Circular economy

Factors affecting the financial performance of product take-back systems

Uhrenholt, Jonas Nygaard; Kristensen, Jesper Hemdrup; Rincón, Maria Camilla; Jensen, Steffen Foldager; Wæhrens, Brian Vejrum

Published in:
Journal of Cleaner Production

DOI (link to publication from Publisher):
10.1016/j.jclepro.2021.130319

Publication date:
2022

Document Version
Publisher's PDF, also known as Version of record

Journal of Cleaner Production 335 (2022) 130319

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Circular economy: Factors affecting the financial performance of product take-back systems

Jonas Nygaard Uhrenholt [a,b,*], Jesper Hemdrup Kristensen [a], Maria Camila Rincón [a], Steffen Foldager Jensen [a], Brian Vejrum Waehrens [a]

[a] *Center for Industrial Production, Department of Materials and Production, Aalborg University, 9220, Aalborg Øst, Denmark*
[b] *Technology & Business Department, University College of Northern Denmark, 9200, Aalborg SV, Denmark*

ARTICLE INFO

Handling Editor: Mingzhou Jin

Keywords:
Closed-loop supply chain
Circular business model
Circular product design
Literature review
Sustainability
Re-manufacturing

ABSTRACT

Product take-back systems are fundamental for Circular Economy (CE) and focus on recovering value by taking back products to be recycled, re-manufactured, or refurbished. In theory, the expected value from CE is undeniable. However, in practice product take-back systems are often in small/pilot scale or have difficulties becoming financially viable, which is an obstacle towards the widespread adoption of CE in practice and thus a barrier to achieving a sustainable manufacturing system. This study uses a structured literature review to explore the factors affecting the financial performance of the product take-back system and investigate how 12 factors, clustered into three different dimensions; context, supply chain, and company, affect financial performance. Based on these findings, two propositions are made on how these factors are interrelated in a system perspective and how further research should build on these findings.

1. Introduction

The CE, in which product take-back is an essential element, is promoted as an alternative to the traditional and currently dominating linear economy. The difference between the two is the emphasis on the regenerative and restorative elements in CE, as opposed to the current take-make-use-dispose mindset of the linear economy. In a European context, CE is estimated to have the potential of increasing the European Union's GDP by 0.5% while creating approximately 700,000 new jobs (Cambridge Econometrics et al., 2018).

As a result, CE is gaining traction within academia and industry (Geisdoerfer et al., 2017). Some authors have focused on how to incorporate CE into organizations by emphasising re-design of business models (Yang et al., 2018), product design (Bocken et al., 2016), reverse logistics, e.g. through biomimicry (Bockholt et al., 2019), or legislation (Atasu and Van Wassenhove, 2012). Others have emphasized the link between digital technologies and CE by focusing on using information technology to enable reverse logistics (Jayaraman et al., 2008) or the use of Internet-of-Things technologies and Big Data to enable Product Service-Systems (Pagoropoulos et al., 2017). Among these, Take-back systems are argued to play an important role in the CE to realize the exploitation of residual value of products by closing the loop between end-of-life and production (Bocken et al., 2016). Despite the potential benefits from CE and increasing academic interest in this domain, the industry is challenged in designing economically feasible take-back systems (Sepúlveda-Rojas and Benitez-Fuentes, 2016), e.g. Hvass and Pedersen (2019) call for research in the development of economically viable business models based on take-back systems. This is one of the barriers to widespread adoption of CE practices. To remedy and explore this potential, the objective of this study seeks to understand the factors influencing the financial performance of product take-back systems. This is explored through the research question:

What factors affect the financial performance of product take-back, and how do they affect the financial performance?

The paper aims to explore the factors within the system of a product take-back system that affects its financial performance. By identifying factors affecting the system's financial performance, we aim at enabling managers to assess and establish take-back systems, overcoming a central barrier, namely the economic viability (Sepúlveda-Rojas and Benitez-Fuentes, 2016), as well as providing areas for further research. To do so, it is crucial to understand how the building blocks of financial performance stack up, how they influence the overall performance and each other, following the system perspective advocated in CE related studies (e.g. Alamerew and Brissaud, 2020). By product take-back

* Corresponding author. Center for Industrial Production, Department of Materials and Production, Aalborg University, 9220, Aalborg Øst, Denmark.
E-mail address: jonasn@mp.aau.dk (J.N. Uhrenholt).

https://doi.org/10.1016/j.jclepro.2021.130319
Received 12 May 2021; Received in revised form 15 December 2021; Accepted 28 December 2021
Available online 1 January 2022

systems, the focus in this study is on discrete products, i.e. the technical sphere of the well-known butterfly model by the Ellen MacArthur Foundation (EMF, 2013).

The remainder of the paper is structured as follows: Section 2 describes the conceptual framework used to guide the literature study. Section 3 describes the research methodology utilized in performing this review. Section 4 presents the descriptive findings of the papers identified during this review. Section 5 presents the findings of the review, focusing on the identification and analysis of design factors. Section 6 present the discussion, focusing on the systems perspective in this research domain. Lastly, section 7 provides concluding remarks of this study.

2. Conceptual framework

For this study, a conceptual framework is developed to guide the design and analysis of the review. The conceptual framework is defined according to our prior understandings and expectations of the primary elements/categories/sources of factors influencing the financial performance of take-back systems, which will be iteratively expanded during the review process. We define a take-back system as an operational set of processes including the collection of end-of-life (EoL) products, transportation, sorting and disassembly, requalification, and re-engagement of the recovered material, components or products in the forward supply chain. From the organization's point of view, the financial performance of this system is affected by factors on both macro, meso, and micro levels. At the macro-level, external factors, such as national and international legislation (García-Quevedo et al., 2020), affect financial performance. The individual organization cannot control these factors. However, the organization can improve its financial performance by adopting its activities in accordance with these external factors. At the meso level, the supply chain-related factors, such as reverse logistics (Bockholt et al., 2019), influence financial performance. These factors are partially controllable by the organizations, as collaboration with external partners often limits the absolute control of the system. At the micro-level are the internal factors which the organization can control, such as the business model (Yang et al., 2018), product-related- (Bocken et al., 2016) and operations related factors, such as product design or use of technologies (Jayaraman et al., 2008).

These three levels are utilized as a guiding structure for conducting this literature review; however, they are referred to as *Context* (macro), *Supply chain* (meso), and *Company* (micro). These three categories are considered to be nested in a hierarchy. The context is overarching both the supply chain and the company, and the supply chain is overarching the company, as depicted in Fig. 1.

3. Research methodology

This study utilizes the systematic review technique (Quarshie et al., 2016; Jeagler et al., 2017), with the goal defined as "integrating a number of different works on the same topics, summarizing the common elements, contrasting the differences, and extending the work in some fashion" (Meredith, 1993, p.8). In this study, the purpose is to extend the knowledge of economic factors in CE. The study utilizes the five-step method developed by Denyer and Tranfield (2009): formulating questions, locating studies, selecting and evaluating studies, analysing and synthesising, and reporting and using the results. All method steps are utilized throughout this study, therefore are explained in this methodology section; except for the final step. Step five, *reporting and using the results*, is the output of the subsequent sections.

3.1. Formulating questions

The first step of the systematic literature review concerns formulating researchable questions to guide the review. The research question for this study was formulated in the introduction, and is repeated here:

RQ: "What factors affect the financial performance of product take-back, and how do they affect the financial performance?"

3.2. Locating studies

The purpose of the second step in this method for a systematic review is to search for academic material within the investigated field from the research question. It is done by utilizing a range of explicit criteria determining whether to include or exclude the material (Denyer and Tranfield, 2009). Therefore, the following pre-specified criteria are proposed to select the literature to include in this study:

- The papers included in this study should be written in English and have been peer-reviewed.
- Scopus (www.scopus.com) database is chosen for this review as it is a recognized database used widely in academia (Falagas et al., 2008, Tukker, 2015; Pinho and Mendes, 2017). Furthermore, this database is considered the largest source of abstracts and academic citations (Sehnem et al., 2019).
- The type of papers included should be articles and reviews. These should only be within the subject area of 'Business, Management and Accounting', as defined by the Scopus database, as a means to target papers concerning industrial development and operations management.
- The keywords' circular economy' or 'take-back' is searched for the title of the papers. In contrast, the keywords' financ*', 'economic*' or 'business case*' was searched for title, abstract and keywords in the papers.

In many other literature reviews, a criterion for publication date is specified to ensure that the included studies represent the newest data (e.g. Geissdoerfer et al., 2017; Govindan and Hasanagic, 2018). No publication date limit was defined for this study, as a search in the Scopus database revealed a lack of publications before the year 2006 when utilizing the criteria mentioned above.

The research domain of CE has a legacy in other research topics that are not included in the search keywords. This is expected to limit the findings in the sense that the legacy topics are only included to the

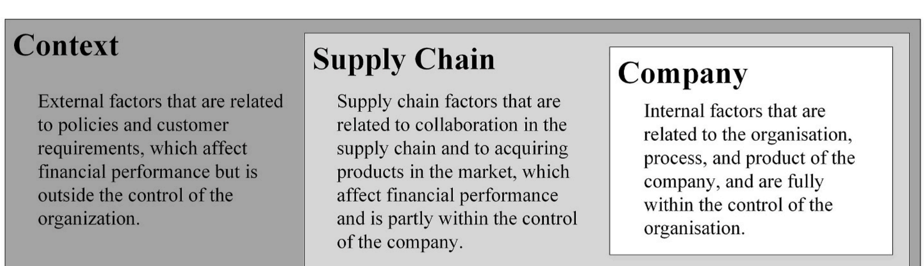

Fig. 1. Conceptual framework.

degree that the identified research papers are based on these topics. The legacy topics include, but are not limited to, Economics (Boulding, 1966), Industrial Ecology (Frosh and Gallopoulos, 1989), and eco-innovation (Rennings, 2000). Within the domains of operations and supply chain management, the topics are reverse logistics (e.g. Blackburn et al., 2004), green and sustainable supply chains (e.g. Genovese et al., 2017), and product re-manufacturing (e.g. Hatcher et al., 2011).

3.3. Selecting and evaluating studies

The third step aims to define the explicit criteria utilized to include or exclude the papers identified in the search. The criteria are the following:

- Related: By consulting the abstract of said papers, those not related to the scope of this study are excluded. A paper is deemed related when it satisfies the following four criteria:
  - o The paper must address Circular Economy as a primary topic.
  - o The paper must address economic performance.
  - o The paper must address the context of the company.
- Relevance: By consulting the entirety of the remaining papers those that are not relevant for this study are excluded (i.e. design factors for take-back systems)

Fig. 2 summarizes our process for the literature review. The search, conducted at the beginning of January 2021, utilized the criteria for the location of studies, resulted in 284 papers from the Scopus database.

The abstract of 284 papers was investigated to determine if their individual content was related to the scope of this study; this was done according to the four previously defined criteria. The authors divided the located papers into three equal parts. Each author investigated the abstracts ("Are the papers related?") for one part of the papers. Subsequently, the remaining papers were rotated among the authors for the relevance check and coding of the papers. This rotation of papers among the authors was meant to mitigate the limitation of researcher bias, as at least two authors handled every paper. In both phases, all authors investigated a few papers. The authors discussed these papers and their coding of the paper to ensure coherence among the authors. From this investigation, it was found that 125 papers satisfied all four criteria of fit. The remaining 159 papers were excluded and will not be considered for the remainder of this study. From reading the full papers, it became evident that several papers were not relevant to this study, despite their abstracts indicated otherwise. A total of 46 articles were removed from the investigation, leaving 79 papers for the remainder of the study.

3.4. Analysing and synthesising

By adopting Mayring (2010) framework, for category selection and material evaluation, the deductive and inductive approaches are deployed iteratively (Mayring, 2010; Merli et al., 2018). The deductive approach is utilized to select and evaluate the material, i.e., predefined selection and evaluation criteria. These variables worked as a guideline for the initial coding of the research findings. The initial variables, Table 1, are based on the authors' knowledge and expectations of relevant design factors in this field. When reviewing the identified papers, the coding for the factors is included when the financial performance of the factor is addressed, i.e. it is affected by the particular factor. In

Table 1
Initial coding keys for literature review.

Coding Category	Coding variables
Meta	Title, Authors, Country, University, Year, Journal, Method, Aim of study, Context
Context	Trans-national legislation, National legislation, ISO standard. Branding/Goodwill
Supply Chain	Supply chain tiers, Countries involved, Relationship and power balance, Contact with product or customer, Logistic provider relation, Business model, Spare part management, Integration into forward supply chain
Company	Functional value*, Material value, Recyclability, Product clock speed, Modularity, Wear and tear, Composition of material, Product life cycle, Maintenance plans, Manufacturing quality, Internal capabilities, Disassemble or recycling options, Salary level, Process cost, Handling cost, Inventory cost, Investment cost, Overhead cost
Miscellaneous	Miscellaneous

*The value provided by the functioning product (e.g. the washing machine washing clothes, rather than the material the machine is built from).

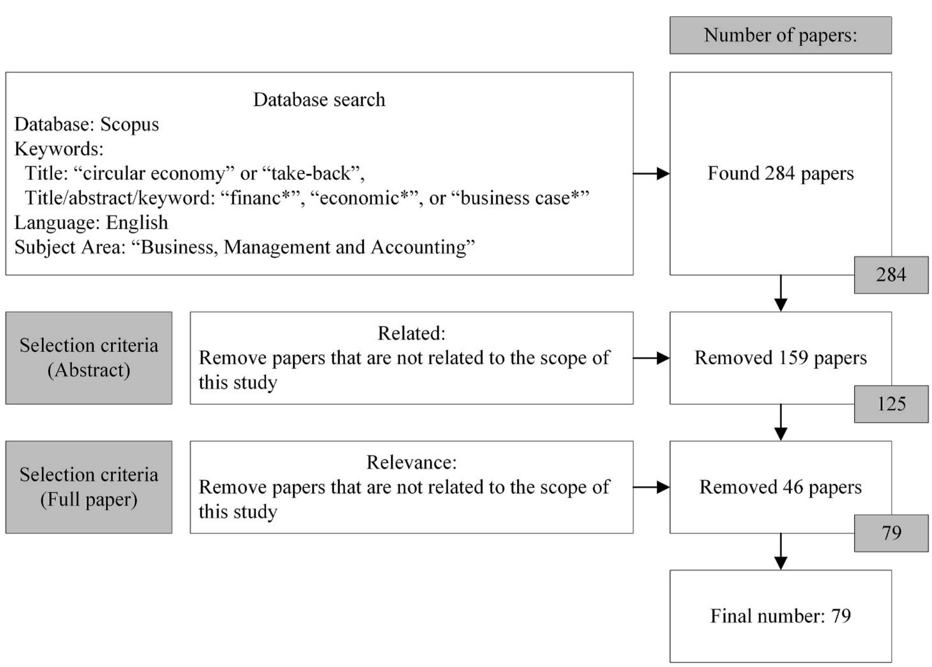

Fig. 2. Data collection and selection.

financial performance a distinction is made between cost, i.e. increase or decrease of expenses of operating take-back systems and value, i.e. increase or decrease of the value generation such as revenue in the take-back system. The inductive approach is utilized during the categorization of findings from the reviewed material. The categorization and thereby the clustering of the findings are derived from the material itself, i.e. categories emerge when a topic is addressed repeatedly in several sources within the limits of this review. Before categorising findings from the review, a range of descriptive dimensions, namely: year of publication, representation of journals, representation of affiliations, are considered in this study.

4. Descriptive analysis

The descriptive dimensions are studied to unfold the current research efforts put into the design factors affecting take-back systems, which serves as indicators for the current maturity of this research topic.

4.1. Publication year

The distribution of the 79 analysed papers in the year of publication is presented in Fig. 3. The number of publications concerning economic factors in take-back is relatively low; indicating the current research into this domain is underdeveloped. However, the number of publications is increasing significantly from 2016 and onwards, which shows that the academic interest in economic factors of take-back systems is growing. From the academic point of view, the interest in this topic emerged in 2009 which can be assumed to be caused by the increasing interest from governmental entities, such as China, which began its regulatory implantation in 2009 (Geissdoerfer et al., 2017; Govindan and Hasanagic, 2018). The delay from the regulatory implementation to the increase in publications may be explained by the nature of this paper search as economic performance usually is not the first aspect of the domain to be dominant in academic publications, given the transition from descriptive to normative theory. Furthermore, the development of CE, and therein take-back, is currently moving from a societal level to an organizational level which can justify the increased attention towards economic factors at the micro-level (Merli et al., 2018).

4.2. Publication outlet

A clear trend is found in the outlet utilized for the publication of investigated studies. While many different journals (15) are represented in the selected material, few are repeatedly found. The Journal of Cleaner Production dominated the field of outlets as this journal alone represented 42 of the 79 (53.17%) included publications. Business Strategy, and the Environment (10.13%) and International Journal of Production Research (6.33%) are the second and third most represented journal, respectively. The wide representation of different journals is indicative of the multi-disciplinary nature of CE. According to Scopus, the utilized database, the represented journals concern research domains such as, but not limited to, Arts and Humanities, Business Management and Accounting, Environmental Science, and Social Sciences. This multi-disciplinary nature of CE emphasizes the need for adopting a systems perspective when embarking on take-back systems, as adopting a single-discipline view limits the potential of creating and capturing value (Howard et al., 2019).

4.3. Author affiliation

A wide array of countries are represented in the analysed papers. However, the United Kingdom (45 authors affiliated in the United Kingdom), Brazil (29), Italy (29), China (21), Denmark (20), and the USA (19) are engaged in most of the research relevant for the scope of this study. According to this count, major economies are falling behind, which can be explained by a different national focus in research of CE. The top-down approach deployed in China may result in more macro- and meso-economic related research, while the bottom-up approach in the European Union incentivises research in the micro and meso-economic areas (Ghisellini et al., 2016).

4.4. Methods

The papers included in this review are categorised according to their deployed method, here, a majority of the analysed papers, 26 papers, are case studies (32.91%). This is a mix of single- and multiple- case studies. The second most used method, 15 papers, are modelling (18.99%). The third most represented method, 12 papers, is literature review (15.19%), dominantly systematic literature reviews. These are not specifically focusing on take-back, rather CE or sustainability. However, take-back is referred to, e.g. as being enabled by the theme in question for the individual literature review. Generally, for the analysed papers the focus is on a narrow range of the identified economic factors, i.e. some papers have a primary concern for the product in take-back while others are focusing on legislation, etc. No paper is found, presenting a complete overview of economic factors.

4.5. Context

Current research containing insights into the economic feasibility of take-back is conducted in a wide variety of contexts. The most frequent context, 13 papers, found in the papers are concerning one or multiple specific countries (16,45%). This is indicative of the heterogeneous nature of CE, i.e. differences in legislation related take-back or differences in infrastructure, etc. (e.g. Atasu et al., 2012). The second most frequent context, 8 papers, is concerning textiles (10.13%) (e.g. textile, clothing, leather) followed by electronic, 7 papers, (8.86%) (e.g. household electronics, smartphones, disk hard drives) as the third-most frequent context. Common for all contexts, which are studied more than once, is that they are often highlighted in the general sustainability

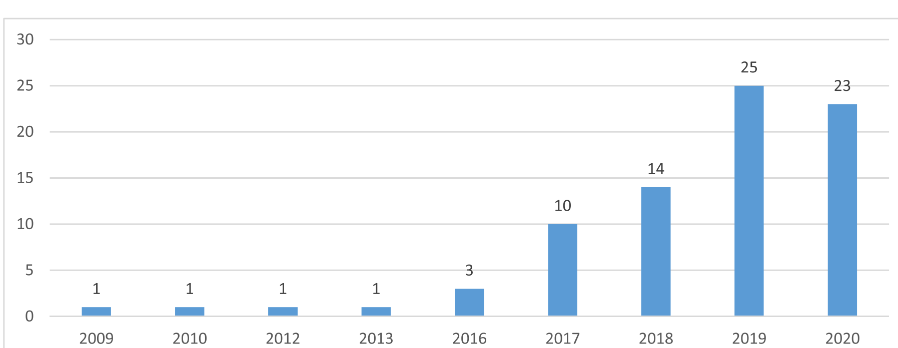

Fig. 3. Distribution of papers (years).

discussion for being high-value and/or high-waste contexts (e.g. Bundgaard and Huulgaard, 2019).

5. Findings

During the analysis, 12 factors were identified and subsequently clustered into three overall dimensions, one containing two sub-dimensions of a take-back system. The dimensions are:

- *Context* – External factors to the individual organization, such as public governance structures.
- *Supply Chain* – Factors related to the supply chain of the individual organization, such as supply chain actors and collection methods.
- *Company* – Internal factors to the organization such as earning models and customers. Two sub-dimensions are identified:
  - o *Product* – Factors directly related to the product, such as the EoL value and product design.
  - o *Operations* – Factors related to the handling and treatment of collected EoL products.

5.1. Context

Legislation and regulation is primarily referred to as constraining to the financial performance through taxation on labour (Veleva and Bodkin, 2018) and weight (Atasu et al., 2013) rather than resources and material composition, as well as imposing regulatory obsolescence, as found in Chouinard et al. (2019), decreasing the value generated by the product in the market. Furthermore, lack of regulatory homogeneity across the European Union also imposes costs for organizations operating in certain countries. This is exemplified by Daddi et al. (2019), as Italy have a ministerial decree imposing requirements for hygienic sanitization of products, which imposes processing cost and thus negatively influences competitiveness. Lastly, legislation is in some cases found to be limiting business model innovation, such as providing product-as-a-service (PaaS) through dynamic earning models across supply chains (Fischer and Pascussi, 2017), limiting the incentive for improving materials and product utilization. At an operational level, the cost of complying with regulation, i.e. the time and resources put into administrative and legal procedures, is identified as a barrier to CE adoption (García-Quevedo et al., 2020). E.g. the European waste directive impose increased documentation requirements when transporting EoL products, containing hazardous parts, across country borders, which, in turn, decrease availability of logistics providers (Bockholt et al., 2020). However, the legislation also forces positive change by providing enabling infrastructure to reduce cost and create market conditions through, for instance, municipal-controlled collection systems (Atasu et al., 2009), or by introducing fees for discarding EoL products, creating an incentive for consumers to re-use products (Parajuly and Wenzel, 2017).

Standards, when existing, are found to be beneficial for financial performance. Hopkinson et al. (2018) found that the focal case improved their financial performance by using standards (e.g. ISO or EMAS), specifically through reduced cost by influencing broader system enablers and conditions to support circularity. In addition, they found that industry standards for categorising re-manufacturing products to guaranteed original specification increased value by reducing customer uncertainty.

Financing of CE is essential for enabling investments towards the take-back system. It is found that financial institutes lack awareness and trust of profitability within the domain (Fischer and Pascussi, 2017), leading to the perception of investments as a barrier to achieving better financial performance, whether being through cost reductions or increased value capture (Daddi et al., 2019). Alternatively, co-financing options are emerging in stakeholder collaborations and governmental funding is becoming viable options when pursuing investments to promote CE in organizations (Fischer and Pascucci, 2017). As an alternative means for raising capital, public financing is argued to provide governmental support to CE development in the private industry. From their study of financial sources, Ghisetti and Montresor (2020) argues that self-financing should be the most preferable way of financing the CE transition, followed by public financing, and lastly debt financing.

As summarized in Fig. 4, the context is found to affect cost and value through three factors; Legislation, Standards and Financing. Several cases found that legislation negatively affects the financial performance, both through cost and value, of CE through several means. This indicate a need for further actions within the domain to stimulate the adoption of CE in practice. Standards are reported as positively affecting CE financial performance, especially by removing the barrier towards customers unwillingness to purchase re-manufactured products. Lastly, lack of financing options is seen as an obstacle that affects the companies' ability to seek cost reductions and increased value capturing, calling for more awareness on CE from banks, as well as the option for public co-financing if the companies cannot finance initiatives themselves.

5.2. Supply chain

Partnerships and collaboration are highlighted in the domain of take-back e.g. exchanging knowledge and experience with universities, research centres, suppliers and retailers (Rossi et al., 2020). Similarly, by collaborating across their supply chain, e.g. with third party waste collectors, companies are enabled in achieving economies of scale, e.g. by pursuing multiple reverse loops from one take-back operation rather than only pursuing one recovery strategy (Hopkinson et al., 2018). However, major companies report low and varying maturity across supply chains (Veleva and Bodkin, 2018), resulting in increased cost for product recovery and reduced value capture. This is due to the need for close collaboration to build technological capabilities for up-cycling EoL products (Fischer and Pascussi, 2017), leaving value unrecovered and/or making operations more expensive. In this discussion, the large companies call for more industry collaboration to catalyse efforts, through seamless transaction of product and use data (Veleva and Bodkin, 2018). Hvass and Pedersen (2019) presents a case concerning a partnership between a manufacturer and waste handler, in which the profitability of the manufacturer is linked to the collected volumes. Other examples of such collaborations revolve around the extended producer responsibility (EPR) where manufacturers are found to outsource this responsibility to Producer Responsibility Organizations (PRO). Through economies of scale, the PROs can provide more economically efficient recovery and recycling of products (Singh and Ordoñez, 2016).

For *reverse logistics,* the extant literature presents a primary trade-off between achieving economies of scale, e.g. by partnering with third party waste collectors, and maintaining control and IPR. The cost of reverse logistics is highlighted by Bockholt et al. (2020) in their discussion of consolidation. Less consolidation of products in the reverse logistics result in more frequent shipments with lower quantities, leading to higher reverse logistics cost. Hopkinson et al. (2018) point towards lack of homogeneity in the European market as a constraining cause as organizations operating in multiple European countries are unable to achieve economies of scale in their take-back operations, as they are forced to manage different take-back systems in different countries. However, while the consolidation of EoL product collection has the benefit of economies of scale, it comes at the expense of control (Zhang et al., 2019). While companies maintain IPR in isolated collection systems, lack of scale makes such systems costly to operate (Atau and Wassehove, 2012). The collection infrastructure for EoL products is assumed to have a linear cost-to-product ratio when municipal actors conduct the collection, but non-linear when the individual organization conducts the collection (Atasu et al., 2009). When organizations choose to manage the logistics internally, proximity to products and customers is highlighted as essential for a cost-efficient take-back system (Hvass

Context	Financial performance: Cost	Financial performance: Value
Legislation	**Increased** due to taxation of labour and weight, and the disparity between national legislations. **Decreased** due to creating infrastructure for take-back.	**Decreased** due to regulatory obsolescence.
Standards	**Decreased** due to affecting system enablers.	**Increased** through standards for remanufacturing products removing customer uncertainty.
Financing	**Increased** from limited financing options for investment in cost reduction. **Decreased** from potential public financing in take-back	**Decreased** due to limited financing options for improved value capturing.

Fig. 4. The effect of Context of cost and value of product take-back.

and Pedersen, 2019). From a process perspective, early inspection and sorting allow for more appropriate treatment of products (Coughlan et al., 2018) and reduced inventory cost (Hopkinson et al., 2018) of collected products. In cases where the organization is dependent on the consumer to sort the materials, Guo et al. (2017) finds that high-value materials and simple materials are recycled more than those of low value and those products with different and hard-to-distinguish materials. Hence, high value and simple materials are less costly to recycle as its in-flow into the take-back system is more effective. Cost savings achieved in re-manufacturing create incentive to put more resources into collecting EoL products (Huang and Wang, 2017). Through modelling, Huang and Wang (2017) finds that achieving cost savings in the re-manufacturing process creates an incentive to put more resources into the collecting process. This redistribution of resources in the reverse logistics network allow for a faster collection process with a more sophisticated decision-making process, allocating the EoL products properly, according to their quality (Huang and Wang, 2017). The manufacturer can face larger recovery fees if governmental entities conduct the collection process, and a misbalance is found between economic and environmental oriented performance measures (e.g. pollution prevention vs. pollution control) (Atasu et al., 2013). Where producers are forced to join monopolistic collection systems (in which, during collection, their products are mixed with other products) their products are recycled for material value only. This removes the incentive to invest in closer recovery loops, e.g. re-use (Atasu and Wassehove, 2012).

As summarized in Fig. 5, the Supply Chain dimension is found to affect cost and value through two factors: Partnerships and collaboration and Reverse logistics. Engaging in partnerships and collaboration is reported to lead to reduced cost, while the lack of engagement imposes increased cost and reduced value generation. In reverse logistics, consolidation and use of 3rd party providers can reduce costs from economies of scale while cost can increase in cases of dispersed products and the need for frequent shipments.

5.3. Company

Business models involving take-back systems are widely discussed in the literature, however, mostly concerning supporting the environment through material efficiency or material sufficiency, which in turn also reduces material cost (De los Rios and Charnley, 2017). A primary element is the interaction with the customer, e.g. leasing, payback variants (Svennson and Funck, 2019), or service plans (Urbinati et al., 2017). One way of creating this relationship is by offering customers a rebate for returning products, reducing revenue and reducing the cost for collecting EoL products (Hopkinson et al., 2018). Furthermore, by keeping ownership of products, through servitized business models companies can increase financial performance through increased value generation, by lengthening the product life-cycle (Tunn et al., 2017). The more servitized the business model the more efficient the product take-back is, as 'pay-per-uptime' business models already have existing reverse supply chains (Bockholt et al., 2020). In the traditional product-based business models, increased complexity and risk of cannibalizing market share of virgin products emerge. Thus, inevitably decreasing the value (Werning and Spinler, 2019) leading to recommendations to keep forward and reverse business models separate (Hopkinson et al., 2018), (e.g. establishing separate retail systems for second-hand products (Bundgaard and Huulgaard, 2019)) and to share both value and risk across supply chain levels (Mishra et al., 2019). Wang et al. (2020) argue that cannibalization between virgin and second life products is limited, as re-manufactured products target different segments in the market. From a less positive perspective, respondents in Jaeger and Upadhyay (2020) study state that recycled material is more expensive than virgin material, in reasoning for the lack of cradle-to-cradle focus in their business model. Additionally, the perception of low assurance of success for adopting circular business models, have led to organizations awaiting demonstrations of other businesses (Gue et al., 2020).

Customer awareness affects the financial performance of take-back

Supply Chain	Financial performance: Cost	Financial performance: Value
Partnerships and collaboration	**Increased** due to not utilizing capabilities in the supply chain from lack of collaboration. **Decreased** by collaborating with 3rd-party waste collectors to achieve economies of scale.	**Decreased** as value if left unrecovered due to not utilizing capabilities of supply chain partners.
Reverse logistics	**Increased** by frequent, dispersed, and low volume shipments. **Decreased** by using 3rd-party waste collectors, early sorting and proximity to products.	**Decreased** if IPR is lost in the consolidated systems.

Fig. 5. The effect of Supply Chain of cost and value of product take-back.

systems, as customers both demand and supply products, thus affecting both cost and value (Lieder et al., 2018). Means such as communicating performance measures (e.g. reduction in CO2 and re-manufacturing cycles) build customer awareness and brand value (Veleva and Bodkin, 2019), thereby affecting sales. Sharma et al. (2020) find that extra cost is imposed to incorporate reused materials and components into products. Consumers tend to avoid products made of waste as this is considered a 'used' product. The study itself, and also the study by Hopkinsson et al. (2018) finds nuances to this, as they find certain customer groups who favour reused or re-manufactured products, creating a potential for new markets and increased value. Hvass and Pedersen (2019) found that providing a discount voucher for returning products both increased awareness, the flow of take-back products and gave a rebound effect for new sales. Thus, increasing the cost through voucher investments, while reducing the cost of take-back.

As summarized in Fig. 6, the Company dimension is found to affect cost and value through two factors: Business model and Customer awareness. The financial performance in take-back is affected by adopting servitized business models, through increased value generation by extending product life cycles and reducing costs (through eased collection) by engaging with the customers. Furthermore, the risk of cannibalizing market share, i.e. reducing value generation, between virgin and non-virgin products leads to increased cost by operating separate supply chains, with the potential benefit of creating a new market for re-manufactured products. Customer awareness is reported to affect value generation both positively and negatively from conflicting perceptions of re-manufactured products. Customer awareness is affected positively by introducing discount vouchers for returned EoL products, which result in a decreased cost for take-back while increasing cost in introducing the voucher.

5.3.1. Product

Capturing *functional value* is seen in cases where products contain up to 80% refurbished components (Hopkinson et al., 2018). Bundgaard and Huulgaard (2019) finds that customers are more inclined to utilize inner resource loops (maintenance, repair) for high quality products. However, wear and tear are barriers to optimal value recovery (Agyemang et al., 2019). Supporting this, Singh and Ordoñez (2016) presents the example of two chairs entering different value recovery cycles despite being produced simultaneously, due to differences in wear and tear. The availability of data from the first product life cycle (e.g. use temperature, ageing, charge cycles) enables more efficient recovery of products for second life cycles, as exemplified in the case of EoL electrical vehicle batteries (EVBs) (Alamerew and Brissaud, 2020). Bockholt et al. (2020) find that while the revenue generated is higher in narrow resource loops (i.e. prolong, re-use, refurbish) the cost of qualifying the product for these loops is also higher, however, they found that the increase in cost is marginal compared to the increase in value.

Capturing *material value* has several financial benefits, e.g. strengthening a company's position in the market from reduced dependence on upstream activities (Agyemang et al., 2019), leading to reduced cost, as less virgin material is needed, or by generating new streams of income by selling waste (Husgafvel et al., 2018; Zhou et al., 2017). Veleva and Bodkin (2018) presents a case of increased supply chain resilience by securing the supply of critical and scarce material from product a take-back system (Veleva and Bodkin, 2018), a finding adding to the principle of keeping control of critical raw materials (Coughlan et al., 2018; Bai et al., 2019). However, this can be unsuitable for high-quality market segments, as recycled material may be of reduced quality (Daddi et al., 2019). Only when handling waste materials of industrial origin the material composition (i.e. material purity) is known (Singh and Ordoñez, 2016). Furthermore, by standardizing the material composition take-back and waste reduction are enabled. Additionally, sustainable materials enable more efficient value recovery activities (Chouinard et al., 2019), while mixed materials (e.g. in clothing) are a challenge (Huysveld et al., 2019). However, the financial incentive to engage in material recovery is limited in cases with low product cost, as the cost difference between virgin and recycled material is marginal or even unfavourable (Singh and Ordoñez, 2016).

Product design is important as it enables circularity, both in terms of ensuring value capturing, but also affects the cost efficiency of the operations. Svensson and Funck (2019) finds in their study how to reduce cost by aligning the materials used in their products (i.e. changing product design) which enable re-manufacturing of products and increase value by extending the life cycle of the products. (Svennson and Funck, 2019). Bockholt et al. (2020) exemplify how the vast amount of different product designs (from decades of product design improvements) entering the reverse supply chain, is found to increase the cost as it leaves little room for standardization and automation in the handling of the EoL products. Timeless product design and high quality enable and encourage customers to utilize inner resource loops (maintenance, repair) as well as creates a demand for a second-hand market increasing the value of the products (Bundgaard and Huulgaard, 2019). In the case of EVBs, standardization of the battery configuration and its components is highlighted as playing a paramount role in the ability to integrate re-manufactured batteries into electric vehicles. This, in turn, leads to reduced cost in disassembly, repurposing and re-manufacturing of EVBs. Additionally, the need for providing adequate information concerning the disassembly process is highlighted to reduce processing cost further, as well as product labelling and component registry leading to reducing the time spent for sorting, testing and dismantling these batteries (Alamerew and Brissaud, 2020). Modularity and principles of 'design for disassembly' save cost by enabling efficient maintenance, repair and disassembly (Bundgaard and Huulgaard, 2019; Ghisellini et al., 2018; Chouinard et al., 2019). However, such principles are also constraining designers from designing 'on a blank canvas' (De los Rios and Charnley, 2017). High value and simplicity of material composition enable consumers to recycle products (Guo et al., 2017), stressing the need to consider recyclability in the early stages of product design (Agyemang et al., 2019), to enable increased value generation. Daddi et al. (2019) display how competitors can collaborate if they are in different market segments. A recovered material collected and treated by the company providing high-end products to the market had less pure properties making it insufficient for that company. However, the recovered

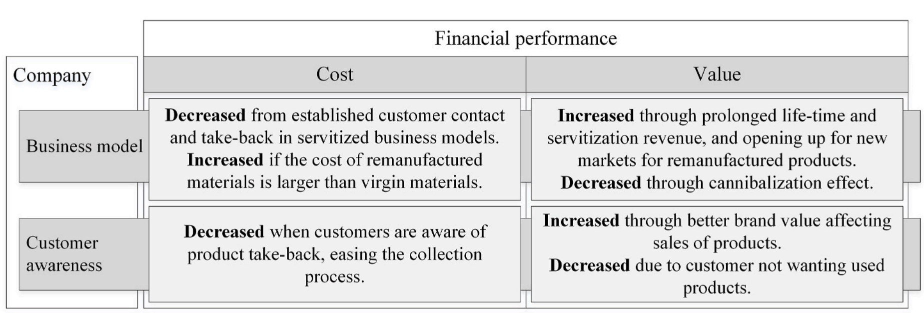

Fig. 6. The effect of Company of cost and value of product take-back.

material is sufficient for a competitor being in the mid-/lower quality market segment resulting in trade between competitors (Daddi et al., 2019). However, for most fast-moving consumer goods, the fast clock-speed make the products unfit for reuse and re-manufacturing as the design has changed too much, leaving only material value to be captured (Kuzmina et al., 2019).

As summarized in Fig. 7, the Product dimension is found to affect cost and value through three factors: Functional value, Material value, and Product design. Extant literature reports that pursuing functional value is more costly while generating more value relative to pursuing material value. However, the increase in cost for pursuing functional value is marginal compared to the increase in value capture. When capturing material value cost is reduced as the supply of critical raw material is secured while value is increased through potential new revenue streams from selling recovered materials. The product design can achieve cost reduction by standardizing materials, components, and product configurations. However, the cost is increased from the complexity of processing decades worth of product designs in take-back. Furthermore, the introduction of modularity limits the product design relative to starting from a blank canvas, hence increasing cost. Lastly, the value potential of certain product designs, i.e. fast-moving consumer goods, are limited from the lack of re-manufacturing potential.

5.3.2. Operations

The type of *methods* utilized in the recovery operation is essential in balancing the cost of recovery, and the value captured. E.g. destructive methods risk contamination of materials, which in turn leads to lower value generation (Ghisellini et al., 2018), but at a lower cost, while disassembly enables capturing more functional value but at a higher cost from the slower process (Ghisellini et al., 2018; Cong et al., 2017). Bockholt et al. (2020) report that internal capabilities, in their case an aluminium oven, increases the financial performance, due to the bypass of the waste handler and that by keeping recycled material in a close loop, its quality is equal to virgin material. Furthermore, keeping packaging material in a closed-loop helps save cost, but proximity among partners is enabling this, as long-distance transportation of empty packaging material evaporates the cost savings (Nandi et al., 2020). Both the role of Lean practices and Industry 4.0 in CE is highlighted in the current literature. The combination of lean and CE, referred to as lean-CE, is argued to improve both environmental and organizational (financial) performance, stemming from labour productivity, leading to an increased competitive advantage (Sartal et al., 2020). Industry 4.0 is highlighted both as an enabler for achieving environmental and financial benefits (Rajput and Singh, 2020), e.g. in the form of product life cycle management systems and monitoring products and parts through multiple life cycles (Lieder and Rashid, 2016) or for locating products in the market (Agyemang et al., 2019). However, up-front investments are needed for digital technologies (Kumar et al., 2019) as well as the use of digital technologies, such as sensors, are incurring high cost due to the unit cost of the technology and the cost of installation, calibration and maintenance (Rajput and Singh, 2020). A lack of information technology currently results in sub-optimal value recovery, i.e. material value is captured over potential functional value. The lack of appropriate technology results in a lack of insight into the recovered product, in terms of remaining functional value, making effective treatment and re-introduction to the market difficult. (i.e. less value) (Singh and Ordoñez, 2016). Digital tags (e.g. RFID) are mentioned as enablers of efficient sorting in the collection process (Atasu and Wassehove, 2012).

Process optimization in take-back operations also includes being effective, which Coughlan et al. (2018) exemplify through early-stage inspection and test of End-of-Use products allowing for a more precise (i.e. cost-efficient) sorting and thereby treatment of the products (Coughlan et al., 2018). Sartal et al. (2020) also exemplify the impact of process optimization by introducing worksheets, standardized work procedures and training plans for the case company, adopting lean-CE. This allowed the company to reduce the water withdrawal and increase the collection of scrap material to be used in by-products (Sartal et al., 2020). Similarly, Hopkinson et al. (2018) report, for agile environments, that: "The key therefore is to predefine an asset's destination prior to its removal from the market, and by understanding the location and condition of assets in markets versus the real-time demand for reused product we can predefine the reuse route of each asset." (Hopkinson et al., 2018). Recycling cost can increase when pursuing high recycling rates (for WEEE), as more advanced and costlier recycling technologies are required (Atasu et al., 2009). Similarly, the disassembly of products is perceived as a costly and time-consuming process, due to the increasing number of materials in products, yet in smaller sizes (Jaeger and Upadhyay, 2020). Lastly, Bockholt et al. (2020) find that salary levels across country borders are influential for the financial performance of take-back operations. In their study, a Danish case company has a 40% higher cost relative to a United Kingdom case, primarily caused by differences in salary levels. The process of purchasing raw material from waste streams is reported as costly in the form of high transaction cost partly from old facility layouts and lack of knowledge (Sharma et al., 2020). Hence, capabilities are needed to operationalize strategic intentions (i.e. decoupling material and value) of take-back systems (Agyemang et al., 2019), thereby increasing the value of take-back products and reducing the cost of operations.

As summarized in Fig. 8, the Operation dimension is found to affect cost and value through two factors: Methods and Process. When adopting more costly methods such as disassembly over dismantling the value generation is increased, while automated and potentially destructive methods are more cost-efficient at the expense of value. From the process perspective, extant literature emphasizes early inspection and sorting to decrease cost while increasing value from the

Product	Financial performance: Cost	Financial performance: Value
Functional value	**Increased** to achieve the inner resource loops due to cost of requalifying products, components or materials	**Increased** by reaching inner resource loops. **Decreased** if data are missing on the usage of the product, or if wear and tear are high, leading to lower value resource loops.
Material value	**Decreased** material cost through reusing materials. **Increased** if virgin materials are cheaper than reusing materials.	**Increased** value from selling waste material. **Decreased** value as reused materials can be of worsened quality.
Product design	**Increased** through changes in design over time, removing the ability for efficient operations. **Decreased** from standardization components and design-for-disassembly principles.	**Increase** for timeless designs, that enable repair and creates a second-hand market. **Decreased** if product design changes rapidly, leaving only material value to be captured.

Fig. 7. The effect of Product of cost and value of product take-back.

Operations	Financial performance: Cost	Financial performance: Value
Methods	**Increased** cost of recovery if manual disassembly is needed. **Decreased** from using automation and digital technologies for locating and sorting products.	**Increased** if disassembled manually and if value recovering capabilities are internal. **Decreased** when destructive methods are used.
Process	**Decreased** by early sorting of products, standardized procedures and training. **Increased** with high recycling rates from the cost of technology and varying salary levels.	**Increased** by matching demand for products with recovery options.

Fig. 8. The effect of Operations of cost and value of product take-back.

appropriate treatment of EoL product. However, the cost is increased by acquiring technology for increasing recycling rates.

6. Discussion

From extant literature, a call for researching CE, particularly product take-back, is made from a system perspective (Bocken et al., 2016). While several studies have investigated the system in business models (Kristensen and Remmen, 2019), there is a need for understanding the system perspective in terms of financial performance (Michelini et al., 2017). This need for adopting a systems perspective is evident from the descriptive analysis, section 4, as existing literature is found in a multitude of differently themed outlets, hence stressing the multi-disciplinary nature of take-back systems, while each paper only represent a narrow range of factors. This review has outlined the factors affecting financial performance and classified them into three different dimensions. These dimensions vary in the degree to which the individual organization influences the factors in the dimensions. However, from a system perspective, the factors are mutually dependent on each other, e.g. one factor within the context dimension might impact the ability of the supply chain to collect product for take-backs. Based on this review, the authors have identified relations across these three dimensions, which are depicted in Fig. 9.

Based on these relations across the dimensions we put forward two propositions related to the financial performance of product take-back. The propositions suggest how the different factors influence the financial performance of product take-back and can be used for companies seeking to exploit CE initiatives and overcome the barrier of financial viability (Sepúlveda-Rojas and Benitez-Fuentes, 2016).

Proposition 1. *From the outside and in: In designing product take-back systems, the external context and supply chain should be considered inputs for decisions regarding internal factors to improve the system's financial performance.*

In designing the take-back systems the organization should take an outside-in view on the factors affecting financial performance. Context factors affect the ability to collect and transport products for take-back at the supply chain level (Bockholt et al., 2020), and through legislation also make demands or incentives for the company level (Atasu et al., 2009). Rarely, are factors found to impact from the lower levels out. For companies, it is important to investigate and build an understanding of their context and their immediate supply chain relations, before making changes within the company level. While factors within these dimensions are external to the organization's influence, they must be acknowledged, and the take-back system must be designed accordingly, to optimize the financial performance with the opportunities and constraints imposed by these external factors. Bockholt et al. (2020) present an example of this, as the WEEE legislation constrains the case company's current supply chain configuration, negatively affecting the financial performance.

Concerning the findings, it is important, from a practical perspective to research how to design take-back systems by taking an offset in the external context and supply chain specific factors before making internal changes to company factors. From a public and legislative perspective, research is needed to understand how legislation, standards, and funding models, that vary across markets and countries, promote or prohibit financial performance, as it is seen as a barrier for CE practices adoption (Sepúlveda-Rojas and Benitez-Fuentes, 2016). Understanding this can promote wider adoption of CE in industry and create a win-win scenario between businesses and the environment.

Proposition 2. *Cost and Value trade-off: In product take-back, high-value capture is achieved at a higher operational cost, while low-value capture comes with lower operational cost. This relation between value and cost suggests a natural optimum for how much cost to put into capturing value,*

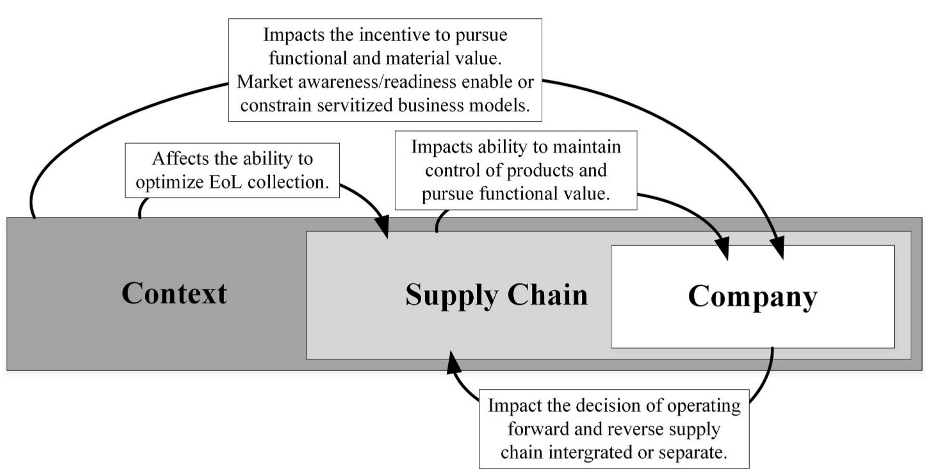

Fig. 9. The interrelations across the three dimensions affecting the financial performance of product take-back systems.

relative to the value of the product.

Extant literature suggests that a trade-off is present in pursuing financial performance in take-back systems, as cost rises with the increase of value capture (Bockholt et al., 2020). Hence, to capture functional value, organizations are putting more cost into acquiring and treating EoL products, such as adopting the costly process of disassembly rather than destructive dismantling for capturing functional value rather than material value (Ghisellini et al., 2018). When embarking on product take-back, organizations should acknowledge their immediate positioning in the three dimensions identified in this literature review and choose a take-back strategy accordingly. The factors provide natural constraints forming boundaries in which the organization should operate for obtaining positive financial performance. E.g. the value of the product, both in its physical form and the perceived value from the customers' point of view, is detrimental for the ability to financially reason for capturing functional value over material value only. The case of luxury consumer electronics by Bundgaard and Huulgaard (2019) provides an example of how high-value products with timeless design, encourage the pursuit of functional value. On the other hand, Kuzmina et al. (2019) argue against pursuing functional value for fast-moving consumer goods due to the frequent changes in product design. This is known as the notion of fit, which is well argued in the literature, however, presented in other research domains, e.g. Fisher (1997) defines the need to distinguish between the efficient and the responsive supply chain to match the product type, being either mostly functional or innovative respectively.

Future research should investigate factors that are important for when to invest more cost into capturing more value, as Bockholt et al. (2020) found that the added value far exceeded the added cost in their case study. Bundgaard and Huulgaard (2019) found that functional value could be captured for luxury products, while Kuzmina et al. (2019) proposed the opposite for fast-moving consumer goods. In addition, these factors are all described in terms of trade-offs, we propose further research into breaking this trade-off between value and cost. We propose to address this from three different perspectives inspired by other domains. From here, the research has focused on breaking the trade-offs through innovative operating models e.g. LEAN (Agyemang et al., 2018), product structures e.g. Modularization (Chouinard et al., 2019) or adoption for technology e.g. digital technology (Nygaard et al., 2020; Colli et al., 2021). While these perspectives are already introduced in CE, lean-CE (Sartal et al., 2020) and digital technologies (Rajput and Singh, 2020), the trade-off persists, leading us to define this call. Second, research into and the adopting of the contingency theory perspective in CE and take-back is needed. Findings in this review suggest that one-size-fits-all is not applicable for take-back systems, making contingency factors influential for the financial performance of take-back systems. Hence, this perspective deserves an explicit role in future research.

7. Conclusions and limitations

This paper outlines the literature findings on which and how factors affect the financial performance of product take-back system. The paper finds that factors are present in three dimensions, being the context (macro), the supply chain (meso) and the company (micro). These dimensions vary in the organization's level of influence on the factors within each, ranging from none (in context) to total control (in company). Within these dimensions, a total of 12 factors are identified, most of which have the potential of affecting the cost or value of the product take-back system both positively and negatively.

From an academic point of view, the research outlines a collected set of factors found to influence the financial performance of product take-back systems. This set of factors have the potential of making the foundation from which fellow researchers can investigate product take-back adoption. In addition, it outlines the need to address product take-back from a systems perspective, as well as to provide insights towards the interaction between dimensions and factors in terms of progression (outside-in) and trade-offs (between cost and value), this outset can complement the currently fragmented state of product take-back research.

The implication of this research for practitioners revolves around the need to overcome the well-documented barrier of the financial feasibility of product take-back systems. Based on this study, managers are encouraged to perceive product take-back systems from the integrative view of the context, supply chain, and company-specific factors in pursuing financial performance.

The future research areas proposed from this literature review call for studies adopting an approach for designing take-back systems in which the external context and supply chain are investigated and internal decisions are made to match these external conditions for reducing cost or improving value generation. Furthermore, future research in breaking the trade-off between cost and value through the adoption of different operating models, product structures, or digital technologies. Lastly, the contingency theory perspective should be adopted in future research from the suggested findings that one-size-fits-all is not applicable for product take-back systems.

The limitation of this study is related to the scope of included papers; while the study encompasses a large volume of papers, the keywords selected focussed on "circular economy" or "take-back", thus potentially neglecting findings related to the financial performance of e.g. reverse logistics and industrial ecology, which might have findings that are relevant for the financial performance of product take-back systems. In addition, the scope only included peer-reviewed papers, and thereby neglected the grey literature (Such as The Ellen MacArthur Foundation), which historically have been used in many academic works on CE. Lastly, the explicit focus on discrete technical products leaves a potential for extending the study to include bio-based products for which the generalizability between the two domains is a primary point of attention.

CRediT authorship contribution statement

Jonas Nygaard Uhrenholt: Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing. **Jesper Hemdrup Kristensen:** Conceptualization, Writing - review & editing. **Maria Camila Rincón:** Writing - review & editing. **Steffen Foldager Jensen:** Writing - review & editing. **Brian Vejrum Waehrens:** Writing - review & editing, Supervision, Funding acquisition.

Funding

This research was conducted at Innovation Factory North at Aalborg University. The research was funded by the European Regional Development Fund and University College of Northern Denmark.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Agyemang, M., Kusi-Sarpong, S., Khan, S.A., Mani, V., Rehman, S.T., Kusi-Sarpong, H., 2019. Drivers and barriers to circular economy implementation. Manag. Decis. https://doi.org/10.1108/MD-11-2018-1178.

Alamerew, Y.A., Brissaud, D., 2020. Modelling reverse supply chain through system dynamics for realizing the transition towards the circular economy: a case study on electric vehicle batteries. J. Clean. Prod. 254, 120025. https://doi.org/10.1016/j.jclepro.2020.120025.

Atasu, A., Özdemir, Ö., Van Wassenhove, L.N., 2013. Stakeholder perspectives on e-waste take-back legislation. Prod. Oper. Manag. 22 (2), 382–396. https://doi.org/10.1111/j.1937-5956.2012.01364.x.

Atasu, A., Van Wassenhove, L.N., 2012. An operations perspective on product take-back legislation for e-waste: theory, practice, and research needs. Prod. Oper. Manag. 21 (3), 407–422. https://doi.org/10.1111/j.1937-5956.2011.01291.x.

Atasu, A., Van Wassenhove, L.N., Sarvary, M., 2009. Efficient take-back legislation. Prod. Oper. Manag. 18 (3), 243–258. https://doi.org/10.1111/j.1937-5956.2009.01004.x.

Bai, C., Sarkis, J., Yin, F., Dou, Y., 2019. Sustainable supply chain flexibility and its relationship to circular economy-target performance. Int. J. Prod. Res. 1–18. https://doi.org/10.1080/00207543.2019.1661532.

Blackburn, J.D., Guide Jr., V.Daniel R., Souza, G.C., Van Wassenhove, L.N., 2004. Reverse supply chains for commercial returns. Calif. Manag. Rev. 46 (2), 6–22. https://doi.org/10.2307/41166207.

Bocken, N.M., De Pauw, I., Bakker, C., van der Grinten, B., 2016. Product design and business model strategies for a circular economy. J. Ind. Product. Eng. 33 (5), 308–320. https://doi.org/10.1080/21681015.2016.1172124.

Bockholt, M.T., Kristensen, J.H., Colli, M., Jensen, P.M., Wæhrens, B.V., 2020. Exploring factors affecting the financial performance of end-of-life take-back program in a discrete manufacturing context. J. Clean. Prod. 258, 120916. https://doi.org/10.1016/j.jclepro.2020.120916.

Bockholt, M.T., Kristensen, J.H., Wæhrens, B.V., Evans, S., 2019. Learning from the nature: enabling the transition towards circular economy through biomimicry. In: Paper Presented at the 2019 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), pp. 870–875. https://doi.org/10.1109/IEEM44572.2019.8978540.

Boulding, K.E., 1966. The economics of knowledge and the knowledge of economics. Am. Econ. Rev. 56 (1/2), 1–13.

Bundgaard, A.M., Huulgaard, R.D., 2019. Luxury products for the circular economy? A case study of bang & olufsen. Bus. Strat. Environ. 28 (5), 699–709. https://doi.org/10.1002/bse.2274.

Cambridge Econometrics, Trinomics, & ICF, 2018. Impacts of Circular Economy Policies on the Labour Market. Publications Office of European Union, Luxembourg. Retrieved from. http://publications.europa.eu/publication/manifestation_identifier/PUB_KH0418564ENN.

Chouinard, U., Pigosso, D.C., McAloone, T.C., Baron, L., Achiche, S., 2019. Potential of circular economy implementation in the mechatronics industry: an exploratory research. J. Clean. Prod. 239, 118014. https://doi.org/10.1016/j.jclepro.2019.118014.

Colli, M., Uhrenholt, J.N., Madsen, O., Waehrens, B.V., 2021. Translating transparency into value: an approach to design IoT solutions. J. Manuf. Technol. Manag.

Cong, L., Zhao, F., Sutherland, J.W., 2017. Integration of dismantling operations into a value recovery plan for circular economy. J. Clean. Prod. 149, 378–386. https://doi.org/10.1016/j.jclepro.2017.02.115.

Coughlan, D., Fitzpatrick, C., McMahon, M., 2018. Repurposing end of life notebook computers from consumer WEEE as thin client computers–A hybrid end of life strategy for the circular economy in electronics. J. Clean. Prod. 192, 809–820. https://doi.org/10.1016/j.jclepro.2018.05.029.

Daddi, T., Ceglia, D., Bianchi, G., de Barcellos, M.D., 2019. Paradoxical tensions and corporate sustainability: a focus on circular economy business cases. Corp. Soc. Responsib. Environ. Manag. 26 (4), 770–780. https://doi.org/10.1002/csr.1719.

De los Rios, I.C., Charnley, F.J., 2017. Skills and capabilities for a sustainable and circular economy: the changing role of design. J. Clean. Prod. 160, 109–122. https://doi.org/10.1016/j.jclepro.2016.10.130.

Denyer, D., Tranfield, D., 2009. Producing a Systematic Review.

Falagas, M.E., Pitsouni, E.I., Malietzis, G.A., Pappas, G., 2008. Comparison of PubMed, scopus, web of science, and google scholar: strengths and weaknesses. Faseb. J. 22 (2), 338–342. https://doi.org/10.1096/fj.07-9492LSF.

Fischer, A., Pascucci, S., 2017. Institutional incentives in circular economy transition: the case of material use in the Dutch textile industry. J. Clean. Prod. 155, 17–32. https://doi.org/10.1016/j.jclepro.2016.12.038.

Fisher, M.L., 1997. What is the right supply chain for your product? Harv. Bus. Rev. 75, 105–117.

Frosch, R.A., Gallopoulos, N.E., 1989. Strategies for manufacturing. Sci. Am. 261 (3), 144–153.

García-Quevedo, J., Jové-Llopis, E., Martínez-Ros, E., 2020. Barriers to the circular economy in european small and medium-sized firms. Bus. Strat. Environ. 29 (6), 2450–2464. https://doi.org/10.1002/bse.2513.

Geissdoerfer, M., Savaget, P., Bocken, N.M., Hultink, E.J., 2017. The circular Economy–A new sustainability paradigm? J. Clean. Prod. 143, 757–768. https://doi.org/10.1016/j.jclepro.2016.12.048.

Genovese, A., Acquaye, A.A., Figueroa, A., Koh, S.L., 2017. Sustainable supply chain management and the transition towards a circular economy: evidence and some applications. Omega 66, 344–357. https://doi.org/10.1016/j.omega.2015.05.015.

Ghisellini, P., Cialani, C., Ulgiati, S., 2016. A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. J. Clean. Prod. 114, 11–32. https://doi.org/10.1016/j.jclepro.2015.09.007.

Ghisellini, P., Ripa, M., Ulgiati, S., 2018. Exploring environmental and economic costs and benefits of a circular economy approach to the construction and demolition sector. A literature review. J. Clean. Prod. 178, 618–643. https://doi.org/10.1016/j.jclepro.2017.11.207.

Ghisetti, C., Montresor, S., 2020. On the adoption of circular economy practices by small and medium-size enterprises (SMEs): does "financing-as-usual" still matter? J. Evol. Econ. 30 (2), 559–586.

Govindan, K., Hasanagic, M., 2018. A systematic review on drivers, barriers, and practices towards circular economy: a supply chain perspective. Int. J. Prod. Res. 56 (1–2), 278–311. https://doi.org/10.1080/00207543.2017.1402141.

Gue, I.H.V., Promentilla, M.A.B., Tan, R.R., Ubando, A.T., 2020. Sector perception of circular economy driver interrelationships. J. Clean. Prod. 276, 123204. https://doi.org/10.1016/j.jclepro.2020.123204.

Guo, B., Geng, Y., Sterr, T., Zhu, Q., Liu, Y., 2017. Investigating public awareness on circular economy in western China: a case of urumqi midong. J. Clean. Prod. 142, 2177–2186.

Hatcher, G.D., Ijomah, W.L., Windmill, J., 2011. Design for remanufacture: a literature review and future research needs. J. Clean. Prod. 19 (17–18), 2004–2014. https://doi.org/10.1016/j.jclepro.2011.06.019.

Hopkinson, P., Zils, M., Hawkins, P., Roper, S., 2018. Managing a complex global circular economy business model: opportunities and challenges. Calif. Manag. Rev. 60 (3), 71–94. https://doi.org/10.1177/0008125618764692.

Howard, M., Hopkinson, P., Miemczyk, J., 2019. The regenerative supply chain: a framework for developing circular economy indicators. Int. J. Prod. Res. 57 (23), 7300–7318. https://doi.org/10.1080/00207543.2018.1524166.

Huang, Y., Wang, Z., 2017. Closed-loop supply chain models with product take-back and hybrid remanufacturing under technology licensing. J. Clean. Prod. 142, 3917–3927. https://doi.org/10.1016/j.jclepro.2016.10.065.

Husgafvel, R., Linkosalmi, L., Hughes, M., Kanerva, J., Dahl, O., 2018. Forest sector circular economy development in Finland: a regional study on sustainability driven competitive advantage and an assessment of the potential for cascading recovered solid wood. J. Clean. Prod. 181, 483–497. https://doi.org/10.1016/j.jclepro.2017.12.176.

Huysveld, S., Hubo, S., Ragaert, K., Dewulf, J., 2019. Advancing circular economy benefit indicators and application on open-loop recycling of mixed and contaminated plastic waste fractions. J. Clean. Prod. 211, 1–13. https://doi.org/10.1016/j.jclepro.2018.11.110.

Hvass, K.K., Pedersen, E.R.G., 2019. Toward circular economy of fashion: experiences from a brand's product take-back initiative. J. Fash. Mark. Manag.: Int. J. https://doi.org/10.1108/JFMM-04-2018-0059.

Jaeger, B., Upadhyay, A., 2020. Understanding barriers to circular economy: cases from the manufacturing industry. J. Enterprise Inf. Manag. https://doi.org/10.1108/JEIM-02-2019-0047.

Jayaraman, V., Ross, A.D., Agarwal, A., 2008. Role of information technology and collaboration in reverse logistics supply chains. Int. J. Logist. Res. Appl. 11 (6), 409–425. https://doi.org/10.1080/13675560701694499.

Kristensen, H.S., Remmen, A., 2019. A framework for sustainable value propositions in product-service systems. J. Clean. Prod. 223, 25–35. https://doi.org/10.1016/j.jclepro.2019.03.074.

Kumar, V., Sezersan, I., Garza-Reyes, J.A., Gonzalez, E.D., Moh'd Anwer, A., 2019. Circular economy in the manufacturing sector: benefits, opportunities and barriers. Manag. Decis. https://doi.org/10.1108/MD-09-2018-1070.

Kuzmina, K., Prendeville, S., Walker, D., Charnley, F., 2019. Future scenarios for fast-moving consumer goods in a circular economy. Futures 107, 74–88. https://doi.org/10.1016/j.futures.2018.12.001.

Lieder, M., Asif, F.M.A., Rashid, A., Mihelič, A., Kotnik, S., 2018. A conjoint analysis of circular economy value propositions for consumers: using "washing machines in stockholm" as a case study. J. Clean. Prod. 172, 264–273. https://doi.org/10.1016/j.jclepro.2017.10.147.

Lieder, M., Rashid, A., 2016. Towards circular economy implementation: a comprehensive review in context of manufacturing industry. J. Clean. Prod. 115, 36–51. https://doi.org/10.1016/j.jclepro.2015.12.042.

MacArthur, E.(E.M.F., 2013. Towards the circular economy. J. Ind. Ecol. 2, 23–44.

Mayring, P., 2010. Qualitative inhaltsanalyse. Handbuch qualitative forschung in der psychologie. Springer, pp. 601–613.

Meredith, J., 1993. Theory building through conceptual methods. Int. J. Oper. Prod. Manag. https://doi.org/10.1108/01443579310028120.

Merli, R., Preziosi, M., Acampora, A., 2018. How do scholars approach the circular economy? A systematic literature review. J. Clean. Prod. 178, 703–722. https://doi.org/10.1016/j.jclepro.2017.12.112.

Michelini, G., Moraes, R.N., Cunha, R.N., Costa, J.M.H., Ometto, A.R., 2017. From linear to circular economy: PSS conducting the transition. Procedia CIRP 64, 2–6. https://doi.org/10.1016/j.procir.2017.03.012.

Mishra, J.L., Chiwenga, K.D., Ali, K., 2019. Collaboration as an enabler for circular economy: a case study of a developing country. Manag. Decis. https://doi.org/10.1108/MD-10-2018-1111.

Nandi, S., Hervani, A.A., Helms, M.M., 2020. Circular economy business models—supply chain perspectives. IEEE Eng. Manag. Rev. 48 (2), 193–201. https://doi.org/10.1109/EMR.2020.2991388.

Nygaard, J., Colli, M., Wæhrens, B.V., 2020. A self-assessment framework for supporting continuous improvement through IoT integration. Procedia Manuf. 42, 344–350.

Pagoropoulos, A., Pigosso, D.C., McAloone, T.C., 2017. The emergent role of digital technologies in the circular economy: a review. Procedia CIRP 64, 19–24. https://doi.org/10.1016/j.procir.2017.02.047.

Parajuly, K., Wenzel, H., 2017. Potential for circular economy in household WEEE management. J. Clean. Prod. 151, 272–285. https://doi.org/10.1016/j.jclepro.2017.03.045.

Pinho, C., Mendes, L., 2017. IT in lean-based manufacturing industries: systematic literature review and research issues. Int. J. Prod. Res. 55 (24), 7524–7540. https://doi.org/10.1080/00207543.2017.1384585.

Quarshie, A.M., Salmi, A., Leuschner, R., 2016. Sustainability and corporate social responsibility in supply chains: the state of research in supply chain management and business ethics journals. J. Purch. Supply Manag. 22 (2), 82–97. https://doi.org/10.1016/j.pursup.2015.11.001.

Rajput, S., Singh, S.P., 2020. Industry 4.0 model for circular economy and cleaner production. J. Clean. Prod. 277, 123853. https://doi.org/10.1016/j.jclepro.2020.123853.

Rennings, K., 2000. Redefining innovation—eco-innovation research and the contribution from ecological economics. Ecol. Econ. 32 (2), 319–332.

Rossi, E., Bertassini, A.C., Ferreira, C.d.S., do Amaral, Neves, Weber, Antonio, Ometto, A. R., 2020. Circular economy indicators for organizations considering sustainability and business models: plastic, textile and electro-electronic cases. J. Clean. Prod. 247, 119137. https://doi.org/10.1016/j.jclepro.2019.119137.

Sartal, A., Ozcelik, N., Rodriguez, M., 2020. Bringing the circular economy closer to small and medium enterprises: improving water circularity without damaging plant productivity. J. Clean. Prod. 256, 120363. https://doi.org/10.1016/j.jclepro.2020.120363.

Sehnem, S., Vazquez-Brust, D., Pereira, S.C.F., Campos, L.M., 2019. Circular economy: benefits, impacts and overlapping. Supply Chain Manag.: Int. J. https://doi.org/10.1108/SCM-06-2018-0213.

Sepúlveda-Rojas, J.P., Benitez-Fuentes, P.A., 2016. Coordination and return uncertainties in closed loop supply chains. In: Paper Presented at the 2016 6th International Conference on Computers Communications and Control (ICCCC), pp. 188–195. https://doi.org/10.1109/ICCCC.2016.7496759.

Sharma, N.K., Govindan, K., Lai, K.K., Chen, W.K., Kumar, V., 2020. The transition from linear economy to circular economy for sustainability among SMEs: a study on prospects, impediments, and prerequisites. Bus. Strat. Environ. https://doi.org/10.1002/bse.2717.

Singh, J., Ordoñez, I., 2016. Resource recovery from post-consumer waste: important lessons for the upcoming circular economy. J. Clean. Prod. 134, 342–353. https://doi.org/10.1016/j.jclepro.2015.12.020.

Svensson, N., Funck, E.K., 2019. Management control in circular economy. exploring and theorizing the adaptation of management control to circular business models. J. Clean. Prod. 233, 390–398. https://doi.org/10.1016/j.jclepro.2019.06.089.

Tukker, A., 2015. Product services for a resource-efficient and circular economy–a review. J. Clean. Prod. 97, 76–91. https://doi.org/10.1016/j.jclepro.2013.11.049.

Tunn, V., Bocken, N., van den Hende, Ellis, A., Schoormans, J., 2019. Business models for sustainable consumption in the circular economy: an expert study. J. Clean. Prod. 212, 324–333. https://doi.org/10.1016/j.jclepro.2018.11.290.

Urbinati, A., Chiaroni, D., Chiesa, V., 2017. Towards a new taxonomy of circular economy business models. J. Clean. Prod. 168, 487–498. https://doi.org/10.1016/j.jclepro.2017.09.047.

Veleva, V., Bodkin, G., 2018. Corporate-entrepreneur collaborations to advance a circular economy. J. Clean. Prod. 188, 20–37. https://doi.org/10.1016/j.jclepro.2018.03.196.

Wang, Y., Zhu, Q., Krikke, H., Hazen, B., 2020. How product and process knowledge enable consumer switching to remanufactured laptop computers in circular economy. Technol. Forecast. Soc. Change 161, 120275. https://doi.org/10.1016/j.techfore.2020.120275.

Werning, J.P., Spinler, S., 2020. Transition to circular economy on firm level: barrier identification and prioritization along the value chain. J. Clean. Prod. 245, 118609. https://doi.org/10.1016/j.jclepro.2019.118609.

Yang, M., Smart, P., Kumar, M., Jolly, M., Evans, S., 2018. Product-service systems business models for circular supply chains. Prod. Plann. Control 29 (6), 498–508. https://doi.org/10.1080/09537287.2018.1449247.

Zhang, A., Venkatesh, V.G., Liu, Y., Wan, M., Qu, T., Huisingh, D., 2019. Barriers to smart waste management for a circular economy in China. J. Clean. Prod. 240, 118198. https://doi.org/10.1016/j.jclepro.2019.118198.

Zhou, Z., Zhao, W., Chen, X., Zeng, H., 2017. MFCA extension from a circular economy perspective: model modifications and case study. J. Clean. Prod. 149, 110–125. https://doi.org/10.1016/j.jclepro.2017.02.049.