

Review

# Unlocking the Linear Lock-In: Mapping Research on Barriers to Transition

Liridona Sopjani , Johan Arekrans , Rafael Laurenti  and Sofia Ritzén

IPD Integrated Product Development, MMK Department of Machine Design, KTH Royal Institute of Technology, 10044 Stockholm, Sweden; arekrans@kth.se (J.A.); rafa@kth.se (R.L.); ritzen@kth.se (S.R.)

\* Correspondence: liridona@kth.se

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**Abstract:** The linear paradigm of take-make-dispose in production and consumption patterns impedes the achievement of global sustainability goals. Strategies for maintaining the added value of resources and circulating them have been discussed as promising for the future. There are, however, many barriers to be addressed to overcome the linear lock-in. The large body of literature on these barriers is notably diverse in terms of theory, methods, sectors, products, and settings. This demonstrates the complexity of delineating implications to the practice and research needs. Without a common framework to analyse barriers, knowledge does not accumulate, hindering the development and implementation of solutions and policies that could effectively address the barriers. In this article, we developed a systematic map of studies on barriers related to the circular transition. The purpose was twofold: (1) to classify published research on barriers; (2) to provide a searchable database for future more rigorous systematic literature reviews. We reviewed the abstract of 527 publications and classified the study according to a developed scheme. This classification scheme includes the research paradigms (circular economy, sharing economy, collaborative consumption and product-service systems), circular strategy (recycling, remanufacturing, component/product reuse, and access-based consumption), country, sector/industry/product, and research approach and method. The resulting research map is open source, serving also as an adaptive digital database for researchers alike to perform systematic reviews and contribute further to its collaborative development.

**Keywords:** circular economy; sharing economy; collaborative consumption; product-service systems; barriers; systematic map

## 1. Introduction

Research on new strategies and mechanisms addressing systemic transformations in the present socio-technical and production-consumption systems has increased over the past few decades [1]. Specifically, the research paradigms of circular economy (CE), sharing economy (SE), collaborative consumption (CC), and product-service systems (PSS) are part of these large-scale change efforts that have gained traction across academia [2]. A paradigm is a framing set of concepts, beliefs, and standard practices that guide human action [3], containing a set of structures on top of which social action is created [4]. The translation of these paradigms into strategic goals and agendas for private businesses, public institutions, and cities frameworks has become increasingly relevant [5]. This phenomenon is attributed to, inter alia, the spreading awareness of natural resource exploitation, rocketing increases in waste [6], and other environmental externalities of current linear and open-ended production-consumption processes of our contemporary economic system [7–9]. Implementing the necessary changes to move from linear to circular thinking is however challenging and complex. A transition requires us to fundamentally rethink not only the way our entire economy works but

also how business, materials, product design, business models, global supply chains, and consumer behaviour are managed.

Recognising the challenges and the complexity, researchers in numerous fields have typically addressed barriers (hinderances/obstacles, etc.) to the implementation of various CE, SE, CC, and PSS strategies. A large number of publications have a clear focus on barriers and several researchers have attempted to categorise barriers or prioritise them in relation to each other, all with a desirable intention to drive the required transition from the prevailing linear economy today, see, e.g., [1,10,11]. Literature reviews to date pertaining to barriers to CE [10,12–18], SE/CC [19,20], and PSS [21–23] illustrate the complexity in delineating the literature due to the high variation in terms of theoretical underpinnings, analytical frameworks, nature and methodology of studies, research methods used, and distribution across publication journals. In particular, the CE and SE paradigm are noted with criticism for being disorganised, offering little relevance for practitioners and policy makers [24]. In addition, the case studies are more challenging, ranging widely across industries and layers of the economy such as micro, meso, macro, as well as social layers applied to them, e.g., political, regulatory, community, organisational, or individual, among others. Although a cross-fertilisation of research paradigms, research methodologies, and methods is widely embraced as fruitful, it challenges the knowledge application in practice and actionable goals.

The lack of a clear systematic overview of research, particularly when characterised by interdisciplinarity, hampers our understanding of the knowledge development as well as of its application in policymaking. Therefore, the main objective of this paper is to classify and systematically map the published research on barriers to circular strategies. To achieve this, we chose to review publications on circular economy, sharing economy, collaborative consumption and product-service systems as four research paradigms. The study was conducted using a systematic mapping method, resulting in a searchable database that enables in-depth systematic literature reviews. A comprehensive systematic literature review following this mapping is in progress for a forthcoming paper.

## 2. Theoretical Background and Conceptual Model

As stated in the introduction, literature regarding the paradigms CE, SE, CC and PSS covers various fields of research and is also frequently of a cross-disciplinary or multi-disciplinary nature. There is also a large number of sources relating to barriers for a transition to a circular or sharing economy, or to problems, hinderances, obstacles or other comparable concepts. This is natural considering the early stage of development that these paradigms are in [16] and the recent great increase in research in the area, together with the growing interest also from a practitioner's perspective [25]. The pressing need from actual changes in practice and high motivation in society and industry is most likely having an effect on the research to build knowledge on how to find solutions to closing material loops, implementing sharing platforms, or achieving accessibility of functions rather than of products; a focus on barriers is therefore expected and constructive. However, in an initial review, the literature reveals a divergent literature base in terms of both scientific rigour and validation of relevance, as well as contradictions. While many of the previous sources focus on a specific barrier (e.g., recycling of batteries [26], lacking efficient ICT platforms [27], contaminated interaction [28], institutional barriers [13] among a few), a stream of research in the area has focused on compiling and contrasting barriers found in literature, e.g., Araujo Galvão et al. [29], de Jesus and Mendonça [1], and Kirchherr et al. [10]. Several sources list categories of barriers and also define levels of priorities. Pinheiro et al. [30] derive barriers from 23 sources and find 9 categories of barriers where barriers relate mostly to consumers and society, and in the least to legal aspects. Galvao et al. [29] review 195 papers and find barriers in 30 of these. They present, without reporting how barriers were identified, 7 groups of barriers where the most frequent barriers relate to the group "Policy and regulatory aspects". Both these sources identify that many barriers are found in the category or group "Technological aspects", similar to the findings of Govinda and Hasanagic [17]. While this source is vague regarding the identification of barriers, it reveals most references regarding barriers within the "Technological aspects"

group. Furthermore, Kirchherr et al. [10] provide a well-defined method for identifying categories of barriers, which also stands out as they build on empirical data from experts in the field. They find four major categories: culture, market, regulation and technology-related barriers and illustrate dependencies between them, though without defining the most important category. The literature on barriers is a treasure trove in that it can provide a research-based impact on practice. However, not only is there a need to condense findings, identify contradictions, and define dependencies in order to make an accurate impact, but there is also a need to find a way to structure sources and data to make research accessible in an efficient and goal-oriented way, thus strongly supporting the aim of this paper to classify and systematically map research on barriers to CE, SE, CC and PSS.

Although CE, SE, PSS, and CC have developed on their own path, there are commonalities within these paradigms, and they are largely steered around core common goals or objectives. CE emphasises redesigning products and processes to ensure continuous reuse of resources, proposing an industrial system that is restorative or regenerative by intention and design, almost mimicking a natural ecosystem's processes [7,31]. SE explores reusing products and increasing the utilisation rates of available resources (products, goods, and services) through shared access to resources [32]. SE was originally termed “collaborative consumption” [33] and this is often used interchangeably [34], however, both are included in the map as we will explain in the methodology section. PSS includes preventing or reducing waste through avoiding unnecessary purchases, increasing or extending the usable life of products, and creating value through leveraging unused assets or sharing existing items [35,36]. PSS can be regarded as a subset instrument of realising CE and SE, without any explicit guarantee for reaching the outcomes which the CE initiative aims for [37].

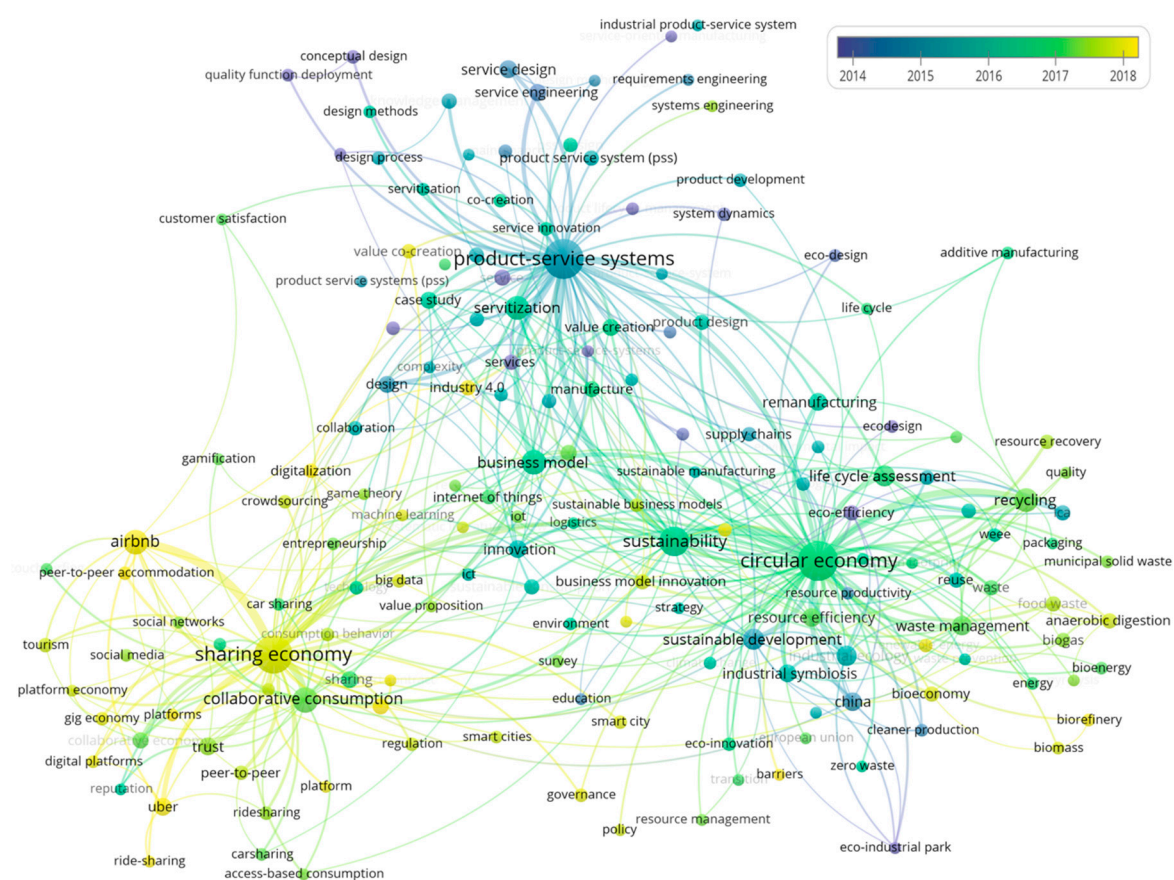
Essentially, the overarching goal within these paradigms is to keep added value of material resources (i.e., consumer goods) circulating in the use phase, while reducing further natural resource exploitation and avoiding waste [38,39]. With the overarching goals, there is a need for clear strategies to realise the envisioned goals. In a wider sense, strategy can be defined as a coherent set of analyses, concepts, policies, arguments, and actions that respond to a high-stakes challenge [40]. One recurring concept across the analysed paradigms is the R-framework (e.g., Reuse, Repair, Remanufacture). The R-principles suggest circular strategies towards closing or narrowing the material loops. While the number of Rs included in the frameworks varies significantly [31], they commonly highlight the following needs: 1) to use and manufacture products in a smarter way, e.g., reducing resource usage or rethinking the functionality of products; 2) to extend the total lifespan of products and individual components, e.g., through repairs, remanufacturing or reusing; 3) to use materials in a restorative and responsible way, e.g., through energy recovery and material recycling; and 4) to redirect from ownership-based to access-based consumption, e.g., through circular business models such as peer-to-peer sharing or business-to-customer (B2C) pay-per-use [5]. Another way to look at these is, for example, from the perspective of the concept of ‘reuse’. Four variations of reuse practice have been identified by Tukker [35]:

1. Consumers buying used goods from other consumers (transfer of ownership, C2C)
2. Consumers donating used goods to other consumers (transfer of ownership)
3. Companies offering services instead of products (temporary access to goods/pay-per-use)
4. Consumers granting access to their private assets to other consumers (C2C) mediated by the internet (peer-to-peer sharing).

The type 3 variation is a CE strategy referring to PSS, whereas type 4 can be understood as an emergent phenomenon of SE, hereby referred to as the circular strategy of B2C Access and C2C Access respectively.

To further exemplify the relationships between the research paradigms and verify whether they stand alone and, if not, how they are interconnected, we produced a network of terms that co-occurred in different publications. We extracted the bibliographic information from the publications in Scopus on ‘circular economy’, ‘sharing economy’, ‘collaborative consumption’, and ‘product-service systems’.

Then, we used the software VOSViewer (version 1.6.13) [41] to generate the term map. Figure 1 below shows the network of co-occurrence of the terms' appearance in the title, abstract and authors' keywords. The size of the circles represents how frequently the terms appear, whereas the proximity of two circles indicates how often they appear together (the colours are designated by a Natural Language Processing algorithm). We can see a pattern where three clusters are clearly visible and they are unified by the concepts 'business model', 'innovation', and 'sustainability'. Moreover, the oldest cluster is product-service systems, whereas sharing economy is the most recent one. Understandably, a simplified view of the relationships between the paradigms may not include the intricate and complex nature of and within each paradigm. However, we select such a perspective only for the purpose of a pragmatic classification of the literature so as to begin a systematising research agenda among the research communities involved in these areas, which we hope will spark discussion and further contribution.



**Figure 1.** Overlay network of co-occurrence of terms. The colours represent the average publication year.

Hence, this study interconnects the four paradigms through the lens of barriers, obstacles, or challenges identified, conceptualised, and theorised in literature to date. With regard to the above, the research objectives (ROs) were set to the following:

- RO1. Classify the studies according to their different contexts;  
RO2. Provide a searchable database for future more focused reviews; and,  
RO3. Obtain a clearer overview of the literature on barriers regarding CE, SE, CC, and PSS.

The systematic mapping should allow for understanding, in a fine level of granularity, of the relationship between barriers and the context in which a study was carried out, as well as identify gaps in the research. The final set of mapped research is also intended to provide an open and searchable



database for further and comprehensive literature reviews. The rationale behind providing such a database is that it would (1) enable a more informed selection of papers based on our accumulated learning from the mapping process, and (2) result in a more objective selection of papers, as the decision for inclusion/exclusion per paper would be based on the coded meta-data and not be subjective. The following research questions (RQs) guided the construction of the map and the reporting of the results:

1. RQ: What are the publication trends with regard to barriers to the paradigms of CE, SE, CC, and PSS?
2. RQ: Which are the dominant research paradigms and circular strategies in the literature to date in relation to barriers?
3. RQ: What research approaches, methods, and sources of data have been used to identify barriers?
4. RQ: How have barriers been conceptualised (the epistemological basis) in the literature?
5. RQ: What is the contextual framing of barriers in relation to the level of analysis (e.g., industrial sector)?

### 3. Materials and Methods

#### 3.1. Systematic Mapping

The methodology for the systematic mapping process in this paper is largely adapted from the guidance developed in the fields of environmental sciences [42] and social sciences [43]. These works were consulted and consolidated into an overall process following the steps. Systematic mapping studies or scoping studies are designed to give an overview of a research area by providing a structure through classification and categorisation, often giving a visual summary, the map, of its results [44,45]. This involves searching the literature in order to know what topics have been covered in the literature and where the literature has been published [45]. There is a range of reasons for why systematic mapping is considered to be a suitable approach, as suggested by Okoli and Schabram [46]. Unlike systematic literature reviews, the mapping approach does not aim to answer a specific question; instead, the method enables the collating, describing, and cataloguing of available evidence relating to a topic of interest, such as ‘barriers’ in this case. Systematic mapping also differs from systematic literature reviews in a number of ways, such as goals, breadth, and depth [44]; meanwhile, the same rigorous, objective, and transparent processes are followed as in systematic reviews. The outcome of a systematic mapping study is an inventory of papers on the topic area that is mapped to a classification and can provide a valuable baseline preceding systematic reviews [44]. ‘Meta-data’, a set of data that describes and gives information about other data, about each study (e.g., study setting, design, intervention/s, population/s) and the article it appears in (e.g., author, title, year, peer review journal, conference proceeding) is extracted [43]. In this paper, the mapping is performed by extracting meta-data from the abstracts of the published literature. The mapping has initially been limited to a review of the abstracts, while taking an adaptive reading depth for classification depending on the structure of the abstracts [45]. Given that abstracts are limited in length, they can often be misleading and lack important information. A further level of detail in such cases has been extracted by examining the paper in full as suggested by [45]. A comprehensive systematic literature review extending this study is forthcoming.

#### 3.2. Protocol

To ensure that all researchers involved were aligned with the mapping process, we developed a detailed protocol document to guide the research process. In addition, we found the work by [45–49] particularly helpful in developing the protocol for the screening and extracting of data from the publications. The protocol established the search engine, search string, criteria for inclusion and exclusion of studies, and guidelines and principles for the review team to extract meta-data. The process was reviewed a number of times within the team to ensure consistency in the execution of the mapping by ensuring that each team member understood the overall procedure and agreed-upon

scope, definitions, and delimitations. This protocol was consulted and discussed on a weekly basis between researchers to follow up as the research progressed.

### 3.2.1. Search Engine

A number of search engines were discussed and briefly scanned by all the researchers such as Scopus, Web of Science, Google Scholar, and EBSCO. The search engine chosen for the mapping was eventually limited to Scopus, since it contained more indexed articles than the rest in the areas concerning this review. Scopus is the largest database in the fields of science, technology, medicine, social sciences, and arts and humanities and indexes about 70 per cent more sources than the Web of Science [30,50]. Google Scholar has a broader range of data compared to Scopus but lacks the same quality control and interface suitable for bibliometrics studies. Furthermore, several records in Google Scholar are in fact duplicates [51], which would impair the results of a systematic mapping.

### 3.2.2. Search String

A number of different search strings were tested while developing the protocol. First, an understanding of the keyword 'barrier' was established where synonymous keywords were also discussed in relation to this, e.g., hinder, obstacle, inhibitor, hurdle, challenge. These were all included in the search strings. Second, the researchers jointly discussed different streams of literature and simultaneously scanned the results of different search strings in the database regarding the domain fields circular economy, sharing economy, product-service system, collaborative consumption. The publication overlaps of search strings, including different combinations of keywords, were explored. Specifically, keywords such as collaborative consumption, sharing economy, sustainable, sustainability, product service systems (or PSS), circular economy, and servitisation, combined with an additional filter of words related to 'barrier', were the focus of the initial scanning. This experimentation led to some insights on how the different keywords were interrelated, as well as words to avoid. For example, 'sustainable product-service-systems' was initially considered but was regarded as a significantly small subset of a much larger stream of literature which might be relevant. Furthermore, the abbreviation 'PSS' is not limited to product-service-systems but a number of other uses, which creates false positives. Hence, the final search string resulted in: (TITLE-ABS-KEY ("circular economy" OR ("product-service system") OR "sharing economy" OR "collaborative consumption") AND TITLE-ABS-KEY (barrier OR hinder OR obstacle OR inhibitor OR limitation OR hurdle)) AND (LIMIT-TO ( LANGUAGE, "English"))).

### 3.2.3. Search Results

The search was executed in Scopus and exported on 23 January 2019, which resulted in 527 publications. The search was limited to abstract, title, and keywords. Bibliographic information, including abstracts, of the resulting publications was imported into a shared online spreadsheet. Each publication was designated an identification number. All four members of the mapping team could access and edit the same sheet simultaneously.

### 3.2.4. Screening of abstracts for inclusion and exclusion

Fink [49] lists several criteria upon which studies can reasonably be excluded from consideration for the practical purpose of limiting the scope of the study (pp. 55–56). Publications were assigned as 'excluded' from the full abstract mapping when the following occurred:

- the main topic was not about circular economy, product-service system, sharing economy, or collaborative consumption (false positive);
- they were not about barriers (false positive);
- no abstract was available.

Of the total 527 publications, 140 were excluded for not meeting the inclusion criteria. These were identified as false positives or had no abstract available, hence were excluded from further review. Worth noting is that among these publications there was a considerable number of studies that resulted in false positives due to the term ‘limitation’ being commonly used in abstracts. Many journals use the term ‘limitation’ but are not related to the objective of this study. Furthermore, seven papers were excluded because their abstracts were not available, and nine entries were identified as special issue reports.

### 3.3. Meta-data Extraction and Classification Scheme

There is no clear way of defining classification schemes for systematic mapping as that depends on the research questions and topic of interest being studied according to [45]. They suggest keywording of abstracts by reading a few of the papers in the total sample, where reviewers read the abstracts and look for keywords and concepts that reflect the contribution of the paper. The set of keywords from different papers is then combined together into a high-level understanding about the nature and contribution of the research (ibid.).

In the study, an initial classification scheme was developed to extract the key information available stated in the abstracts regarding the barriers, such as which research paradigm they related to, type of circular strategy they addressed, type of research, methods used, etc. Figure 2 below shows an overview of the meta-data, outcomes, and contextual information that was considered to be relevant based on the study objectives. A summary of conceptual definitions is shown in Appendix A. Each category was represented by a column in the shared working sheet. Some of the categories were predefined and some were grounded in an organic approach, e.g., country or analytical perspectives of the research. For example, given the diversity of research contributions, we could have not known in advance the sector, industry, or product category (if any), hence, data were extracted organically as reading progressed. Furthermore, during the extraction of information for different types of circular strategies, some abstracts would refer to multiple concepts, e.g., remanufacturing and reuse or recycling and B2B, and these have been classified as “more than one type” to avoid double counting.

Several core concepts are known to be intertwined and difficult to untangle. For example, making remanufacturing feasible for manufacturing companies is not only a technical challenge related directly to the remanufacturing process, but also a question of a shift in the business model [52]. Therefore, papers could fit both within the code ‘B2B Access’, referring to the business model as a prerequisite, or the code ‘Remanufacturing’. However, the main topic is often clear when aggregating the information from the abstract, the chosen title, and the author keywords. In cases where this interpretation could not be made with confidence, it was left for discussion with the team.

A ‘not clear’ category was added to classify abstracts which did not clearly describe the method, type of study, or other essential information based on the objective of this study. Furthermore, we also added a ‘not specified’ category to classify abstracts that simply did not state or mention the information needed to answer our research questions. The reason for having these two categories was to avoid subjective interpretation of the abstracts’ text and meaning. Instead, the team focused on extracting the data primarily based on what is stated in the abstract.

In order to calibrate and align the understanding of the abstract review process between the members of the review team, ten papers were distributed to each member for individual reading and coding of abstracts to test the classification scheme. In this way, a notable difference in interpretations of important concepts was mitigated. To ensure consistency in the classification scheme, the team shared a working log, recording the progress, modifications in the working sheet, categories added, as well as important points to be discussed or checked by another member. A free-text field was used for leaving notes to explain the thought process. If consensus was not reached, it was brought up for discussion with the rest of the team.

Furthermore, while the mapping was in progress, it was noted that the quality of the abstracts varied significantly. To make a note of this inconsistency, a five-point ‘Coding confidence scale’ was

introduced, where the researchers could rate how easily and objectively the meta-data could be extracted (1—very low confidence; 5—very high confidence). This measure was added to enable a more consistent interpretation of coding categories by all reviewers. For example, articles rated lower than 3 were re-read by a second reviewer iteratively to improve the classification, thus enhancing the quality of the mapping process. Abstracts were excluded when both reviewers had given similar coding confidence in relation to the relevancy of the abstract and the objectives of the study. The team also held follow-up meetings every second week during the data extraction phase to monitor progress.

<b>PARADIGM, CIRCULAR STRATEGY</b>	<b>Framed as</b>	<b>Circular strategy</b>	<b>Sector/Industry/Product*</b>		
	Not clear	Recycle	*organic, grounded		
	Circular economy (CE)	Reuse product/component			
	Sharing economy (SE)	Remanufacture			
	Collaborative consumption (CC)	B2C access			
	Product-service system (PSS)	C2C access			
		B2B access			
	Industrial ecology (IE)	More than one type			
<b>RESEARCH DESIGN</b>	Industrial symbiosis (IS)	Not clear			
	Performance economy (PE)				
	Eco-industrial park (EIP)				
<b>BARRIERS IDENTIFICATION, CONTEXT</b>	<b>Publication type</b>	<b>Type of study</b>	<b>Research approach</b>	<b>Research method*</b>	<b>Data source</b>
	Journal article	Conceptual	Qualitative	Not clear	Primary
	Conference paper	Empirical	Quantitative	More than one method	Secondary
	Book	Literature review	Mixed-method	Case study	Primary and secondary
	Book chapter	Systematic literature review	Theoretical analysis	Discourse analysis	Not clear
	Special issue in a journal	Not clear	Not clear	Ethnography	
	Popular science article			Focus group	
				Interviews	
<b>WORK LOG</b>				Survey	
				...	
				*organic, grounded	
<b>WORK LOG</b>	<b>Barrier focus</b>	<b>Barrier identification</b>	<b>Level of analysis*</b>	<b>Geographic Context*</b>	<b>Country if specified*</b>
	Barrier(s) are not the focus	Empirically identified by paper	Not clear	Not specified, N/A	Not specified, N/A
	Barrier(s) are the focus	Predefined/known/assumed	More than one level	More than one	More than one country
	No barrier is mentioned	Indirectly mentioned	Business model	Africa	
	Not clear	No barrier is mentioned	City scale	Antartica	
		Identified through literature review	Governance/Policy	Asia	*organic, grounded
	<b>No. barriers studied</b>	Not clear	Material flows	Europe	
	One		Organisation	Middle East	
<b>WORK LOG</b>	More than one		Value network	North America	
	Not clear		Product/Technology/Design	Oceania/Australasia	
			User/Individual	South America	
			...		
			*organic, grounded	*organic, grounded	
<b>WORK LOG</b>	<b>Reviewed by</b>	<b>Status</b>	<b>Coding confidence</b>		
	Researcher 1	Done	1		
	Researcher 2	Undone	2		
	Researcher 3	In progress	3		
	Researcher 4	Check	4		
		Exclude, out of focus (false positive)	5		
		Exclude, no abstract available			

**Figure 2.** Classification scheme.

### 3.4. Synthesis

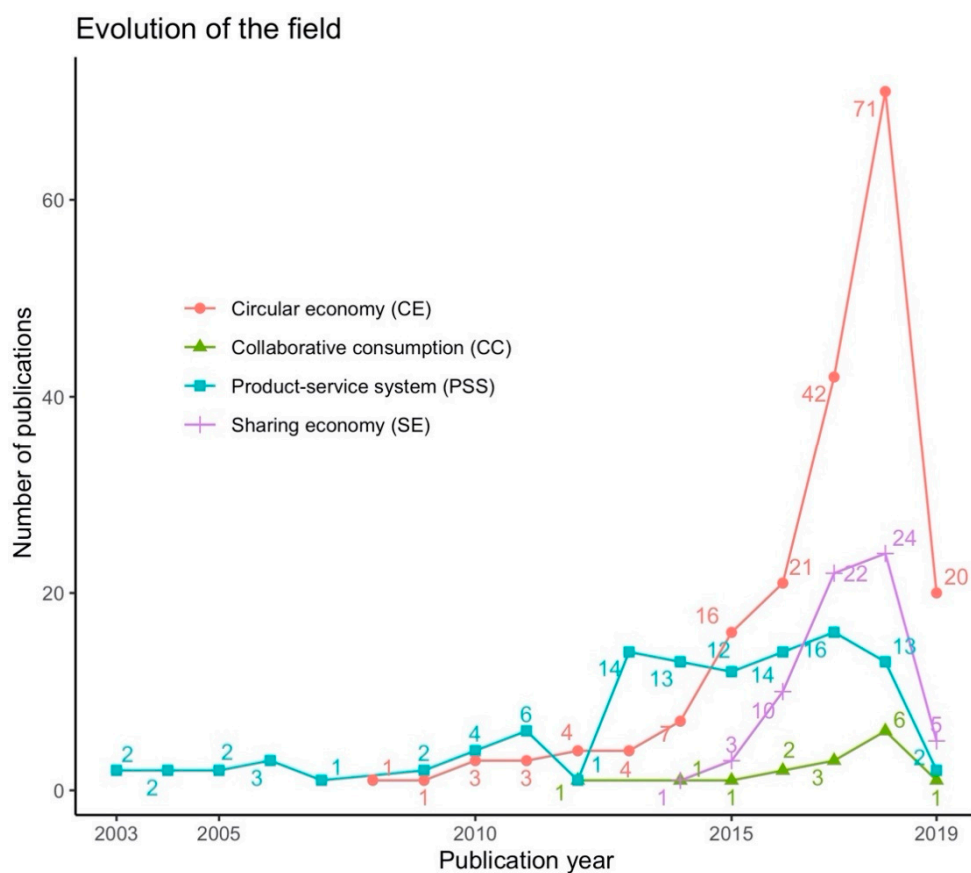
A total of 380 publications were included for mapping. The resulting database is available in Supplementary Material 1 accompanying this study. The title, abstract, and authors' keywords of the 380 abstracts were read, and information for each abstract was extracted according to the classification scheme. Given the broad scope of the systematic mapping, individual articles were not appraised for quality at this stage (i.e., detailed assessment of research design and study characteristics). Instead, appraisal was limited to assessing the overall confidence of the codes attributed to each publication. We used the statistical programming language R to analyse the data. The map was imported into RStudio (version 1.2.5001) using the package 'googlesheets4'. The coded data were sorted and compiled into an interrogable database using the packages 'dplyr' and 'tidyr'. Visualisation of descriptive statistics was done using the package 'ggplot2'.



## 4. Results

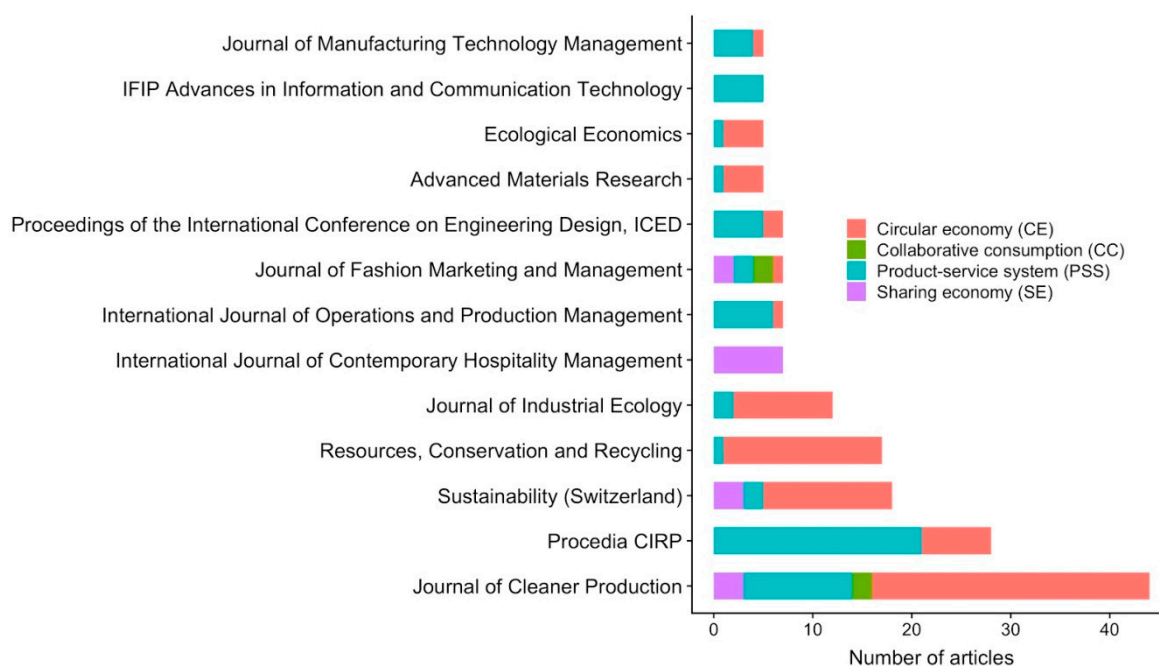
### 4.1. Article Publication Trends

Over the last decade, in accordance with previous studies, our results show that there has been a steady rise in the number of articles published on barriers relating to circular economy, sharing economy, collaborative consumption and product-service systems. Figure 3 shows the distribution of articles over time. A steep growth in the number of published articles can be seen during 2015–2019, with a total of 114 articles published in 2018. The numbers look different for 2019, given that this was the time when the mapping was conducted, hence, publications only until 23 January 2019 are included. Article publications in peer-reviewed journals are shown to be predominant and conference papers follow. A number of reviews can be noted as well in 2018, which show that the stream of research in CE, SE, CC, and PSS may be more frequently reaching the maturity stage in which scholars synthesise work.



**Figure 3.** Evolution of the publications on barriers to CE, CC, PSS and SE. The data refer to publications on Scopus up to 23 January 2019.

Figure 4 below presents the spread of article publications in different sources. Notably, the *Journal of Cleaner Production* ( $n = 44$ ) attracted most publications from the publications included. The journals *Sustainability* (Switzerland) ( $n = 18$ ), *Resources, Conservation, and Recycling* ( $n = 17$ ), as well as the *Journal of Industrial Ecology* ( $n = 12$ ) are included. Meanwhile, for conferences, two channels seem to be of the utmost relevance for publications, *Procedia CIRP* ( $n = 28$ ) and *Proceedings of International Engineering in Design* (ICED) ( $n = 7$ ). The rest of the publication channels contained less than five articles published and hence are not shown in the figure. The distribution of publications is spread across a wide variety of channels, demonstrating the variability of the research topics and areas of application in CE, SE, CC, or PSS.



**Figure 4.** Journals and conference proceedings with five or more articles on barriers.

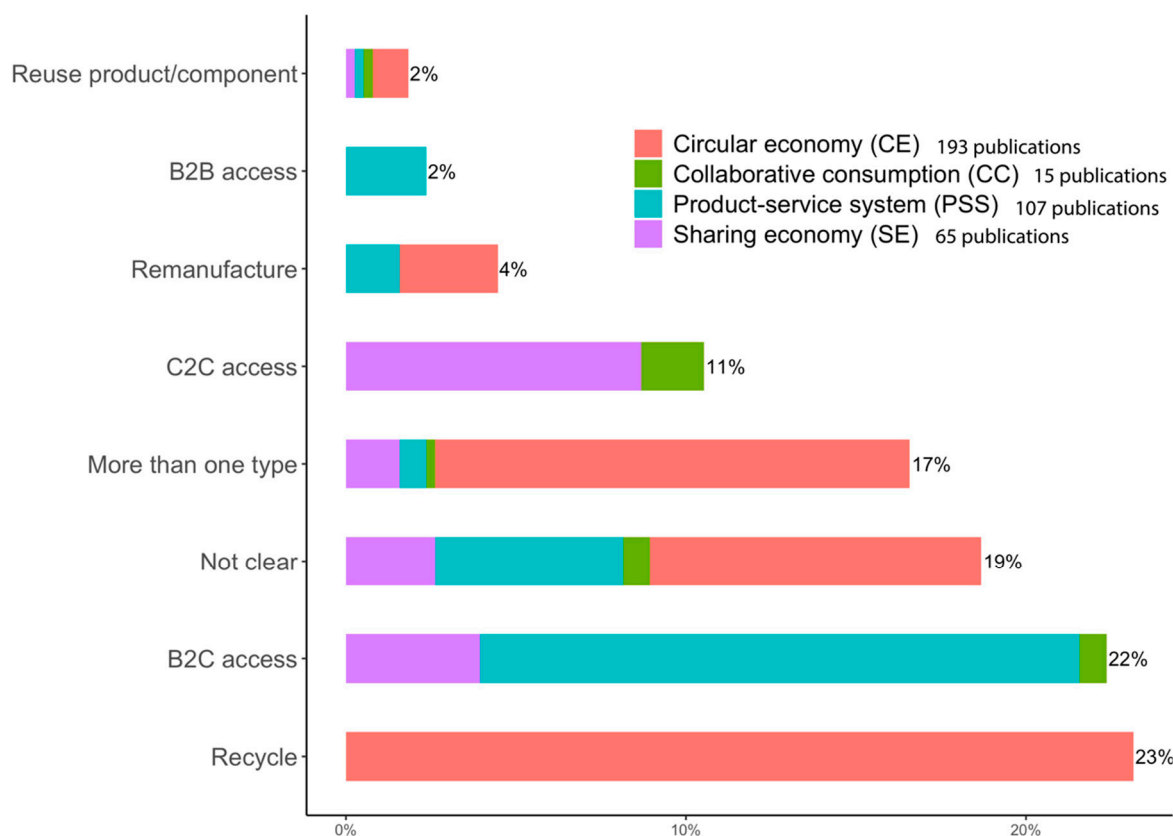
The most popular channels for circular economy publications are the *Journal of Cleaner Production*; *Sustainability* (Switzerland); and *Resources, Conservation, and Recycling*. This is very similar to the results shown by Geissdoerfer et al. [53]. While their review covers circular economy as a whole, the focus in this study is narrowed down to barriers. For the sharing economy, the greatest volumes are found in the *Journal of Cleaner Production*, *Sustainability* (Switzerland) and, notably, the *International Journal of Contemporary Hospitality Management*. This can possibly be attributed to the popularity in the growth of shared accommodation platforms in tourism, e.g., Airbnb. For product-service systems, the majority of publications come from *Procedia CIRP* and the *Journal of Cleaner Production*, while others with high scores are the *International Journal of Operations and Production Management*, *IFIP Advances in Information and Communication Technology*, the *Journal of Manufacturing Technology Management*, and *Proceedings of the International Engineering in Design* (ICED). Studies on barriers from all of the four paradigms seem to be most represented in engineering and technology science and least in social studies, such as consumer behaviour, or cultural studies.

#### 4.2. Dominant Paradigms and Circular Strategies

While the mapping was in progress, the grounded approach allowed six publications to be classified as industrial symbiosis (IS), five were classified as industrial ecology (IE), three were classified as eco-industrial park (EIP), and one as performance economy (PE). After the completion of the mapping, the full text of these publications was reviewed by the team and categorised as circular economy, given that they were addressing the circular economy paradigm explicitly, or one of the R strategies. In the final mapping, CE dominates with a total of 193 publications, followed by PSS with 107. Third is the SE with 65 publications, and last is CC with 15 publications.

Through this classification we identified which particular paradigm is dominant in the publications. Furthermore, it was possible to specify the distribution of different circular strategies associated with each paradigm (see Figure 5). For example, ‘recycling’ as a circular strategy is observed in 23% of the articles selected, whereas approaches such as remanufacturing, reusing (e.g. products, components, or materials) were observed less. Only 4% of the papers contained remanufacturing, and as few as 2% contained reusing as core strategies. These were associated in the main with the circular economy paradigm and product-service systems. A small number of papers on recycling and industrial

symbiosis highlighted in their abstracts the relevance of their findings to CE; thus, the underlying literature may not be captured if search strings are limited to a set of paradigm concepts. Twenty-three percent of papers addressed B2C access, the majority of which reside under the umbrella of the PSS paradigm, and 11% addressed C2C access, the majority of which are listed under the sharing economy paradigm. Interestingly, only 2% of papers had B2B as their main strategy, and this was primarily in PSS.



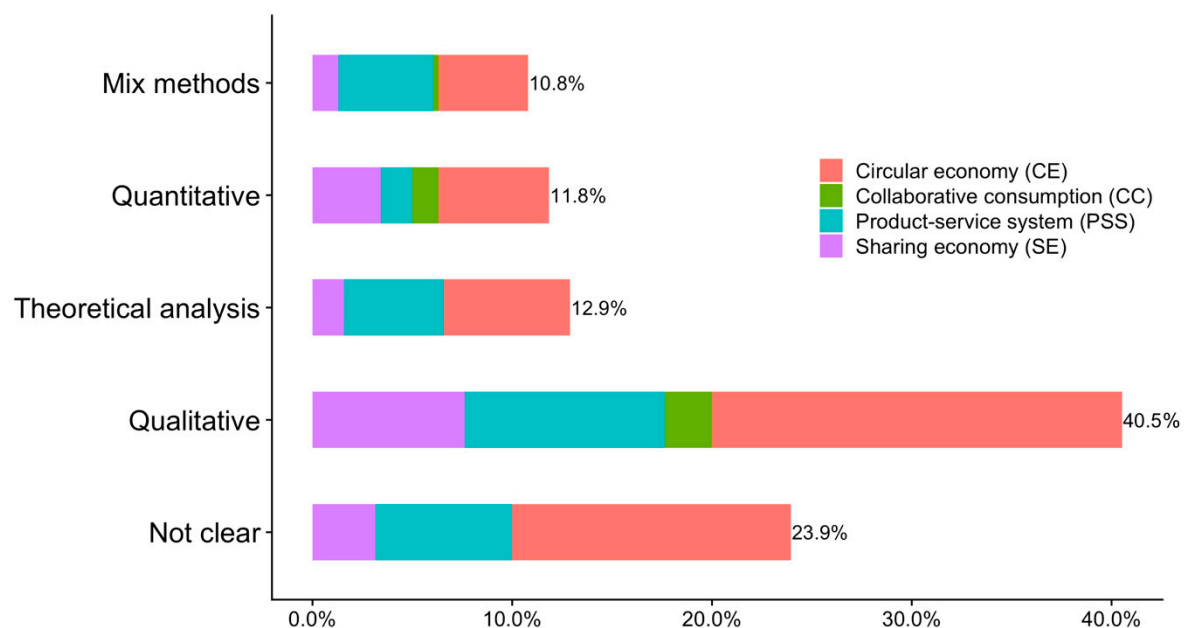
**Figure 5.** Percentage of publications for different circular strategies and the number of publications for each dominant research paradigm.

Publications that addressed, for example, a C2C sharing platform and B2C access in the same paper were classified as “more than one type of strategy”. Of the articles included for mapping, 17% contained more than one strategy, and this was predominantly observed in papers under the circular economy paradigm or the sharing economy paradigm. Interestingly, 19% of papers were not clear in the type of strategy they addressed, and this was prevalent among all the paradigms noted. One explanation is that the papers addressed the paradigms in general terms as a whole and not any particular subset, or these were not specified in the abstracts. However, the lack of specification in cases where this was possible may create further complexity in reaching literature conclusions. For example, a B2B remanufacturing approach can have a completely different supply chain compared to a B2C reusing approach.

#### 4.3. Methods Used by the Studies

The research approach and type of studies in all the abstracts screened are diverse, and mixed methodologies seem to be widespread across the literature for all the four paradigms. Figure 6 shows that a qualitative research approach is the dominant one, comprising 40.5% of studies, among which the majority of papers are empirical studies, followed by systematic literature reviews. Only 12.9% of studies employ a quantitative research approach, and these are predominantly empirical studies,

whereas 10.8% of studies use a mixed-method approach with a majority of articles also being empirical studies. Interestingly, quantitative studies are considerably low among product-service systems favouring a more mixed method approach. However, in 23.9% of abstracts, the research approach was not clear or not directly implied. Hence, we classified them through our own inference of type of study in which we distinguished between conceptual, empirical, literature reviews or not clear at all. Even so, inferring the methodological approach from the abstract was evidently unclear, considerably affecting the mapping process and consequently the analysis.



**Figure 6.** Percentage of publications that adopted different research approach and the distribution between the research paradigms.

Similarly, in terms of the research methods used, Figure 7 shows 29.7% of abstracts lacked an indication of the type of method used and hence were classified as not clear. This can create challenges for systematic mapping since lack of specification can jeopardise the selection process for further evaluation and analysis in systematic literature reviews. On the other hand, in 14.2% of the abstracts, the research method employed is a case study. In 11.1% of the abstracts, more than one method was used to conduct the study, followed by literature reviews (8.9%), interviews (7.4%), and surveys (7.1%); other methods were also present within the literature (see Figure 7). The results show that case studies constitute the largest portion (14.2%) of identified research methods, which can indicate that the generalisation of findings needs to be viewed with caution. In addition, this demonstrates the need for a clear communication of the study approach, methodology, and methods in the abstracts relating to CE, SE, CC, and PSS in order to enable a better analysis of studies and their implications.

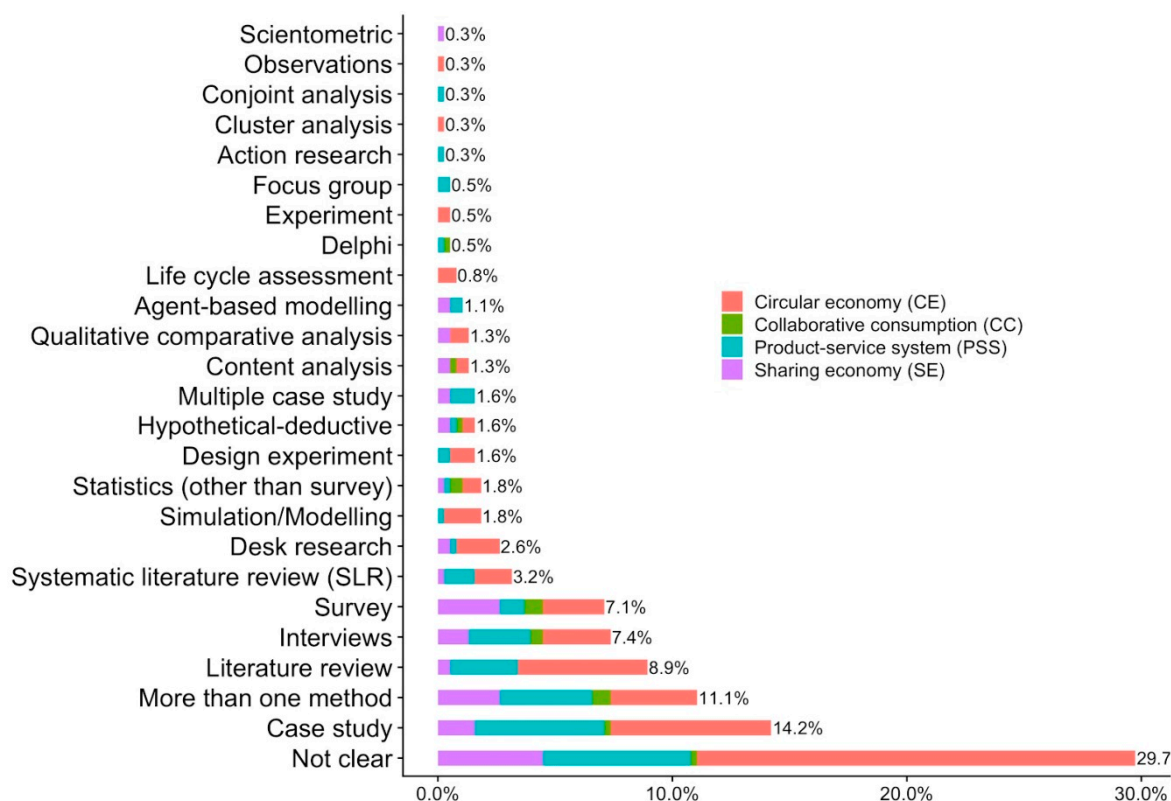
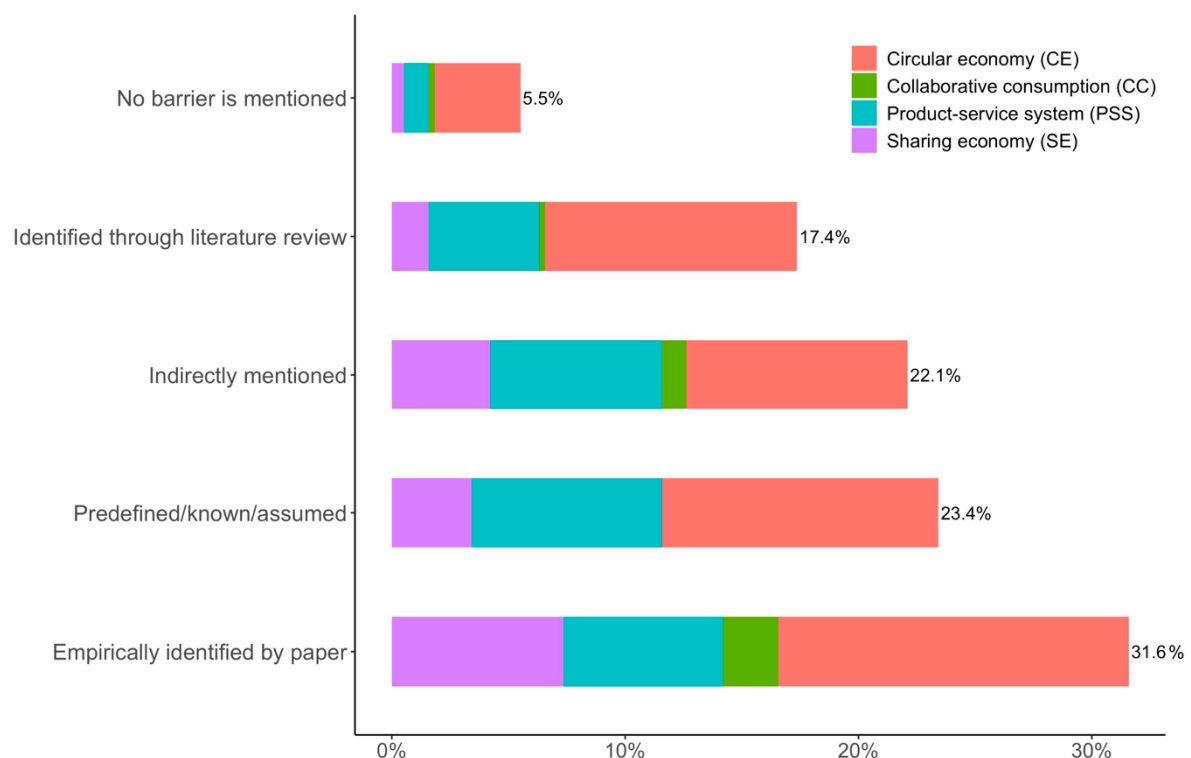


Figure 7. Distribution of the research method used in the selected publications.

#### 4.4. Barriers Identification

During the mapping process, the objective was to distinguish how barriers are understood and identified in the literature, hence we classified where barriers were the core focus of publications and where they were not the core focus. As seen in Figure 8 below, 120 (31.6%) publications identified barriers empirically through case studies, or other qualitative and quantitative research methods. In contrast, 89 (23.4%) publications identified barriers through assumptions, by generalising knowledge or based on predefined problems by other scholars. For example, several abstracts discussed the barrier of user acceptance towards a circular strategy, assuming that this is a true barrier and building the entire research design around this assumption, while relatively few papers attempted to validate this through empirical evidence or other approaches. In 66 (17.4%) publications, barriers were identified through literature reviews, including both systematic literature reviews and background studies. In the majority of the publications, barriers were the main focus in relation to CE, PSS, SE, or CC. However, regardless of whether the keyword search was specified to include only publications related to barriers, hinderances, and challenges alike, 84 (22.1%) abstracts did mention barriers but did not directly study the barrier(s). After the mapping was complete, another 21 (5.5%) publications were identified as not addressing any barrier per se, although they did contain the keywords. A similar pattern distribution can also be observed when we further break down the data and show all the subset strategies categorised within CE, SE, CC, and PSS.





**Figure 8.** How barriers were identified in the selected publications. This classification was based on the information contained in the abstract of the publications.

#### 4.5. Barriers Context

In terms of the context of the barriers, studies can be distinguished by different levels of analysis. Figure 9 below shows that 24.2% of the abstracts studied barriers in relation to more than one variable or were difficult to classify into one category, hence, these were classified as containing more than one analytical perspective. Barriers in relation to the business models were found in 15.5% of abstracts. In 13.2% of abstracts, barriers were related to the user or individual context such as consumer behaviour, adoption, acceptance, or experiences with regard to CE, SE, PSS, or CC, regardless of what strategy the papers were addressing. In 9.5% of the abstracts, governance or policy barriers together were found, and 9.5% of the papers contained barriers in relation to products, technologies, or the design of these. In the rest of the abstracts, barriers were related to material flows (7.6%), organisational barriers (6.6%), and barriers in value networks (5.5%), which were initially expected to be much higher given the complexity of organising for circular or sharing systems. However, these can also be identified using the business model perspective since value networks, organisation, and material flows can be considered as part of the business models as well.

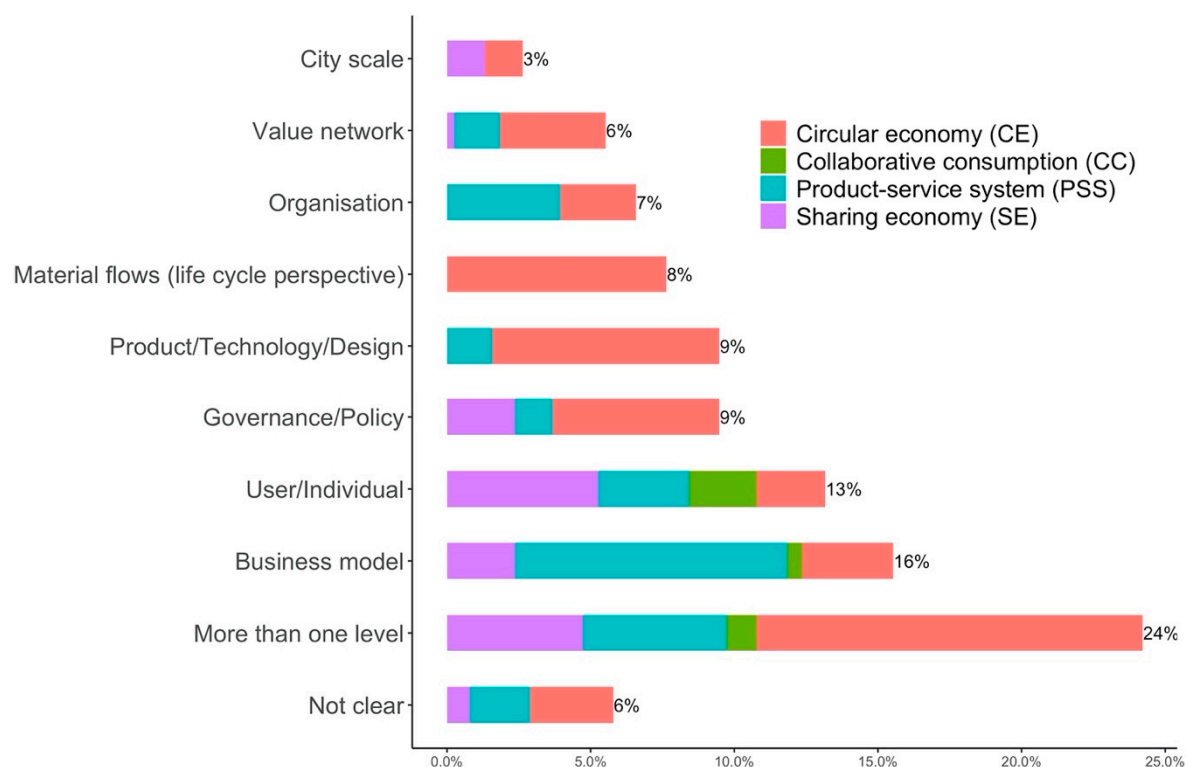


Figure 9. Percentage of publications for different level of analysis.

Studies could also be classified with regard to barriers being experienced within different sectors, industries, or product categories. This was of particular interest in order to understand whether similar patterns of obstacles could be traced across different industrial activities. This category was organic as the reading progressed, due to the diverse nature of the studies. The results in Figure 10 show that within the four paradigms, barriers are experienced across different sectors and industries as identified by research. In 18% of the abstracts, barriers situated in or related to manufacturing and heavy industry were found. Energy and infrastructure systems barriers were found in 7%, and this was followed by transport and mobility, among others, as shown in Figure 10 below. Even when coding for a specific industry such as mobility, for example, studies differed between types of mobility, e.g., car sharing, bicycle sharing, public transport, and more. However, 29% of the abstracts were categorised as unclear, whereby the abstracts either did not mention the type of sector, industry, or product, or such specification was not possible due to the nature of the study. Most abstracts were not explicit in this regard, and interpretations were made based on all the available information. Despite this, the percentage coded as unclear remains high, which may imply that studies, although highly case based (as shown above), lack specification of the study approach, making it challenging to explore barriers in industry-specific aspects or a product-specific context. Another 11% of the abstracts were also categorised as ‘more than one type’ meaning they were cross-industry studies, combined sectors, or multiple products.

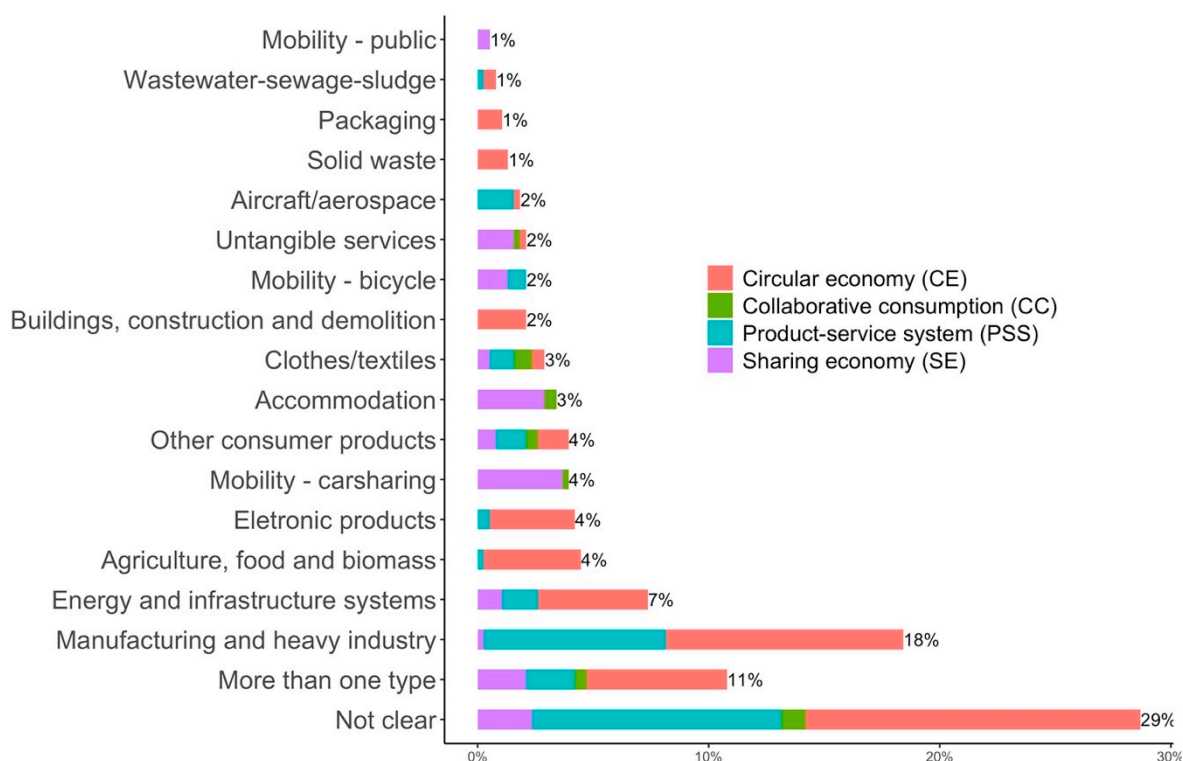


Figure 10. Percentages of publications for different industrial sectors and product types.

## 5. Discussion

Numerous publications have contributed to the body of literature about the barriers and challenges to implementing circular strategies but without a systematic overview of knowledge across different research paradigms.

This paper is therefore aimed at systematically mapping published research on barriers through scoping the CE, SE, CC, and PSS research paradigms in order to gain an overview of research trends on how barriers are delineated and conceptualized and their contextual framing across various analytical perspectives.

This study has compiled the largest synthesis of research articles documenting barriers to realising circular strategies to date. It presents the compilation classified at a fine level of granularity and in the format of a searchable database, taking a step ahead from previous systematic review efforts. The compilation offers several general insights, where a few patterns are evident, into the state of the research concerning barriers.

First, it shows the (re)emergence of the paradigms of circular economy and sharing economy in the context of the practical implementation of circular strategies, in particular over the last two years. Second, although the majority of publication channels are the Journal of Cleaner Production, Sustainability (Switzerland), and Resources, Conservation, and Recycling, there is a large distribution across diverse publication channels and sources (journals and conferences). These resonate with the results shown by [53], but only partially considering that their study is focused on CE as a whole. Furthermore, the studies on barriers regarding the four paradigms are mostly represented in engineering, technology, and science journals and conferences (as shown in Figure 4), with a lower presence in social science, such as consumer behaviour, or cultural studies journals or relevant venues among others. One possible explanation is that the fields are just starting to enter the social realms in terms of applications reaching markets or strategies being implemented in society. This should, however, be viewed with caution, since the channels where these studies are published also contain

interdisciplinary studies which mesh technology and engineering together with social behaviour, organisational, or governance studies.

In terms of the specific circular strategies, we found that barriers related to the circular economy paradigm dominate the publications, among which, with a particularly high score, is realising “recycling” as a circular strategy, which is much higher than remanufacturing or reuse. This could be due to recycling being a more established process in the industry, where more attention has been paid. Furthermore, it could also signal that the application of other circular strategies is yet to be tested, hence, fewer studies have been published with regard to barriers to their implementation. However, a large proportion of studies addressed more than one circular strategy, especially in relation to CE and SE. The challenge in distinguishing studies in terms of the particular circular strategy they address is evident when reviewing abstracts, hence inferring conclusions is rather difficult even when categories have been developed to classify them. This can lead to misinterpretations of conclusions if they are based solely on the systematic mapping and reviewing of abstracts, therefore further analysis is suggested.

On the other hand, from the classification, we noted that barriers are predominantly addressed from a B2C point of view within the context of PSS strategies, or C2C access within the context of SE. However, interestingly, a very small fraction of papers discuss barriers in relation to B2B, which is a surprise as we assumed that this perspective would be addressed more, given that, in theory, most circular strategies are linked with supply chains of materials, goods, and services; hence, we would assume barriers to be more evident in B2B contexts as well. On the other hand, this can also be interpreted as meaning that there is a potential research gap and opportunity to further address the inter-organisational challenges in relation to implementing CE, SE, and PSS.

The use of a large variety of research methods and a dominance of qualitative research were identified. The majority of studies that address barriers to CE, SE, CC, and PSS are qualitative case studies and interviews. This may indicate that the fields are still expanding in application and testing, while at the same time, the analysis suggests that the generalisation of findings needs to be viewed with caution, particularly when studies are contextual. Moreover, a large percentage of abstracts were found to be difficult to classify with no clear research approach or none directly implied. Hence, we suggest the need for clear communication of the study approaches in scholarly work in order to improve quality assessment as well as enable better analysis when performing systematic reviews alike.

Furthermore, the findings suggest that the majority of the publications have identified barriers empirically through both qualitative and quantitative research approaches; however, a considerable proportion of the abstracts reviewed identify barriers by assuming that they exist, relating to barriers known or predefined by other scholars. These patterns could be observed even when we scrutinised the categorised data further and showed all the subset strategies within CE, SE, CC, and PSS. We paid particular attention to the framing of research objectives and aims within the abstracts, wherein it became evident that further research on study validation and results verification and reproduction may be necessary as the fields develop.

When it comes to the context of barriers, almost all studies found barriers to be interrelated or interacting with multiple variables or units of analysis, e.g., business models and user adoption. The rest of the studies found barriers specifically in relation to the business models, e.g., uncertainties, operational challenges of delivering circular models, or lack of integration in existing business; followed by studies pointing at barriers in relation to the users or individual context, e.g., trust in providers, contamination of circular products, and social norms; governance and policy, e.g., lack of political and technical frameworks supporting circular strategies, prevailing and conflicting regulations, and entry barriers for circular businesses; and lastly, products and technologies or design, e.g., product use patterns, material limitations, and technical feasibility. Interestingly, a small fraction of abstracts addressed barriers in relation to the material flows and organisational and value networks, which were expected to score much higher initially. Predominantly, these barriers are more prevalent in relation to organising for circular systems. We are not sure whether the findings imply a hierarchy of barriers or if the research interest is largely oriented towards businesses, hence further review of the publications

in full is being conducted following this study, where in-depth review of each barrier context is to be analysed. The trend is clear, that there is a highly interdisciplinary and cross-fertilisation of strategies, cases, methodologies, and empirics, whereas the industrial context is widespread across different sectors and industries in which studies are conducted. As discussed, the majority of the studies reviewed are case studies, many of which lack specification of the study context at this stage. This was especially evident in terms of the industrial sector or geographical context, which makes it challenging to explore barriers in industry-specific aspects, business-specific context, or product-specific context, among others.

Lastly, through these findings, we have identified salient gaps on how the context, sector, circular strategy and research method are reported in the abstracts of publications. Our results are aligned with those of [10,54] in showing that the studies on barriers have varied implications depending on the contextual factors of the study in question, particularly in the circular economy paradigm where challenges seem to stem from all socio-technical levels such as organisational, value chain, employee level, market, and institutional level [55]. We suggest future scholarly work to delineate the context of studies, especially when different contextual factors may come into perspective, hence affecting the application of circular strategies. Future studies should make these explicit, as well as the other constructs developed in this research. This seems even more important when extracting solutions or propositions in papers, and a deepened study of barriers and solutions in contexts is needed.

The systematic map developed allows the accumulation of knowledge, which is particularly important to the consistency and maturity of the field. A clear and discrete typology is also relevant to policymaking and interventions. Finally, this systematic map should enable other researchers to rapidly locate and assess the state of the research on barriers. It allows for the development of more focused systematic reviews (for instance for a specific paradigm, circular strategy, or sector). Our map has provided a single snapshot of the existing research to date, but could become dynamic with periodic updates every 3–5 years.

### *Limitations*

There are limitations with regard to such systematic mapping as a method for review, two of which were particularly critical. The first is developing well-founded categories for classifying the studies. A challenge among the research team was to develop a common understanding for delineating, for instance, the industrial sectors and their boundaries, given the diversity of studies, including the core definitions of CE/SE/PSS/CC, since these were not always clear and we had to rely on our own interpretations. Measures were taken early on to tackle this core issue, such as the confidence level scale and the opportunity to ask another researcher to check each other's coding. However, this does not in any way guarantee a stringent process, as noted by [44,45]. The second is differentiating between the perspectives and lenses of the analysis in various studies, even when a classification scheme has been developed to guide the reviewer. This is because if a classification system is developed in advance, it can jeopardise and exclude some studies based on its criteria, or when organically grounded categorisation is enabled, then numerous subcategories emerge creating challenges to clustering and generalising the results. Our approach has been to extract essential meta-data in a transparent way, while limiting ourselves to the topic of interest of this study.

## **6. Conclusions**

To date, publications on barriers to realise circular strategies have neglected the importance of specifying the context in which the barriers reported were identified. This paper aimed to address this gap by reviewing 527 abstracts on the topic and classifying them according to the specificities of their contexts. Studies were classified according to their research paradigm (circular economy, sharing economy, collaborative consumption and product-service systems), circular strategy (recycling, remanufacturing, component/product reuse, and utility-based non-ownership B2B/B2C/C2C access), country, sector/industry/product, and research approach and method. This system of typology can be used not only in future empirical investigation on barriers, but also in more in-depth systematic



literature reviews, where what the different barriers are can be specified systematically. Our analysis initially focused only on one side of the four dominant paradigms, through an overview of barriers, obstacles, or challenges identified, conceptualised, and theorised with regard to the implementation of CE, SE, CC, and PSS, with a later goal to determine what actual barriers exist and to identify solutions and mechanisms that address barriers. Hence, further studies could contribute greatly by further observing what barriers there are, in which research paradigm, with which strategy, and by which method they interact with various contexts such as geographical, industrial, socio-economic, and cultural contexts, among others. We suggest future research that focuses on a further understanding of the interactions between barriers and the extent of complexity in addressing them through research, practice, and policy.

**Supplementary Materials:** The following are available online at <http://www.mdpi.com/2071-1050/12/3/1034/s1>, Supporting information 1: Mapping database.

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## Appendix A

**Table A1.** Supplementary classification scheme and conceptual definitions.

Category	Definition	Classification Scheme
Research paradigm	The body of literature or research paradigm that the study addresses or belongs to	Circular Economy, Sharing Economy, etc.
Core strategy	The circular strategy that is addressed in the paper	Remanufacturing, Recycling, etc.
Publication type	Outlet of the publication	Journal, conference, etc.
Type of study	Characteristics of the research approach	Empirical, Conceptual, Literature review, Systematic Literature Review (SLR)
Research approach	Chosen design for conducting the research	Qualitative, Quantitative, Theoretical analysis, Mixed
Research method	Chosen method for data collection	Interviews, Survey, Focus group, etc.
Data source	Data collected specifically for the particular study or not	Primary, Secondary, Combined
Barrier focus	If barriers are addressed explicitly as the core focus of the paper	Barriers are/are not the focus
Barrier context	The way barriers are contextualised, e.g. as an empirical finding or as background	Empirically identified, Indirectly mentioned, etc.
No. barriers	Number of barriers listed	0, 1, more than one
Level of analysis	Location, size or scale of the implied research target	Business model, City scale, User/Individual, etc.
Sector, industry or product	If the study is grounded in a certain sector, industry or product	Energy and infrastructure, Packaging, etc.
Human development	If the study explicitly relates to a certain HDI	Developed countries, Developing countries
Geographical context	If a certain geographical region is specified	Europe, Asia, Africa, etc.
Country	If a certain country is specified	Sweden, Germany, etc.
Suggestion for the SLR	Suggestion for inclusion in a full systematic literature review	Select, Exclude, Not sure.
Notes	Free text, for notetaking and discussion	-

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