgensen, R., & Scarso, E. (2023). Information as a Circular Resource: Facilitating Information Exchange to Extend Product-life. *Measuring Business Excellence*, 27(4), 651-662. <https://doi.org/10.1108/MBE-09-2023-0131>

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## Information as a circular resource – Facilitating information exchange to extend product-life

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### *Structured abstract*

#### **Purpose**

The transition from a linear to a circular economy model necessitates the creation of new services with embedded information exchange capabilities, in order to extend product life through maintenance and repair. Information exchange has been identified as a critical factor in advancing the principles of a circular economy, and this research was conducted to illustrate how information exchange can facilitate maintenance and repair.

#### **Design/methodology/approach**

The study has a case study approach collecting data through semi-structured interviews and questionnaire.

#### **Findings**

Information exchange on what and when to do something engage end-users in maintenance and facilitates learning. For repair, the problem description and possible solutions is information that must be exchanged. Both types of information exchange are facilitated by simple tech solutions relying on known and inexpensive technology (e.g., email service, video call, and text-messaging).

#### **Originality/value**

To the best of the authors' knowledge, this study is unique as it is empirically based insights on how information exchange can extend product life through use of simple digital tools.

#### **Research limitations/implications**

The study contributes to the organizational development and knowledge management fields with novel insights on how information exchange, and circular economy are related and can be facilitated.

**Practical implications**

The study provides insights for companies looking for solutions on how to generate revenue from services and reduce resource consumption. The findings of the study suggest that the development of circular business models does not always require expensive high-tech solutions.

**Keywords** – Circular economy, information exchange, product lifetime, case study

**Paper type** –Research Paper

## 1 Introduction

Circular economy aims at reducing energy and material leakage from systems to disconnect goods manufacturing from raw material and energy usage (Bocken et al., 2016; The Ellen MacArthur Foundation, 2013). To promote circular economy within businesses legislators are developing new policies e.g. European Circular Economy Action Plan, with the intent of increasing business focus on product life-time. Focus on product life-time is also promoted by changes in customer awareness and behaviours towards after-sales services to ensure better economic and environmental performance of products (Shokohyar et al., 2014). Changes in policy and customer awareness offer new business opportunities and force companies to change from a linear to a circular business model. A linear business is mainly characterized by financial value generated from material consumption for production of new goods. A circular business model contrasts with a linear business model by generating financial value by prolonging the useful life of the product, part and material in continuous cycles of maintenance, repair, reuse, refurbishing, remanufacturing and recycling (Geissdoerfer et al., 2020). From a resource perspective maintenance is generally prioritized over recycling because the functional value of the product is retained through maintenance (The Ellen MacArthur Foundation, 2013). Thus, policy and customer requirements change market conditions making the product life-prolonging activities *maintenance* and *repair* impending for companies to develop in the transition from linear to a circular economy.

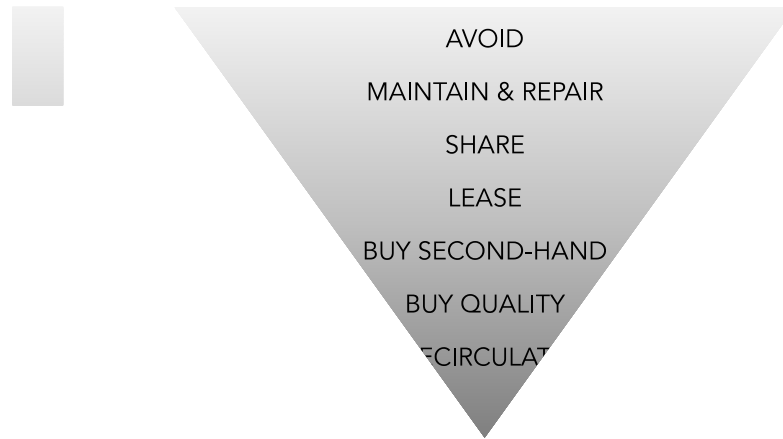
The efficiency and effectiveness of business models in a circular economy is dependent on information exchange spanning intra- and extra-organizationally (Bhatia et al., 2020; Bressanelli et al., 2022; Guldmann & Huulgaard, 2020; Škapa, 2019). However, there is scarce empirical evidence of integration between information exchange and circular business models (Atiku, 2020; Klapalová, 2019), and the link between information exchange and the principles of circular economy (Jäger-Roschko & Petersen, 2022). In particular there is limited research on after sales services and product life extension (Islam & Huda, 2018).

This study aims to contribute to the scarce research by investigating the case of two companies that facilitated information exchange to prolong the useful life of the product. Company A sold a service that assisted consumers in maintaining their white goods (e.g., washing machine and dishwasher), and company B refurbished and sold pre-owned white goods and guided consumers virtually in repairs. Collectively, the cases inform an analysis

of how information exchange prolongs product life through maintenance (Case A) and repair (Case B) and how information exchange is facilitated between actors in a circular economy.

## **2 Background: Circular economy and information exchange with customers**

A circular economy aims at keeping products in use for as long as possible to reduce the production of new goods and reduce waste volumes. An important enabler of keeping products (e.g. white goods) in extended use is to maintain and repair them (See Figure 1). The goal of maintenance is to avoid failure or decline so the product remains in the existing state of quality, functionality, and/or cosmetically. The goal of repair is to return a product to a usable state by fixing a defective or broken product or component (The Ellen MacArthur Foundation, 2013). Thus, maintenance and repair keep a product in good working condition and capable of delivering functional value to the end-user, thus increasing the functional value realized over time (Morseletto, 2020). Extending the lifetime of a product is not always a straightforward decision (Boldoczki et al., 2020) and requires assessment of *‘environmental benefits/drawbacks of extending the operating time of products that can be achieved due to specific design and maintenance actions, in comparison to their replacement with newer ones’* (Ardente & Fabrice, 2012, p. 72). This study focuses on repair and maintenance as services facilitated by information exchange between the product owner and a company providing the service. The two case companies provide empirical insights about how businesses can capitalise on circular economy through services prolonging product usage thereby supporting the claim that business models are required to facilitate the circular economy (Nußholz, 2018).



*Figure 1 – Consumer behaviour hierarchy (Maitre-Ekern & Dalhammar, 2019).*

### *2.1 Consumers role in Circular economy*

To transition from a linear economy to a circular economy the market must change from being dominated by a goods selling logic to a combined goods and service logic (Stahel, 1994). The shift requires that the role of a consumer changes from buying goods to buying more services, making the consumer an actor that contributes to the circular economy by buying and participating in services e.g. maintenance and repair (Maitre-Ekern & Dalhammar, 2019). Consumers become actors by becoming knowledgeable about the maintenance need of specific products, doing or buying maintenance, and accepting that products are exchanged less frequently (Maitre-Ekern & Dalhammar, 2019; Wilke et al., 2021). To increase repair, consumers must prefer to pay for repair instead of buying a new one, participate in repair, engage with repair communities, and accept more products as durable goods with a long lifespan (Maitre-Ekern & Dalhammar, 2019; Wilke et al., 2021). Enabling consumers to become actors of the circular economy requires addressing a range of barriers; product repairability, information about maintenance need, reducing the prices for repair and maintenance, spare part availability, and accessibility to service providers/centres (Cole et al., 2019).

## 2.2 *Information exchange to support circular economy.*

Extant studies underline the positive implications for integrating information flows with the circular economy (De Marchi & Di Maria, 2020). Still, intra-organizational information exchange requires facilitation of the actors' collaboration (Hansen & Schmitt, 2021), and a key enabling factor is trustworthy and strong relations between firms and units (Van Wijk et al., 2008). Relationship building can occur via actor collaboration on documents, e.g., maintenance guides (Mason & Leek, 2008). However, current information exchange practices focus on supporting production and sales of new goods, whereas the information flow related to repair and maintenance has received limited attention (Jäger-Roschko & Petersen, 2022). A central barrier to address for increased information flow is the facilitation of information access for actors in a circular economy network (Jäger-Roschko & Petersen, 2022). Removal of barriers is critical because information flow enables consumer to become actors within the life-cycle of a product and engage in life-prolonging maintenance and repair (Emmanouilidis et al., 2018).

## 3 **Research questions and methodology**

The study aims at increasing knowledge about the interaction between information exchange and circular economy, and to fulfil this aim the study is guided by two research questions:

1. What information needs to be exchanged between a consumer and a service company to facilitate maintenance and repair?
2. What facilitates the information exchange?

### 3.1 *Methodology*

To explore how information exchange support product life extension, the study uses a case study approach in the collection of data from two Danish start-up companies. A case study approach is relevant to explore the in-depth perspectives of an emerging phenomenon like circular business models that are in operation (Yin, 2009). Both companies were born circular with the purpose of extending the lifetime of white goods and home appliance (e.g. washing machine, dishwasher, coffee maker etc.). The companies were selected through purposeful sampling given the very limited number of potential cases and the ease of access to data. Company A informed the study of information exchange for maintenance and

company B informed the study of information exchange for repair. Data collection was facilitated by the lead author, who cofounded company A and B.

Case company A was a start-up born circular offering life-prolonging preventive maintenance for white goods and was called FIXRS. The company operated for 3 years (from 2020 to 2022) and assisted the end-user through a virtual DIY (Do-It-Yourself) solution comprising emails, monthly reminders (Figure 2) and video-guides (Figure 3). The reminders and guides were sent monthly and divided in a wheel lay-out, and the guides were accessible via the website and paying customers were emailed the reminders. The reminders were developed as short stories with video, pictures, and text, and the picture in Figure 3 show step 3 in the guide on how to clean the filter of a washing machine. The company had approximately 70 paying customers at the time it was closed, and the customers were both private and public (e.g. offices with small kitchens). The company closed because the business model was not financially viable.



Figure 2 – Overview of maintenance tasks for a year



Figure 3 – A still from a video guide in story format

Case company B existed from 2019-2022 and was called SimpleVerySimple (SVS). SVS was a privately owned company established with the purpose of creating a profit by reusing and refurbishing whitegoods and selling them to B2C and B2B. The company had a combined workshop and store near greater Copenhagen, where units were refurbished and sold as pre-owned. SVS incorporated information exchange between technicians and



customers to remotely diagnose problems and complete repairs through virtual guidance of the customer by the technician. Information exchange on repairs was initiated to reduce the cost of repairs by avoiding transport and to reduce the downtime of the unit. During the 3 years, approximately 3300 machines were processed of which 1100 machines were either reused or refurbished and sold, and the remaining 2200 were recycled at a professional recycling facility. SVS main supplier of raw material (used whitegoods) was the largest Danish retailer of whitegoods, which was supplemented with used whitegoods from various sources. The company was closed as it was not possible to find investors.

### *3.2 Data collection and analysis*

Data was collected and analysed with different methods for company A and B to cater for their differences in services provided, type of information exchanged, and methods used for facilitating information exchange.

Company A had a uniform customer base that received a comparable service; therefore, data was collected through a questionnaire to infer general conclusions about the impact of information exchange. Furthermore, during a workshop with key persons from the company data on the company information exchange flow was collected. The data was collected and analysed as follows:

1. The questionnaire was developed and validated with three independent informants. The questionnaire comprised three questions regarding the usage and impact of the reminders and guide and included an open-ended text field. A short questionnaire was preferred to increase response rate.
2. The questionnaire was emailed to previous customers with an explanatory message. No reminders were sent.
3. The questionnaire data was analysed and corroborated with quotes from the text field.
4. The information flow and one exemplary information exchange case were described during a workshop with two key persons.

Company B had limited cases (Situations with information exchange to repair a unit) and each case was considered unique in terms of the situation (Problem and repair) and the

customer. The characteristics suited a case approach studying the particularities, contextual factors, and common traits to inform general insight on information exchange for repair.

Data from Company B was collected and analysed as follows:

1. Two paradigmatic examples where a technician solved a problem and completed a repair over the phone were identified.
2. Semi-structured interviews with the technician were performed by the lead author to inform a qualitative based analysis of the identified examples. The interviews were recorded, transcribed, and coded.
3. Examples were analysed to derive findings of general validity.

## **4 Results**

In the following pages, the results of study are briefly illustrated.

### **4.1 Company A: maintenance**

The questionnaire was sent to 70 previous customers and 31 responded, yielding a response rate of 43%. Nine respondents left positive comments in the text field regarding the service in general and two respondents left critical comments about difficulties of judging the impact of maintenance, thus reducing their motivation. The majority of the respondents of question 1 (60.3%) affirmed that they to a large extent or complete extent learned something new about maintenance through the guides. One comment was positive towards the content of the guides e.g. *‘For a non-handyman the guides were great’*. However, two other comments raised an issue: The character of maintenance and how it fits the end-user's capabilities appear to have an impact, as two respondents left comments on maintenance tasks, they were unable to perform, such as moving a washing machine or refrigerator. Exemplified by this quote from a respondent: *‘It was demotivating to be reminded of tasks that I could not do, for example, pulling out the washing machine’*.

More than half (56.7%) of the respondents of question 2 considered the reminders to have a high or decisive degree on their behaviour for getting the maintenance done. This finding is supported by the open text field, where 9 of the respondents indicated that reminders were important to get maintenance done, as exemplified by this quote: *‘I think*

*the product was great, particularly because I was reminded of maintenance*'. One respondent stated that they already did some maintenance, and no negative comments were stated regarding the reminders. Most of the respondents to question 3 (53.1%) preferred either a specialized service company like company A or the producer (i.e. the OEM) as the provider of a maintenance service.

#### *4.1.1 Information exchange facilitation*

Company A organized the information exchanged between actors for maintenance purposes according to when, how, materials and why (see Figure 4). Company A enabled the information exchange between actors by aggregating, consolidating, and organizing information from multiple sources, such as Original Equipment Manufacturers (OEMs), interest groups, and publicly accessible resources. An example of this information exchange is the task of removing limescale from a washing machine. The user was informed as to when they should perform this task through a guide which was sent via email on a quarterly basis. The guide detailed how to remove limescale, including instructions on where to place the citric acid, what temperature setting should be used, and any additional maintenance required (e.g. cleaning the soap tray and filter). The necessary materials were also indicated in the guide. Lastly, the end user was informed as to the necessity of removing limescale (due to reduced power consumption and extended life of the heating element), as well as the rationale behind additional measures such as using the highest temperature setting, which helps eliminate grease and soap that accumulate alongside limescale inside the machine.

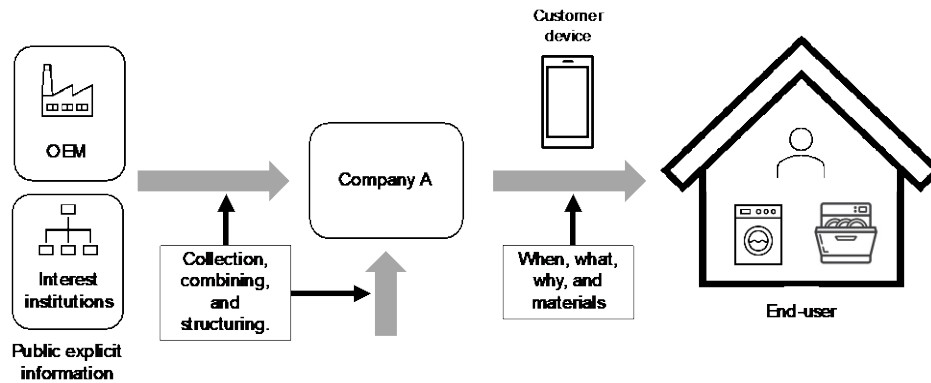


Figure 4 - The information exchange flow of company A

#### 4.2 Company B: Repair

Two cases of repair assisted by information exchange were identified with company B. These are examples of simple repairs that were handled over the phone and potentially avoid a technician driving out to the customer or the customer scrapping the machine.

##### 4.2.1 Case A: A piece of glass in dishwasher pump

A complaint was received from an end-user (customer of the company) in regard to a noise coming from their dishwasher during operation. A call was arranged between the end-user and technician to investigate the issue further. During the first call, the technician requested that the customer take note of any specific times during the wash cycle that the machine made the noise. Following a second call, wherein the customer indicated that the noise occurred when pumping water out, the technician hypothesized that a foreign object (e.g. a small piece of glass or porcelain) had become stuck in the pump and instructed them to vacuum it out for removal. Upon completing this action, confirmation was sent via mail confirming successful resolution of the problem.

##### 4.2.2 Case B: Lack of cleaning

An end-user reported a malfunction in their washing machine, which was experiencing slower than usual draining. Subsequently, a call was arranged with a technician who provided advice on how to thoroughly clean the pump-filter located within the unit. This filter captures larger objects such as coins and hairpins that are inadvertently deposited into

the machine with the laundry, and if blocked can affect the pump's performance. Following completion of this task, the end-user verified that the issue had been successfully resolved.

#### 4.2.3 Information exchange facilitation

In both cases A and B, the problem was identified and solved using a simple technical solution that facilitated the conversation between technician and end-user (See Figure 5). In both cases the information was exchanged between the technician and the end-user using a device (smart-phone) for audio call, video call, and email.

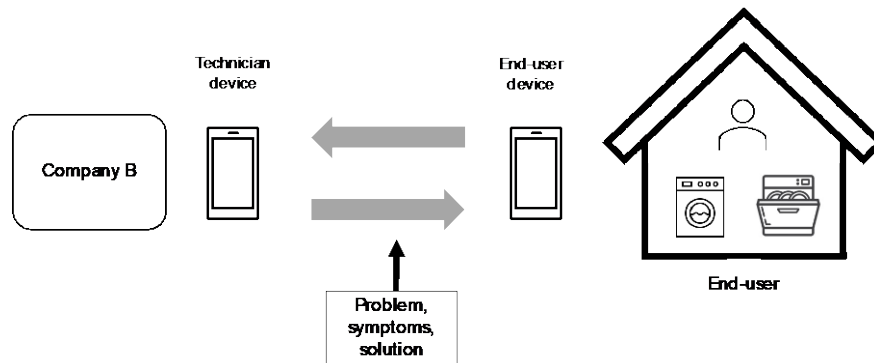


Figure 5 – The information exchange flow of company B

## 5 Discussion

The study aimed at increasing knowledge about the interaction between information exchange and circular economy through a case study attempting to answer two research questions: 1. What information needs to be exchanged between a consumer and a service company to facilitate maintenance and repair? 2. What facilitates the information exchange?

### 5.1 Information exchanged

In regards of question 1 the study finds that the information needs of end-users are different for maintenance and repair, respectively.

For maintenance end-users require knowledge about when to do something and what to do, which can be integrated to one information flow where a monthly reminder comprises

when and what. The information needed can be identified and comprised using existing and available knowledge on maintenance. The findings of the study highlight that end-users have limited knowledge about maintenance indicating the existence of a potential for operationalization of circular economy through reminders of maintenance.

For repair the information need is instantaneous, i.e., when a machine stops working, and the needed information exchange cannot be prepared but resides *in situ* with the end-user that must describe the problem, and the technician that must identify and communicate a remedy.

The study finds that user engagement with maintenance reminders declines with time, as demonstrated by a downward trend in emails being opened and clicked. This could indicate that end-users learn and thus are less prone to use the guides which is supported by the 60.3% of the respondents that learned something new through the guides. However, the decline could also indicate a need for feedback on the impact of maintenance to continuously engage end-user (Geelen et al., 2013), something which company A did not provide to their customers. Future studies could explore the user engagement by adopting a longitudinal approach to study barriers and enablers of long-term engagement which appear critical to motivate consumers to pay for services instead of goods (Maitre-Ekern & Dalhammar, 2019). Future research could also explore how communities of practice could be intentionally developed to support a maintenance practice and develop maintenance guidelines (Jørgensen et al., 2019).

## 5.2 Facilitation of information exchange

Regarding question 2, the study determined that basic technological solutions (which rely upon existing and readily available technology, such as email subscription services and text messages) can support information exchange and facilitate life-extending maintenance and repair. Companies can employ a standard email/text messaging system to communicate with consumers about maintenance, while video guides can be produced using free software. For repair purposes, a simpler video/voice call service was utilized.

The technologies being employed by these companies are uncomplicated and come at an exceptionally low cost. This differs from previous research, which identified slow diffusion of technology as a hindrance to information exchange, often attributed to high investment expenses (Jäger-Roschko & Petersen, 2022). This study introduces a novel

perspective on this barrier: while the diffusion rate of technology remains slow, cost is not the primary impediment. Instead, the slow adoption rate may be attributed to companies' failure to create services reliant on the technology, or possibly their tendency to pursue overly ambitious technological solutions, thereby neglecting straightforward and readily accessible alternatives.

The technical solutions identified in this study do not rely on monitoring end-users through sensors; thus, the barrier of privacy is not present (Kim et al., 2017). However, not having sensors makes the advice on maintenance simpler by relying on pre-determined timing on when to do something instead of analyzing data and providing specific advice. This could potentially reduce the impact of maintenance. The findings suggest a potential trade-off between a simple-tech, low-cost, and non-intrusive solution and a high-tech, high-cost, and high-intrusive solution, and future studies could address the trade-off and how the different solutions engage end-users.

### *5.3 Facilitation of network information exchange*

The research confirms that information sharing plays a crucial role in promoting the concept of a circular economy (De Marchi & Di Maria, 2020). Furthermore, the study underscores the importance of streamlining information exchange between various stakeholders, with the companies examined in the case study taking on the role of information facilitators. In this context, Company A emerged as a vital facilitator for the exchange of information. This was especially important because homeowners typically possess white goods from multiple Original Equipment Manufacturers (OEMs), necessitating the accumulation of knowledge from various sources to effectively present it to consumers. By expanding the conceptual network of actors to include OEMs, the process of information exchange can potentially gain increased value. Because when OEMs facilitate activities like maintenance and repair for their products, the activities can contribute to ESG reporting as scope 3 reducing initiatives (Figure 6). Companies facilitating the information exchange and that have access to product brand and information regarding maintenance and repair, have the potential to monetize the data by selling it to OEMs.

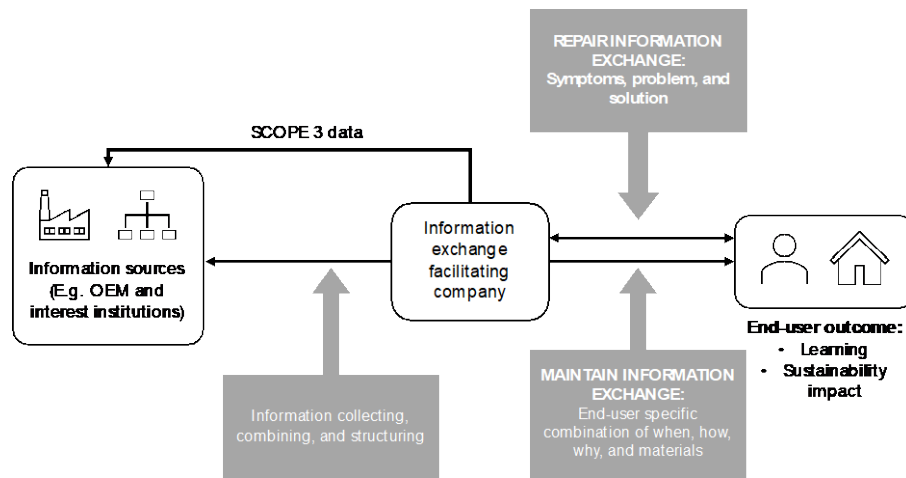


Figure 6 – The extended information flow

## 6 Conclusions

Circular business models are important enablers of the transition towards a circular economy, and integration of information flow with the use of a physical product improves efficiency and effectiveness of the business model. There is, however, a lack of empirical evidence for the link between information flow and the life-prolonging activities maintenance and repair (Jäger-Roschko & Petersen, 2022). This study contributes with empirical data from a case study aiming at answering the research questions: 1. What information needs to be exchanged between a consumer and a service company to facilitate maintenance and repair? 2. What facilitates the information exchange?

The study finds that information exchange depends on to the specific nature of the activity in question: For maintenance information exchange about what and when to do something facilitates that end-user's engagement, however, the long-term engagement remains unclear. Information exchange for maintenance can be facilitated through low-tech and low-cost solutions. For repair, the problem description and possible solutions is information that must be exchanged when the problem emerges, and a simple voice and video call can facilitate repairs that prolong product life with a minimum cost for the end-user.



For practitioners, the study provides suggestions on tools that can facilitate information flow and what kind of information to share with the end-user to engage them in extending product life.

The study is not without limitations. In particular it is affected by the usual limitations of a case study methodology, and especially the difficult generalization of the results from just two case companies. However, given the scarce number of circular business models in operations the limited data set demonstrates a potential calling for further studies and experiments with creating circular business models.

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