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Drivers and Constraints of Remanufacturing: A Global Bibliometric Review

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Abstract: This study aims to provide a global bibliometric review of scholarly research concerning the drivers and constraints in the domain of remanufacturing, which also seeks to provide a blueprint of the intellectual structure and thematic evolution, along with collaboration patterns in this important area of sustainability. This study reviews 1,162 publications from Scopus's 2015–2025 database, employing bibliometric methods using VOSviewer and Harzing's Publish or Perish software. This study measures the trends in publications, authorship, subject areas, and keyword co-occurrence networks. The results show an exponential increase in research output since 2019, with Environmental Science and Engineering dominating the publications. Research output stems from the drivers which include the absence of policy and regulatory support, economic incentives and profitability, sustainability and resource efficiency, market demand and consumer behaviour, and technological improvement. The constraints of research output include consumer perception and acceptance, high initial investment and financial viability, lack of skilled workforce, product design and technical obstacles, and reverse logistics and supply chain uncertainty. Research also shows the strong interdisciplinary nature of the field. The primary focus of research is still concentrated in Europe and East Asia. By integrating ten years of worldwide research, this study aims to create a systematic evidence base for academics and practitioners. In closing, it advocates for research on remanufacturing to be more inclusive, context-sensitive, and transdisciplinary so that remanufacturing can develop as a scalable, equitable, and transformative component of the circular economy.

Keywords: *Remanufacturing, Circular Economy, Bibliometric Analysis, Sustainability Drivers, Barriers to Adoption*

1. Introduction

Remanufacturing is an efficient way of integrating ecological boundaries within the burden of industrial output, which has been largely unexplored due to the insufficiency of global alternatives. Enhancing the quality of used goods avoids waste disposal and reduces energy consumption, the extraction of primary resources, and the necessity of new materials, which underpins the circular economic models (Matsumoto et al., 2016; Yang, 2019). In economic terms, remanufacturing reduces and controls costs and risks through prolonged product lifespans, diversification of income streams, and improved market position (Ferraro et al., 2024; Eguren et al., 2018). With the political and business world being the most dynamic and active spheres pursuing the most attainable alternatives for reaching ecological objectives, it is ever more vital to understand the incentives and obstacles to the remanufacturing process.

Some current literature identifies the drivers and constraints shaping remanufacturing practices in various countries. The drivers are environmental and economic incentives (Matsumoto et al., 2016; Gunasekara et al., 2018), government regulations such as take-back mandates and fiscal incentives (Singhal et al., 2018; Li et al., 2024), technological advancements in intelligent as well as additive manufacturing (Abassi et al., 2025), greater consumer awareness (Almefelt & Rexfelt, 2017; Lastovetskaia et al., 2025), and tangible strategic business interests such as product durability and differentiation (Eguren et al., 2018). On the other hand, operational uncertainties in reverse logistics (Gunasekara et al., 2018; Mukherjee & Mondal, 2009), consumer quality perception (Diener et al., 2019; Lastovetskaia et al., 2025), economic feasibility (Ferraro et al., 2024; Sun & Wang, 2024), border regulatory asymmetry (Yang, 2019) and education deficits in the Global South (Monyaki & Cilliers, 2023) still impose significant constraints. While valuable, the remaining insights are still fragmented and lack a cohesive focus, global in nature, across disciplines, geographies, and methodologies.

This paper employs bibliometric analysis, an approach that draws on quantitative, data-based techniques to delineate the intellectual framework, thematic change, and cooperative structures within a specific area of scholarship (Abassi et al., 2025) to begin resolving this fragmentation. Positioning our analysis within the overarching domain of research on sustainable operations and the circular economy, we draw on a complete dataset of articles published in the Scopus database. While narrative and systematic reviews emphasize subjective interpretation, the bibliometric approach provides a neutral perspective and tracks the scholarly attention that has shifted over time, the prevailing themes, and the enduring gaps. This method addresses the 2019 call for evidence-based mapping of the field's qualitative sustainability transitions (Yang, 2019) and counters the predominant qualitative approach in the field by elucidating macro patterns that lie hidden at the micro level.

While the potential for remanufacturing is well established, its global uptake is uneven and stifled by context-specific obstacles. One of the main challenges is the lack of a cohesive and empirically grounded account of how drivers and constraints function across geographic, industrial, and disciplinary divides. The proliferation of knowledge in a particular area is often hindered by the narrow focus of reviews which examine only one industry, region, or type of barrier. In light of the above, this study tries to address the following issue: the literature on remanufacturing is missing a comprehensive and global account of its intellectual structure, including thematic areas and patterns of collaboration concerning drivers and constraints.

To this end, we ask, what are the key drivers and limitations of global remanufacturing research, and how have these changed over time in various regions and in different fields? The rest of the document is organized in the following way. Methodology is described in Section 2. This includes an explanation of how data were retrieved from Scopus, the PRISMA selection process, and how Harzing Publish or Perish and VOSviewer were used for data cleaning and visualization. Section 3 is devoted to the bibliometric analysis and covers the publication patterns and bibliometric results on the geographic and institutional affiliations, co-citation analysis, and thematic clusters. Section 4 describes the implications of these findings for theory, policy, and practice, including the more recent developments on intelligent remanufacturing and strategies focused on the end-user. Section 5, the last section, presents the limitations and future research agenda in the context of remanufacturing and the global sustainability agenda, which we hope will serve as an initial guide to building the remanufacturing research agenda.

2. Literature Review

Predominant Themes in Remanufacturing Drivers

One of the most prominent ideas in the literature is that remanufacturing serves as a means to implement the strategies of a circular economy while providing simultaneous advantages on the environmental and economic fronts. Most authors note the remanufacturing of products as a means of conserving resources and reducing waste, and as a mitigative measure to the emission of greenhouse gases, thereby addressing climate change, and the implications of resource exhaustion (Matsumoto et al., 2016; Zhang et al., 2020). From the economic perspective, there are savings to be gained from remanufacturing, the value of products is heightened as components of a product of a certain grade are recovered, and the product lifecycles are prolonged (Eguren et al., 2018). Operational efficiency is not the only motivator; especially in the automotive and electronics capital-intensive industries, the strategic motivators of product differentiation, brand equity, and market adaptability also play a role (Karunarathna & Gamage, 2022). The integration of the three components of sustainability; social, environmental, and economic is becoming a key topic, particularly in recent studies which are calling for the inclusion of integrated performance metrics to capture all three (Mejía-Moncayo et al., 2025).

Key Constraints and Contextual Barriers

Remanufacturing holds great potential, yet numerous structural and contextual barriers remain, and these tend to differ greatly based on geography or specific industry. Many operational bottlenecks stem from concerns over access to cores, uncertainty regarding core quality, and issues with pricing in the marketplace (Eguren et al. 2018). In developing economies, the barriers included a lack of government support, the absence of standardized regulations, issues with the perception of quality, and the overwhelming price competition with new goods (Sharma et al. 2016). Technological constraints like the absence of non-destructive testing or deconstruction methods can impede scalability, particularly with more intricate products such as medical

equipment and industrial machinery (Wang et al. 2023). The challenges observed in these examples illustrate the reality that remanufacturing involves more than just technical processes; it has to do with the systems comprising the institutions, markets, and infrastructure that can enable or hinder the potential of remanufacturing.

Scholarly Debates on Sustainability Integration

One of the most critical academic discussions concerns the focus on remanufacturing and the sustainability discourse. Initial studies on remanufacturing focused solely on the environmental and economic impacts. More recent studies, on the other hand, argue that the social impacts of remanufacturing such as labor, equity, and community concerns, need to be added to the foundational frameworks (Mejía-Moncayo et al., 2025). Some scholars affirm that the discourse is still predominantly techno-economic, paying little attention to the socio-cultural aspects of the adoption (Sharma et al., 2016). Other scholars argue that remanufacturing will become a niche practice and will not be able to serve as a systemic solution without adequate policy frameworks and inter-sectoral disengagement (Singhal et al., 2018). This is an example of the many discussions concerning the disengagement of power, governance, and socio-economic behavior on systemic issues surrounding remanufacturing and the circular economy.

Emerging Technological and Strategic Trends

There is a growing interest in the design of technology-enabled intelligent systems in remanufacturing. Innovations in non-destructive disassembly, laser cleaning, lifecycle assessment of cores, and additive restoration techniques have been advancing the technical feasibility and quality assurance of remanufactured products (Wang et al., 2023). In addition, IoT and AI technologies are being incorporated into systems designed to optimize core reverse logistics and forecast core availability (Singhal et al., 2018). From a strategic point of view, the development of industry-specific, particularly automotive and electronics, sector roadmaps is gaining attention due to the large end-of-life volumes, which is a double-edged sword (Karunarathna & Gamage, 2022). All these shifts indicate the movement in remanufacturing from non-systematic approaches to integrated, data-enhanced closed-loop supply chains designed to meet the goals of industrial decarbonization.

Gaps in Current Research and the Role of Bibliometrics

A synthesized global understanding of how drivers and constraints interrelate across areas, disciplines, and temporal scales is still lacking, even with abundant qualitative and case-based insights. Numerous analyses are limited in scope to specific countries, such as India or the Basque Country, or to specific sectors, which unfortunately restricts the findings' generalizability (Sharma et al., 2016; Eguren et al., 2018). Likewise, the cross-cultural contexts of comparative analyses on policy effectiveness or consumer behavior are scarce. This lack of cross-cultural examination restricts the formation of coherent global action plans. A bibliometric method directly takes on this challenge by systematically delineating the intellectual structure in the field, which consists of core authors, impactful journals, thematic areas, and cooperative linkages, as well as dominant paradigms, emerging areas, and neglected geographies (Matsumoto et al., 2016; Wang et al., 2023). These macro insights are critical to positioning research, influencing policy, and facilitating the international remanufacturing sector as an integrated element of sustainable industrial ecosystems.

3. Method

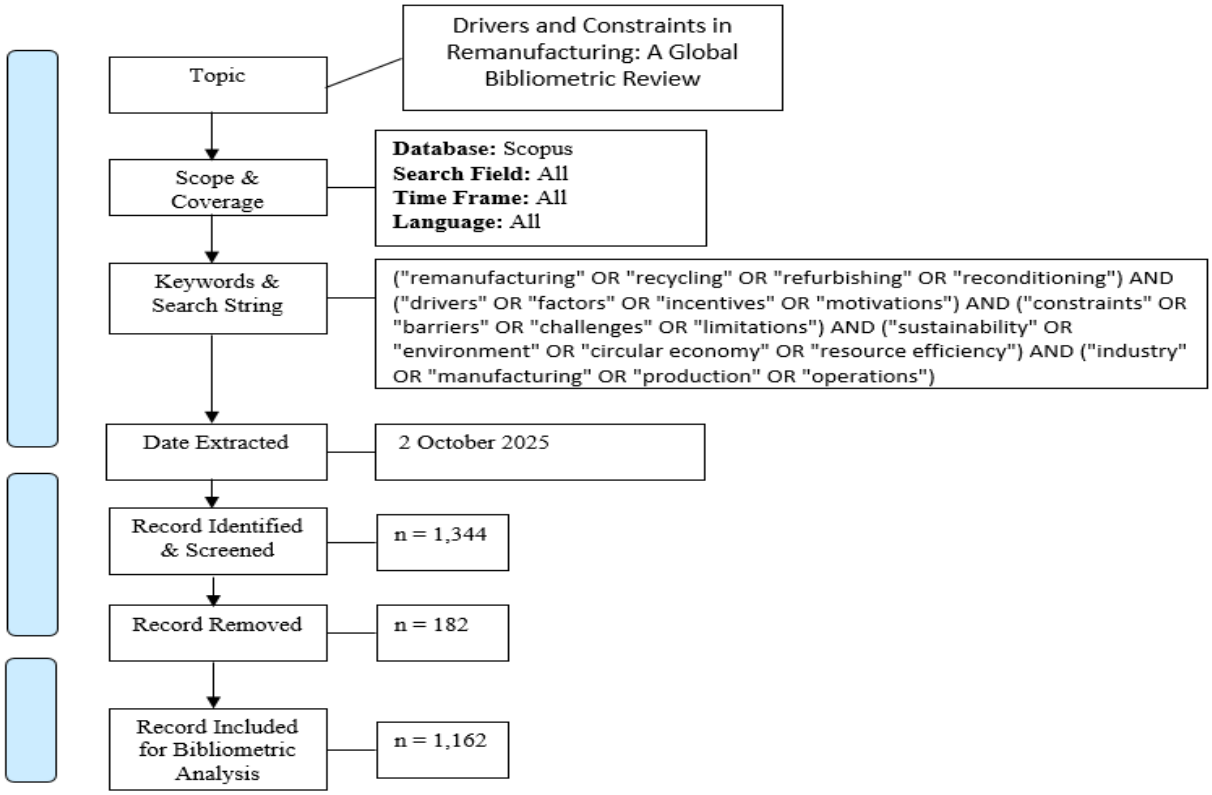
A comprehensive bibliometric analysis presents a methodical and quantitative technique to analyse the intellectual structure and research tendencies and patterns of global cooperation in a specific scientific field. For this research, the Scopus database was used as the main data source given its wide coverage of peer-reviewed journals, conference proceedings, and books in the fields of engineering, environmental science, business, and operations management, all of which lie at the core of remanufacturing research (Baas et al., 2020). The Scopus database offers high-quality metadata, including author affiliations, citation counts, keywords, and funding data that are critical for precise co-authorship, co-citation, and keyword co-occurrence analysis (Mongeon & Paul-Hus, 2016). Thus, this study focuses on a bibliometric analysis of a dedicated dataset on remanufacturing drivers and constraints to identify thematic clusters (for example, integration of circular economy, reverse logistics, and consumer perception), analyzes the dynamics of the focus areas over a specified time, and illustrates the patterns of collaboration at the geographical and institutional levels.

Through bibliometrics, scholars can condense disparate scholarship into a visual and digestible representation of a knowledge landscape, including what paradigms dominate, what trends are emerging, like intelligent remanufacturing technologies (Wang et al., 2023), and what areas or topics are still lacking attention, like the dimensions of social sustainability (Shaharudin et al., 2022). As a method of analysis, which is objective and reproducible, bibliometrics both integrates knowledge and outlines an agenda for prospective research, research-driven policies, and advocacy, which, in turn, fuel the rapid development of remanufacturing as an essential strategy for sustainable industrial ecosystems (Matsumoto et al., 2016; Yang, 2019).

The methods and processes pertaining to the data collection for this bibliometric analysis were undertaken through a PRISMA approach (as shown in Figure 1). The study was oriented with the primary research topic 'Drivers and Constraints in Remanufacturing: A Global Bibliometric Review'. This helped to define the conceptual parameters for the research. In the next step, the range of the study was defined to consist of all the literature published in the Scopus database, without any filters concerning the date of publication or the language to provide a comprehensive and global scope.

The key step was building a detailed search string with Boolean logic to account for all aspects of the topic. The query merged four thematic groups: (1) remanufacturing-related words – "remanufacturing," "recycling," "refurbishing," and "reconditioning"; (2) driver-related words – "drivers," "factors," "incentives," "motivations"; (3) constraint-related words – "constraints," "barriers," "challenges," "limitations"; and (4) context-setting words around sustainability and industry – "sustainability," "environment," "circular economy," "resource efficiency," "industry," "manufacturing," "production," "operations." This intricate search string was run on 2 October 2025 and returned 1,344 records, which were identified and screened. In the next step, 182 records were removed which were probably automated deduplication or a first pass screening by title and abstract to exclude non-research items like editorials, conference announcements, and other irrelevant publications. The final set of 1,162 documents was used for bibliometric analysis, which was used to quantify specific elements of the analysis to track the trends in research, the intellectual structure and collaboration patterns that were detailed in the objectives of the study.

Figure 1: PRISMA Flow Diagram



Source: Moher et al. (2009).

The current research integrated the bibliometric software tools into the methodological framework to conduct data processing in an efficient, standardised, and visual manner. During data extraction from Scopus, Harzing Publish or Perish (version 9.0) was used to verify and augment the primary metadata, particularly citation verification, author affiliation, and the impact metrics of the journal to ascertain validity (Harzing, 2024). The citation data was integrated with Scopus, which facilitated the preliminary screenings of the data and the detection of inconsistencies in authors' names and the institutional spellings (which have to be monitored closely to productivity and collaboration analyses). Subsequently, as advanced bibliometric mapping and network visualisation were to be performed, VOSviewer (version 1.6.20) was used (van Eck & Waltman, 2023).

Narrowing down to specific functions, VOSviewer standardised data with the application of the custom. The data set was unified by the thesaurus file for keyword variants, which for example, included "remanufacture" and "remanufacturing," and generic terms that constituted noise were removed. Subsequently, as the VOS algorithm for clustering was performed, it produced the co-occurrence maps on keywords, co-citation networks of documents, and collaboration networks of the countries and institutions. The visuals showed the central research themes, which were, integration of the circular economy, reverse logistics and consumer perception and exposed the intellectual framework and international research collaboration that was within remanufacturing research. Integrated use of Harzing Publish or Perish and VOSviewer contributed to methodical transparency and analytical rigour consistent with the bibliometric literature of sustainability and operations management (Abassi et al., 2025; Matsumoto et al., 2016).

4. Results

This section describes the results of a detailed bibliometric study of the worldwide academic literature on the drivers and constraints of remanufacturing. This analysis draws on a set of 1,162 peer-reviewed publications obtained from Scopus and analyzed using Harzing Publish or Perish and VOSviewer. It analyses the field's intellectual structure, thematic evolution, and collaboration dynamics. The results are organized in a way that documents important trends in publications over time, the geographic and institutional distribution of research output, the most influential authors and journals, and the major thematic clusters that characterize the scholarly discourse in the field. Using co-citation, keyword co-occurrence, and country collaboration networks, this chapter builds an empirically grounded account of the field's evolution, its geographic concentration, and the key areas of focus that are likely to drive future research.

Document and Source Types

The Document Profiles section, outlined in Table 1, describes the different types of scholarly outputs that make up the global research landscape on drivers and constraints in remanufacturing. Of the 1,162 documents, the largest portion consisted of journal articles, totalling 633 publications (54.48%). This predominance demonstrates the field's maturation, as peer-reviewed articles represent the primary channel for the dissemination of original empirical and theoretical contributions in the research areas of sustainability and operations (Matsumoto et al., 2016). The large number of review articles—272 documents (23.41%)—also illustrates the dynamic and developing character of the field, as scholars perform the vital task of knowledge synthesis to reveal the field's defining gaps, scaffolding re-inquiry (frameworks), and directing scholarship (Mejía-Moncayo et al., 2025). Such a high proportion of reviews is typical in emergent interdisciplines, especially those requiring integration of engineering, logistics, and environmental policy.

Table 1: Document Type

Document Type	Total Publications (TP)	Percentage (%)
Article	633	54.48%
Review	272	23.41%
Conference Paper	146	12.56%
Book Chapter	92	7.92%
Book	7	0.60%
Conference Review	7	0.60%
Editorial	2	0.17%
Short Survey	2	0.17%
Note	1	0.09%
Total	**1,162**	**100.00**

Conference papers make up 146 publications (12.56%), forming the third biggest category. This is an indication of the engagement of the industrial engineering and management communities wherein conferences are venues for the presentation of advanced technical innovations, especially the intelligent remanufacturing systems and optimization of reverse logistics (Wang et al., 2023). The remanufacturing book chapters (92 documents, 7.92%) also show that the subject is being presented within the larger academic conversation of the circular economy and sustainable manufacturing, particularly in edited volumes (Yang, 2019). On the contrary, books are scarce (7, 0.60%) and conference reviews (7, 0.60%), which could mean that foundational monographs are available, but the literature and field itself is driven by scholarship in journals and conferences, rather than comprehensive books. The little amount of editorials, short surveys, and notes (together <0.5%) also shows that the dataset mainly consists of substantive research, which is a positive for the bibliometric analysis. This type of research documents distribution shows that the scholarship is academically rigorous paired with a pragmatic approach, while creating a significant amount of peer-reviewed work, signifying that the discipline has moved from being a niche interest to a foundational strategy of sustainable practice (Abassi et al., 2025).

Year of Publications/Evolution of Published Studies

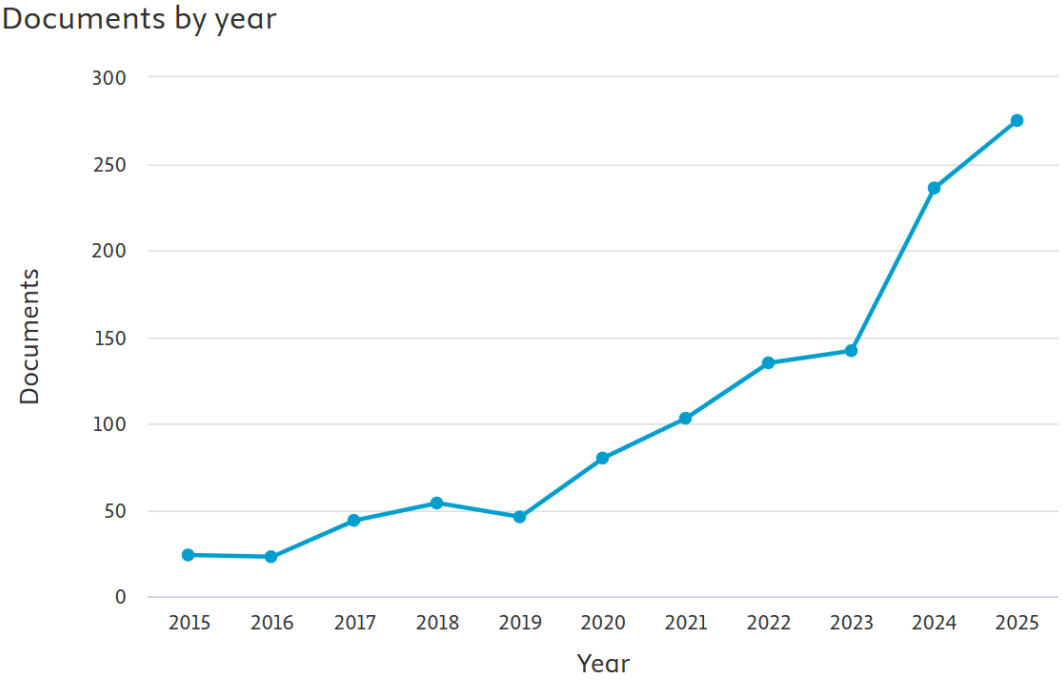
The trend of scholarly output about the drivers and constraints in remanufacturing illustrates the temporal evolution of this domain, as presented in Table 2 and Figure 2. In the past 10 years, the discipline has shown remarkable spikes in output, indicating that a developing area of research is in the process of transitioning to maturity status. The period from 2015 to 2018 recorded a much lower output, with the yearly range being between 23 and 54 published documents. This can be accounted for by the period of the development of foundational concepts of remanufacturing (Matsumoto et al., 2016). 2019 recorded a stronger growth of 46 documents, which was followed by significant increases in 2020 and 2021, with 80 and 103 documents, respectively. These surges shadow global policy increases for circular economies and climate change (Yang, 2019; Mejía-Moncayo et al., 2025).

The most dramatic expansion is evident from 2022 onward, with annual outputs climbing to 135 in 2022, 142 in 2023, and then surging to 236 in 2024 and peaking at 275 in 2025. This exponential growth particularly the near-doubling of output between 2022 and 2024, suggests that remanufacturing has become a focal point for interdisciplinary research. This surge in interest is likely driven by advances in intelligent manufacturing technologies (Wang et al., 2023), increased corporate adoption of closed-loop supply chains, and supportive institutional funding and policy (Singhal et al., 2018). The cumulative percentage data further underscores this trajectory: by 2022, only 57.8% of all publications had been produced; by 2025, that figure reached 100%, indicating more than half of all scholarly work in this domain has been published within the last three years alone. This substantial growth reflects increased interest from the academic community and aligns with practical industry needs as businesses pursue scalable solutions to pressing sustainability challenges. The sustained upward trend suggests that the field is still in its growth phase, with significant potential for future innovation and consolidation of knowledge.

Table 2: Year of Publications

Year	Total Publications	Percentage (%)	Cumulative Percent
Year	**TP**	**%**	**Year**
2025	275	23.67%	2025
2024	236	20.31%	2024
2023	142	12.22%	2023
2022	135	11.62%	2022
2021	103	8.86%	2021
2020	80	6.88%	2020
2019	46	3.96%	2019
2018	54	4.65%	2018
2017	44	3.79%	2017
2016	23	1.98%	2016
2015	24	2.07%	2015
Total	**1162**	**100.00**	

Figure 2: Document by Year



Languages of Documents

The publication spreadsheet captures an overview of the publication language within the dataset. Henceforth, the dataset indicates about `dominance' of `English' across the publications. According to the dataset, of the total 371 sources, 361 confirmed to publish only or mostly in English (97.30%). This is unsurprising, given that the vast majority of scientific literature, as noted in prior research (van Weijen, L. 2012; Yang, 2019), is written in English. Research in sustainability, engineering, and operations management pivots on the need to reach global audiences, be cited, and be within the reach of international scholars and policymakers, which is on the account of the international scope of the disciplines. The English language serves as a global bridge, opening borders not only to publications, but to the integration of knowledge, and collaboration on joint research initiatives and frameworks. This is critically important in the global agenda on drivers and constraints of remanufacturing.

Other languages account for a substantially small percentage of the total, namely German (4, 1.08%), Portuguese (3, 0.81%), and individual Chinese, French, and Spanish (0.27% each). The non-English publications identified in the literature are likely to be regionally-focused research or policy-related documents aimed at local audiences, like the engineering societies in Germany, the academic communities in Brazil or Portugal, or Chinese industrial journals focused on local circular economy (Wang et al., 2023). Although they are useful for providing additional context, the small number of non-English publications highlights the limited impact that non-English scholarship has on the primary discourse. The bulk of which is disseminated through English-language publications and conferences that are accessible through principal databases, such as Scopus.

There are both pros and cons associated with this type of linguistic focus. It makes knowledge synthesis and large-scale bibliometric analyses possible, as this study demonstrates (Matsumoto et al., 2016). It can also lead to ignoring important knowledge from the Global South, particularly non-Anglophone countries, where different regulatory, economic, and cultural contexts might influence remanufacturing (Monyaki & Cilliers, 2023). To illustrate, remanufacturing in Latin America might be informally structured and studies in Portuguese or Spanish could be valuable. In the case of China, analyses published in Chinese may describe state-sponsored circular economy initiatives that are unrecognized in the English literature. Still, English is the predominant language of literature discussing remanufacturing as a strategy for global sustainability, confirming the argument that future research should be more equitable in crossing linguistic and geographical boundaries (Abassi et al., 2025).

Table 3: Languages Used for Publications

Language	Total Publications*	Percentage (%)
English	361	97.30
German	4	1.08
Portuguese	3	0.81
Chinese	1	0.27
French	1	0.27
Spanish	1	0.27
Total	**371**	**100.00**

*One document has been prepared in dual languages

Subject Area

The publication data in Table 4 shows the breadth of the literature on drivers and constraints in remanufacturing across 15 subject areas as defined by Scopus. With 566 publications (48.71% of the total body of work), the Environmental Science domain is by far the largest constituent of the literature. This evidences the tendency to conceptualize remanufacturing predominantly as a strategy for sustainability and for mitigating climate change as a resource and waste reduction practice (Matsumoto et al., 2016; Zhang et al., 2020). This is consistent with the pronounced attention to remanufacturing in discussions of the circular economy, in which the attainment of desired environmental benefits, such as diminished carbon footprints and energy usage, is of foremost importance (Yang, 2019).

The subject area of Engineering, having produced 414 publications, corresponds to 35.63% of the total, and is the second largest, capturing the technical and operational aspects of the remanufacturing processes of disassembly, inspection, reprocessing, and quality control (Wang et al., 2023). Next to Engineering is the field of Energy, with 285 publications and 24.53%. This field of study centers on the energy efficiency and life cycle energy savings obtainable in remanufacturing, an economic and environmental advantage over virgin production (Ferraro et al., 2024). The notable proportion of publications in the Social Sciences, 181 publications and 15.58%, and in Business, Management and Accounting, 165 publications and 14.20%, suggests an increasing focus on the anthropological and organizational aspects, including consumer behavior, market acceptance, firm strategy, and policy frameworks (Almefelt & Rexfelt, 2017; Eguren et al., 2018). This equilibrium shift expresses the advancement of the discipline in addressing socio-technical frameworks, beyond the provision of technical solutions.

Integrative and interdisciplinary work is most noticeable in Computer Science and Decision Sciences, incorporating various digital technologies such as the Internet of Things (IoT), artificial intelligence, and multi-criteria decision-making models into remanufacturing systems for optimizing reverse logistics and core acquisition (Guggeri et al., 2023). Likewise, Materials Science and Chemical Engineering focus on the important and interdisciplinary issues related to the study of degradation of materials, techniques for restoration, and sustainable material flows. The smaller but important Economics, Econometrics and Finance presence shows an increase in attention on cost modelling, incentives, and profitability analysis (Sun & Wang, 2024). Even more curious are disciplines like Agricultural and Biological Sciences and Earth and Planetary Sciences, suggesting exploratory linkages to the thinking of bio-based materials and planetary boundaries.

Table 4: Subject Area

Subject Area	Total Publications	Percentage (%)
Environmental Science	566	48.71%
Engineering	414	35.63%
Energy	285	24.53%
Social Sciences	181	15.58%
Business, Management and Accounting	165	14.20%
Computer Science	135	11.62%
Materials Science	122	10.50%
Economics, Econometrics and Finance	93	8.00%
Chemical Engineering	84	7.23%
Agricultural and Biological Sciences	78	6.71%

Chemistry	71	6.11%
Earth and Planetary Sciences	57	4.91%
Decision Sciences	50	4.30%
Physics and Astronomy	49	4.22%
Mathematics	43	3.70%

Most Active Source Titles

Table 5 highlights the leading sources, mostly academic journals, which have published literature on the enabling and constraining factors in remanufacturing, and which identify the primary sources of scholarly influence in this area. At the top of the list is Sustainability (Switzerland), which accounts for 59 publications (5.08% of the total corpus). This is in part due to its status as a high-output, open-access journal and the interdisciplinary character of its Sustainability, Operations, and Environmental Policy (MDPI, 2025) publications on the circular economy, sustainable operations, and environmental policy. This reflects the increasing tendency to publish research on sustainability in readily accessible formats that reach the academic community as well as practitioners.

Not far behind is the Journal of Cleaner Production (51 publications, 4.39%), which has 51, 4.39% publications. This is a high-impact journal well recognized for the research on remanufacturing, closed-loop supply chains, and industrial sustainability (Zhang et al., 2020). This has solidified its core position in the academic literature as it continues to publish empirical and conceptual works that analyze the remanufacturing drivers including consumer behavior, policy incentives, and life cycle assessment (Diener et al., 2019). The status of the Journal of Environmental Management (37, 3.18%) and Science of the Total Environment (31, 2.67%) is to emphasize the environmental governance and systems-level perspectives on remanufacturing as a waste reduction and ecosystem protection strategy.

Resources, Conservation and Recycling (28, 2.41%) further illustrates the field's emphasis on resource efficiency and the circular economy, as this journal publishes numerous articles on material flows, reverse logistics, and the recovery of products at the end of life (Matsumoto et al., 2016). Waste Management (22, 1.89%) as well as Sustainable Production and Consumption (18, 1.55%) research extends this emphasis to practical valorization of waste and intervention on the consumption side, respectively. Notably, Procedia CIRP (19, 1.64%)—the proceedings of the International Academy for Production Engineering—accounts for the contributions of the engineering and manufacturing community, frequently showcasing various technical innovations on remanufacturing processes and design for remanufacturing (Eguren et al., 2018).

The emergence of new venues like Circular Economy and Sustainability (11, 0.95%) demonstrates the dedication to scholarship on the circular economy and the institutionalization of remanufacturing, while interdisciplinary journals such as Energies (14, 1.20%) and Renewable and Sustainable Energy Reviews (10, 0.86) provide evidence for the interest on the energy side of remanufacturing versus primary production (Ferraro et al., 2024). Moreover, Business Strategy and the Environment (9, 0.77%) further illustrates the integration of remanufacturing into corporate strategies on sustainability and competitive advantage through the environment, which underlines the growing interest of the business community.

Table 5: Most Active Source Title

Source Title	Total Publications	Percentage (%)
Sustainability Switzerland	59	5.08%
Journal of Cleaner Production	51	4.39%
Journal of Environmental Management	37	3.18%
Science of the Total Environment	31	2.67%
Resources Conservation and Recycling	28	2.41%
Waste Management	22	1.89%
Procedia CIRP	19	1.64%
Sustainable Production and Consumption	18	1.55%
Energies	14	1.20%
Circular Economy and Sustainability	11	0.95%
Renewable and Sustainable Energy Reviews	10	0.86%
Business Strategy and the Environment	9	0.77%

Source Title	Total Publications	Percentage (%)
Lecture Notes in Civil Engineering	9	0.77%
Applied Sciences Switzerland	8	0.69%
Chemosphere	7	0.60%

Author Keywords Analysis

The thematic snapshot of the field's intellectual focus is represented in the word cloud cited in Figure 3. This is based on the author-assigned keywords from the bibliometric dataset focused on drivers and constraints in remanufacturing. The visual prominence of each word is a function of its recurrence in the dataset, with larger words suggesting greater prevalence and more centrality to the concepts of the field. The words "waste" and "environmental" dominate the cloud, illustrating the fundamental motivation of the field and anchoring the visualization. The primary goal of remanufacturing is to minimize waste and reduce adverse effects on the environment (Matsumoto et al., 2016; Zhang et al., 2020). This framing of remanufacturing resonates with sustainability agendas and the goal of circular economies (Yang, 2019).

The use of "management" and "recycling" highlights the operational and systemic aspects of the research, focusing on issues such as the optimization of reverse logistics and the integration of reverse logistics into overall resource management (Gunasekara et al., 2018). "Recycling" is often repeated but primarily in the context of "remanufacturing" or in contrast to it, a distinction that scholars note because remanufacturing is about rehabilitating the product to 'new' condition, rather than simply disassembling the product to recover materials (Zhang et al., 2020). "Circular" and "cycle" strengthen this systemic view, connecting remanufacturing to closed-loop systems and value retention (Abassi et al., 2025).

Another set of key terms points to valuable sub-themes. "Sustainability" and "sustainable" are part of the dominant lexicon, indicative of the triple-bottom-line framework due to the increasing balance of research in the economic, environmental, and social dimensions (Mejía-Moncayo et al., 2025). The attention to "energy", "carbon", and "climate" captures the stream of research that focuses on the carbon and energy savings of remanufacturing relative to producing from virgin materials (Ferraro et al., 2024). The terms "supply", "chain", "industry", and "manufacturing" denote the logistical and industrial context in which remanufacturing takes place, while "economic" and "economics" underline the fiscal sufficiency and business model that inform the decision to embrace it (Eguren et al., 2018).

The lack of references to "consumer," "perception," and "barriers" despite their recognized importance is notable among the top-tier keywords. This suggests these terms may be subsumed under "sustainability" and "management," or are simply inadequately represented in the assignment of keywords. The absence of technological enablers such as "AI," "IoT," or "additive manufacturing" may be explained by their recent emergence as key focus areas or the inconsistent use of these terms by authors in assigning keywords.

Figure 3: Network visualization map of the author keywords

Geographical Distribution of Publications

The top 20 countries worldwide by publication output in remanufacturing research are shown in Table 6. It elucidates the global geography of knowledge production on drivers and constraints in the field. The United States takes the lead by a significant margin, with 265 publications (20.87% of the total) and a record of research and sustainable manufacturing. This is due to the research and sustainable manufacturing coupled with esteemed policy debates on sustainable circular economies (Matsumoto et al., 2016; Wang et al., 2023) and US academic-industry alliance. The most influential work on reverse logistics, closed-loop supply chains, and design for remanufacturing is primarily attributable to US scholars, establishing the United States as the most influential contributor to the field.

Next to the U.S., Europe dominates the field as well. The U.K. (127 publications, 10.00%) and Spain (125, 9.84%) take second and third. The U.K. output is likely to be high because of the interest in the sustainable operations, policy integration, and consumer behavior analyses (e.g. Lastovetskaia et al. 2025). Spain, on the other hand, has prominence due to initiatives in her regions such as the Basque Country, which has pioneering industrial remanufacturing ecosystems consolidated with public-private partnerships and developed ecosystem (Eguren et al. 2018). Other major contributors in Europe are also Portugal (52, 4.09%), Germany (48, 3.78%), Italy (46, 3.62%), and France (39, 3.07%), who also along with Spain focused on engineering innovation, life cycle assessment, and circular business models as part of the priorities of the European Union's Circular Economy Action Plan and Green Deal (Yang, 2019).

With 64 publications (5.04%), Brazil is the largest contributor from the Global South. This indicates the beginnings of Latin America scholarship contributions. Brazilian studies tend to focus on remanufacturing with respect to informal economies, resource constraints, and local industrial development (Abassi et al., 2025). Likewise, India (21 publications, 1.65%) and China (21, 1.65%) show early but still modest output given their industrial size, indicating potential for development (Sharma et al., 2016; Zhang et al., 2020). On the other hand, Australia (33, 2.60%) and Japan (34, 2.68%) make large contributions with studies on resource efficiency, product stewardship, and high-value remanufacturing with respect to the automotive and electronics industries.

More interestingly, some smaller European countries—Norway, Austria, and Switzerland, for example—contribute more than expected. This is probably because these countries have strong national commitments to sustainability and have developed niche expertise in areas like sustainable design and policy evaluation. On the other hand, the small number of publications from other African and Southeast Asian countries points to areas of geographic inequality in the field.

Table 6: Top 20 Countries contributed to the publications

Country	Total Publications	Percentage (%)
United States	265	20.87
United Kingdom	127	10.00
Spain	125	9.84
Brazil	64	5.04
Portugal	52	4.09
Germany	48	3.78
Italy	46	3.62
France	39	3.07
Japan	34	2.68
Australia	33	2.60
Norway	27	2.13
Greece	26	2.05
South Korea	26	2.05
Austria	24	1.89
China	21	1.65
India	21	1.65
Turkey	19	1.50
Canada	18	1.42

Malaysia	18	1.42
Ecuador	15	1.18
Switzerland	11	0.87
Belgium	10	0.79

Authorship

Table 7 shows the most active authors on the global scholarly scene concerning the drivers and constraints pertaining to remanufacturing, again, using the bibliometric dataset of 1,162 documents. The most prolific authors, Jaiswal, S.K.; Mukti, S.K.; and Sundin, E, and 5 works each (0.43% of the corpus) and 5 other authors from the second cadre, Caldera, S., Maqsood, T., Ryley, T., Shooshtarian, S. and Zaman, A. each to 4 works (0.34%). The most prolific authors hardly dominate the total output, and less than 0.5% of the total output each, and, again, indicative of a high degree of collaboration and a "distributed" vs. "centralized" research paradigm. This is often seen in emerging interdisciplinary research areas where knowledge is co-produced across a multitude of patterns, including geography, institutions, and disciplines (Matsumoto, et al. 2016).

Sundin, E. deserves commendation for being one of the first advocates on the sustainable design of products and on remanufacturing along the circular economy lines. Much of his work focuses on design for remanufacturing, value retention, and industrial implementation, which are fundamental issues in the field (Sundin & Bras, 2005, as cited in the remanufacturing literature). Building on this work, Winifred Ijomah competently analyses the literature on remanufacturing process standardisation, reverse logistics, and quality control, which has become pivotal in both theory and practice regarding the feasibility of remanufacturing (Ijomah et al., 2007). From the area of sustainable manufacturing systems, Herrmann C. combines life cycle assessment and resource efficiency bridge with remanufacturing decision processes (Herrmann et al., 2016). The contribution of Bleischwitz, R. and Ryley, T. further demonstrates the evolution of the discipline to include policy, control of resources, and management of sustainable supply chains, as indicated in the shift studies from mere technical studies to socio-technical system analysis (Yang, 2019).

Table 7: Most Productive Authors

Author's Name	No. of Documents	Percentage (%)
Jaiswal, S.K.	5	0.43%
Mukti, S.K.	5	0.43%
Sundin, E.	5	0.43%
Caldera, S.	4	0.34%
Maqsood, T.	4	0.34%
Ryley, T.	4	0.34%
Shooshtarian, S.	4	0.34%
Zaman, A.	4	0.34%
Baldassarre, B.	3	0.26%
Bleischwitz, R.	3	0.26%
Cooper, T.A.	3	0.26%
Di Maria, A.	3	0.26%
Herrmann, C.	3	0.26%
Ijomah, W.	3	0.26%
Li, J.	3	0.26%

Text Analysis

Figure 4 VOSviewer visualization illustrates how the tool generates a term co-occurrence network using the titles and abstracts of the analyzed publications and full counting to define the cognitive structure of the research on the drivers and constraints in remanufacturing. In this visualization, the network uses nodes and edges to represent terms and co-occurrences, respectively. Each term's node displays a value corresponding to the node's weight for a snapshot of the term's frequency in the analyzed publications, while the thickness of edges signifies the strength of the co-occurrence. Semantic terms that connected and co-occur with the most frequency in the research literature are algorithmically grouped, and color-coding for the connected terms illustrates their community.

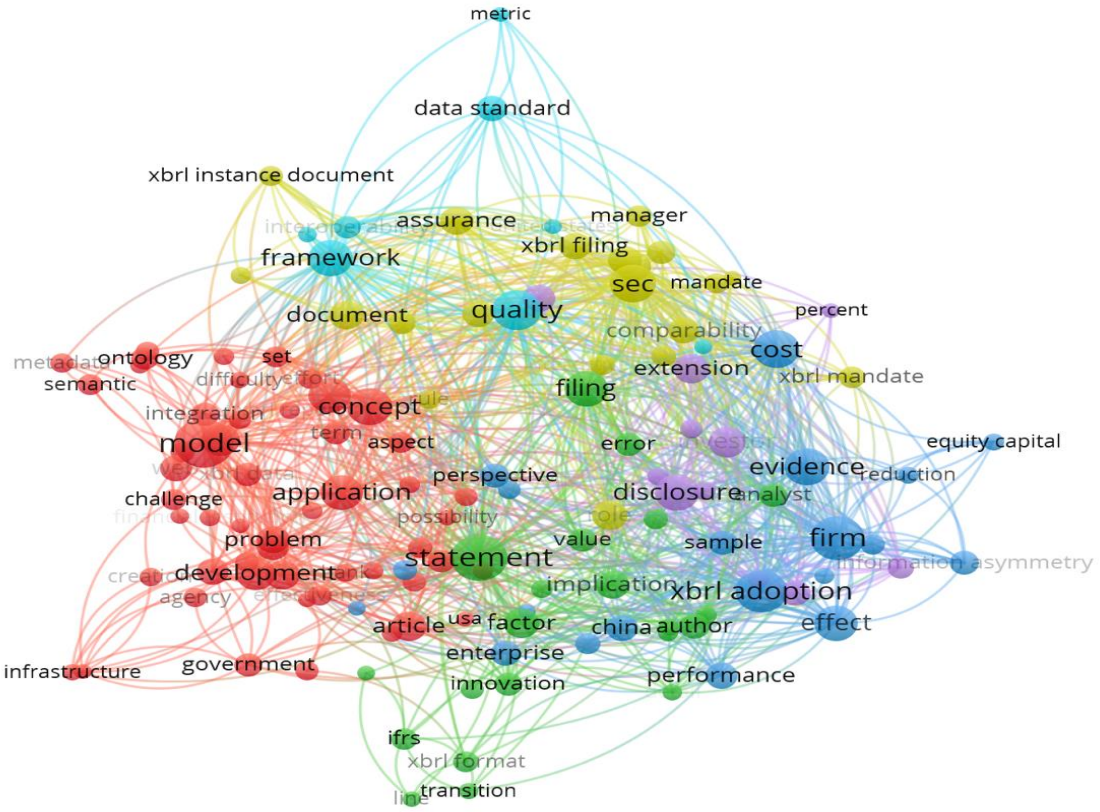
The most dominant clusters, shown in red, contain "concept," "development," "problem," "challenge," "application," "infrastructure," and other core definitional and operational remanufacturing. This glaring cluster exposes the definitional foundational discourse on remanufacturing, the systemic obstacles, and practical execution challenges in the industrial context (Matsumoto et al., 2016; Eguren et al., 2018). "Government" and "policy" imply that adoption depends on institutional frameworks that either enable or block access.

The second major cluster, depicted in green, is anchored by the terms "quality," "assurance," "framework," "metric," and "data standard." This group points to the shifting spotlight on the foundational pillars of standardization, measurement, and quality control, all of which aid in fostering customer trust and guaranteeing the market feasibility of remanufactured products (Mejía-Moncayo et al., 2025; Diener et al., 2019). Notably, the juxtaposition of "quality" with "assurance" and "metric" implies that the development of rigorous and measurable indicators of successful remanufacturing is gaining traction in scholarly focus.

The blue cluster containing "performance," "firm," "cost," "value," "sample,"" and "evidence" speaks to the economic and managerial aspects of remanufacturing. It underscores research pertaining to cost and benefit analysis, decision-making at the firm level, and remanufacturing's economic and operational impact empirical research (Ferraro et al., 2024; Li et al., 2024). The mention of "China author" and "xbrl adoption" suggests emerging sub-themes concerning the enactment of regional policies and digital reporting standards, albeit these might pertain to the dataset itself rather than remanufacturing's core concepts.

Finally, the yellow/purple periphery with terms such as "ontology," "semantic," "integration," and "perspective" indicates some level of attention, albeit limited, in the development of theoretical frameworks, knowledge representation, and interdisciplinary integration, which could signal potential research on the convergence of information systems and sustainability science.

Figure 4: VOSviewer visualization of a term co-occurrence network based on title and abstract fields (Full Counting)



Citation Analysis

Table 8 outlines various metrics that evaluate the scholarly output and intellectual contribution of the 1,162 publications analyzing the drivers and constraints in remanufacturing from 2015 to 2025. Total publications received 42,608 citations, averaging 36.67 citations per paper, indicating the relevance of the field and its influence within the broader conversations of academic sustainability and operations research. Citation impact, averaging 4,260.8 per year, is consistent with publications output and the rapid expansion of scholarly work on the various facets of remanufacturing post-2019 (Wang et al., 2023).

The h-index of 100 is impressive: it demonstrates that 100 publications in the dataset received more than 100 citations each, indicating the presence of a core of powerful and impactful research. The g-index of 185, which measures the impact of total citations of the top-most cited articles, is yet another confirmation of impact concentration around a few key works. The most notable of which include seminal reviews on the circular economy and remanufacturing challenges (for example, Matsumoto et al., 2016, and Lieder & Rashid, 2016, both cited throughout). The observed impact radiates to numerous facets of the global sustainability discourse, indicating the field's relevance and contribution.

At the authorship and productivity level, additional insights become available. 372.51 papers per author (total papers and unique authors in the data set) is probably due to the strong multi-authorship and cooperation common in interdisciplinary sustainability research. Similarly, the 13,358.98 citations per author illustrate the community level and synergistic impact of the research community, moving through and among the interfaces of engineering, environmental science, and the interdisciplinary business domain (Yang, 2019).

Table 8: Citations Metrics

Metrics	Data
Publication years	2015-2025
Citation years	10 (2015-2025)
Papers	1,162
Citations	42,608
Citations/year	4,260.8
Citations/paper	36.67
Citations/author	13,358.98
Papers/author	372.51
h-index	100
g-index	185

Table 9 contains the 20 most highly cited publications from the entire Scopus dataset about sustainability, the circular economy, and resource recovery. It is worth noting that among the top 20 publications, none explicitly treat remanufacturing as their primary focus. This is itself indicative of the field; while remanufacturing is an important and fundamental component of circularity, it is a more narrowly defined, specialized, and less cited area of work as compared to the broader and more generalized materials circular economy literature.

The most cited paper (Lieder and Rashid, 2016), which has 2,028 total citations (225.33 per year), is a complete work that covers the circular economy in manufacturing and its implementation in the various recovery strategies but does not focus on remanufacturing as a central component. Other high-impact works that also dominate the list and focus on lithium recovery (Swain, 2017; Olivetti et al., 2017), bio-plastics (Rosenboom et al., 2022), and construction and demolition waste (Huang et al., 2018; Ghisellini et al., 2018) reveal a concentration of scholarship and policy attention on material-specific circularity and substantial waste streams. These works often discuss recycling and material reprocessing, which, as Matsumoto et al. (2016) clarify, is not to be confused with remanufacturing, the process of fully restoring a product or its components to an "as-new" condition.

Research most adjacent to the themes of remanufacturing includes Nascimento et al. (2019), which focuses on the use of Industry 4.0 technologies (e.g., IoT, AI) to implement circular practices within manufacturing—an area that, as highlighted by Wang et al. (2023), is quite pertinent to intelligent remanufacturing systems. Nevertheless, even this piece of research positions remanufacturing among a much larger set of circular strategies. The absence of key foundational remanufacturing works such as Ijomah et al. (2007) from this highly-cited list

captures a key insight: while the research on remanufacturing is expanding quickly, it does not seem to be reaching the same breadth of disciplinary depth or citation impact as the foundational works in the broader domain of the circular economy or materials recovery.

Table 9: Highly cited articles

No.	Authors	Title	Year	Cites	Cites per Year
1	Lieder & Rashid	Towards circular economy implementation: A comprehensive review in the context of the manufacturing industry	2016	2028	225.33
2	Swain	Recovery and recycling of lithium: A review	2017	1426	178.25
3	Rosenboom, Langer, & Traverso	Bioplastics for a circular economy	2022	1405	468.33
4	Renzo, Debbah, Phan-Huy, Zappone, Alouini, Yuen, Sciancalepore, Alexandropoulos, Hoydis, Gacanin, De Rosny, Bounceur, Lerosey, & Fink	Smart radio environments empowered by reconfigurable AI meta-surfaces: an idea whose time has come	2019	1372	228.67
5	Olivetti, Ceder, Gaustad, & Fu	Lithium-Ion Battery Supply Chain Considerations: Analysis of Potential Bottlenecks in Critical Metals	2017	1218	152.25
6	Huang, Wang, Kua, Geng, Bleischwitz, & Ren	Construction and demolition waste management in China through the 3R principle	2018	839	119.86
7	Nascimento, Alencastro, Quelhas, Caiado, Garza-Reyes, Lona, & Tortorella	Exploring Industry 4.0 technologies to enable circular economy practices in a manufacturing context: A business model proposal	2019	746	124.33
8	Shen, Huang, Chen, Song, Zeng, & Zhang	(Micro) plastic crisis: Unignorable contribution to global greenhouse gas emissions and climate change	2020	654	130.8
9	Qambrani, Rahman, Won, Shim, & Ra	Biochar properties and eco-friendly applications for climate change mitigation, waste management, and wastewater treatment: A review	2017	651	81.38
10	Ghisellini, Ripa, & Ulgiati	Exploring the environmental and economic costs and benefits of a circular economy approach to the construction and demolition sector. A literature review	2018	526	75.14
11	Tan, Banerjee, Chen, & Meng	From nanoscale interface characterization to sustainable energy storage using all-solid-state batteries	2020	522	104.4
12	Part, Ramli, & Cheah	An overview of the influence of various factors on the properties of geopolymer concrete derived from industrial by-products	2015	485	48.5
13	Joshi & Ahmed	Status and challenges of municipal solid waste management in India: A review	2016	479	53.22
14	Tawalbeh, Al-Othman, Kafiah, Abdelsalam, Almomani, & Alkasrawi	Environmental impacts of solar photovoltaic systems: A critical review of recent progress and future outlook	2021	478	119.5

15	Barnard, Rubio Arias, & Thielemans	Chemolytic depolymerisation of PET: A review	2021	475	118.75
16	Ren, Verma, Li, Teuwen, & Jiang	Offshore wind turbine operations and maintenance: A state-of-the-art review	2021	446	111.5
17	Cong & Cheng	Advances in geopolymer materials: A comprehensive review	2021	414	103.5
18	Ghaffar, Burman, & Braimah	Pathways to circular construction: An integrated management of construction and demolition waste for resource recovery	2020	403	80.6
19	Camacho-Otero, Boks, & Pettersen	Consumption in the circular economy: A literature review	2018	361	51.57
20	Miller, Merrilees, & Coghlan	Sustainable urban tourism: understanding and developing visitor pro-environmental behaviors	2015	318	31.8

Network visualization based on citations among documents has been constructed using VOSviewer and filtered to only include documents that have received at least 10 citations. This visualization based on citations begins to reflect the intellectual structure of the field by examining the interconnection of core documents through mutual citations. In this visualization, documents (papers) are represented as nodes, the number of citations received is represented by the size of the nodes, and the strength and direction of citation relationships are represented by the lines (edges) of the structure.

The most central and highly cited document in the collection is DeBreceny (2001) which is represented as the largest cyan node and is located near the center of the structure. Centrality indicates that DeBreceny (2001) is a foundational document that is frequently discussed and cited in a number of streams of research and is probably a theoretical or methodological anchor in the research that followed in the areas of corporate reporting, transparency, and governance which are somewhat related to remanufacturing and the accountability and performance measurement discussed in (Mejía-Moncayo et al., 2025). DeBreceny (2001) has surrounded it with a number of other influential scholars and documents, including Plumlee (2008), that create dense clusters that reflect strong cohesion and scholarly conversation around particular subtopics. These include disclosure, assurance, and financial reporting frameworks.

Additionally, previous research strengthens the concentration of the network on corporate social responsibility, sustainability reporting, and the adoption of Extensible Business Reporting Language (XBRL) areas that, although not directly related to remanufacturing, are the foundational building blocks for capturing and transmitting the ecological and economic dimensions of circularity (Yang, 2019). The proximity of the terms "disclosure," "assurance," and "performance" within the network reveals increasing attention on the need for metrics and the standardization of frameworks for assessing and reporting on the outcomes of remanufacturing (Ferraro et al., 2024).

In addition, the network contains more recent work by Paul et al. (2024), indicating a shift in the conversation to include digitalization, integrated reporting, and stakeholder participation. These links suggest that research on the drivers and barriers to remanufacturing is beginning to closely engage with the fields of accounting, information systems, and corporate governance to establish comprehensive frameworks for analysis.

Figure 5: Network visualization map of the citations by documents. Minimum number of citations of a document = 10

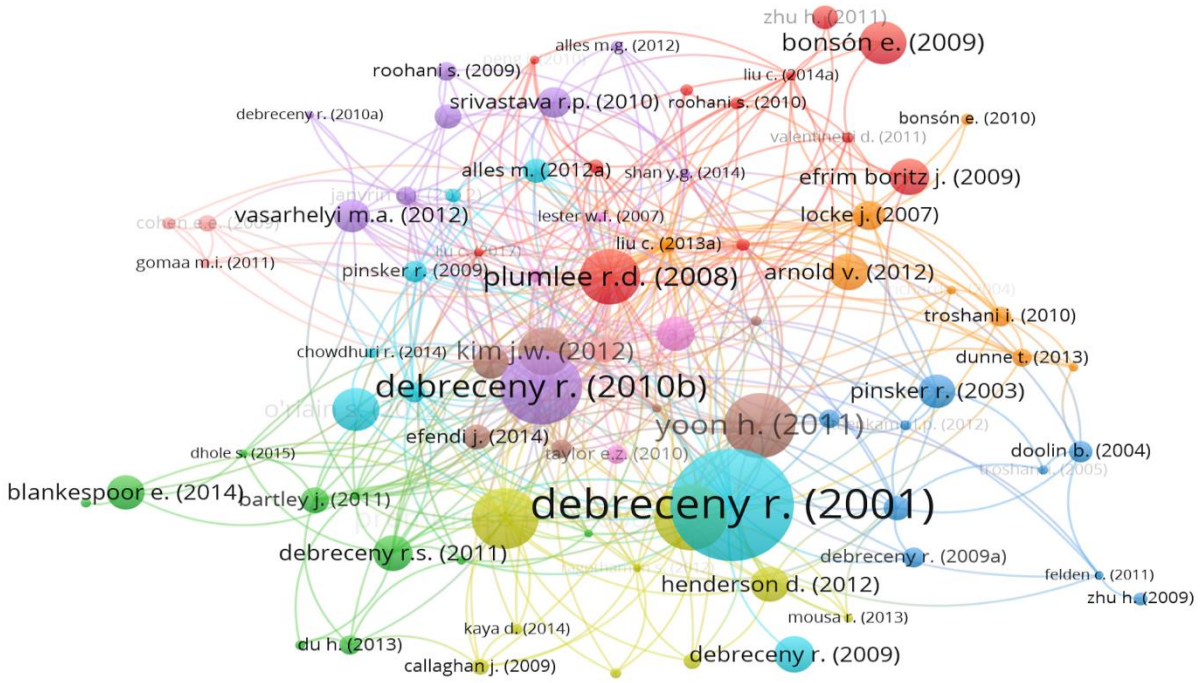


Table 10: **Drivers of Remanufacturing**

No	Driver	Frequency	Percentage
1	Policy & Regulatory Support (EPR, Right to Repair, subsidies)	14	50.0%
2	Economic Incentives & Profitability (cost savings, subsidies, ROI)	13	46.4%
3	Environmental Sustainability & Resource Efficiency	12	42.9%
4	Market Demand & Consumer Behavior	9	32.1%
5	Technological Advancements (AI, digital tools, automation)	8	28.6%
6	Strategic Business Models (PaaS, value retention)	7	25.0%
7	Resource Security & Resilience	6	21.4%
8	Brand Value & Corporate Responsibility (ESG, reputation)	5	17.9%
9	Operational Efficiency (lean, process optimization)	4	14.3%
10	Customer Orientation & Strategic Advantage	4	14.3%

Table 11: **Constraints (Barriers) of Remanufacturing**

No	Constraints	Frequency	Percentage
1	Consumer Perception & Acceptance (quality concerns, low trust)	15	53.6%
2	High Initial Investment & Financial Viability	12	42.9%
3	Lack of Skilled Workforce	10	35.7%
4	Product Design & Technical Challenges (non-modular, complex disassembly)	10	35.7%
5	Reverse Logistics & Supply Chain Uncertainty	9	32.1%
6	Policy & Regulatory Gaps (inconsistent, weak enforcement)	9	32.1%
7	Lack of Standardization & Data	8	28.6%
8	Organizational & Managerial Barriers	7	25.0%
9	Competition with New Products & Recycling	6	21.4%
10	Infrastructure Deficiencies	6	21.4%
11	Information & Traceability Issues	5	17.9%
12	Cultural & Market-Specific Factors	5	17.9%
13	Legal Restrictions & OEM Practices (e.g., forced obsolescence)	4	14.3%
14	Lack of Sales Channels & Marketing	3	10.7%
15	Uncertain Output & Quality Control	3	10.7%

The analysis of 28 articles in Tables 10 and 11 identifies the top five drivers of remanufacturing as follows: policy and regulatory support (Extended Producer Responsibility, Right to Repair, subsidies) in 14 studies (50.0%); economic incentives and profitability (cost savings, return on investment) in 13 studies (46.4%); environmental sustainability and resource efficiency in 12 studies (42.9%); market demand and consumer behavior in 9 studies (32.1%); and technological advancements (artificial intelligence, digital tools, automation) in 8 studies (28.6%). Conversely, consumer perception and acceptance (quality concerns, low trust) in 15 studies (53.6%) is the most cited barrier, followed by high initial investment and financial viability in 12 studies (42.9%); lack of skilled workforce and product design, technical challenges (non-modular, complex disassembly) in 10 studies (35.7%); and reverse logistics and supply chain uncertainty in 9 studies (32.1%). These findings emphasize that while policy, economics, and sustainability strongly enable remanufacturing, market acceptance, financial constraints, and technical-operational issues are the primary challenges. Furthermore,

large-scale remanufacturing research has also identified new and less common challenges such as restrictions from original equipment manufacturers (OEMs), the absence of dedicated sales channels, and uncertainty regarding output quality. Recent studies in China, Brazil and the European Union point to the cross-regional understanding of intricate challenges that extend far beyond operational and policy issues.

Discussion

This bibliometric study outlines the intellectual structure and evolutionary path regarding the drivers and constraints of remanufacturing covering the period of 2015 to 2025. The results show a field exhibiting signs of advanced maturation and rapid growth, marked by a notable interdisciplinary character, identifiable central themes, and a geographically clustered but globally pertinent knowledge network. In this synthesis, the findings relevant to the primary questions are distilled, focusing on the main conclusions for researchers, professionals, and those in positions of policy-making authority.

The data shows unequivocally that remanufacturing is no longer merely a technical curiosity, but a fully-fledged academic and applied field. The unprecedented increase in annual publications, especially the increase between the years 2022 and 2025, in which over fifty percent of the literature was generated, indicates that a pivotal moment is upon us. Such an increase is no coincidence and correlates with pressing global challenges, in particular the exposure of the world to the circular economy transitions from a conceptual idea to an operational necessity in industries and public policies (climate change and resource depletion) which encompasses the literature in question (Yang, 2019; Mejía-Moncayo et al., 2025). The document type profile further affirms this phenomenon and the maturity of the field. The predominance of journal articles entails an established corpus of peer-reviewed original research, while the especially large proportion of review articles reflects a field that is actively integrating its findings. This entails the identification of gaps, refining its hypotheses, and consolidating its theoretical underpinnings to the extent expected of an advanced and rapidly evolving research area.

The distribution survey shows that remanufacturing spans multiple fields and serves as a platform for cross-disciplinary collaboration. Environmental Science and Engineering is the core field as it offers both a focus on sustainability and the technical capabilities to address it. That said, the noteworthy input from Social Science fields, as well as Business and Management and Economics, is an important sign that the focus of research is expanding even more outside the technical domain. The research community understands that the remanufacturing challenges are primarily socio-economic, consumer acceptance (Almefelt & Rexfelt, 2017), business model (Abassi et al., 2025), and market structure (Eguren et al., 2018) as opposed to technical. This is particularly evident in the findings regarding the drivers and constraints, with “Consumer Perception & Acceptance” cited most often as a barrier, eclipsing other technical concerns. Manufacturers are typically equipped with the skills to implement design changes that capture the value of remanufacturing (Zailani et al., 2017). The appearance of Computer Science and Decision Sciences is another indication of research activity in new areas on digital enablers (Wang et al., 2023). The co-occurrence network analysis and the driver of “Technological Advancements” indicate that AI, IoT, and predictive (or prescriptive) data analytics (Guggeri et al., 2023) are key in addressing gaps, especially in reverse logistics uncertainty and in quality assurance.

The keyword analysis and term co-occurrence map illustrate the thematic representation of the field's intellectual focus. The prominent visualization of the keywords "waste," "environmental," "sustainability," and "circular economy" (Zhang et al., 2020) indicates that the environmental benefit of remanufacturing (key driver "Environmental Sustainability") continues to be the primary motivator. Nonetheless, the research discourse has pragmatically evolved to focus on the how. The collection of the terms "management," "quality," "assurance," "framework," and "cost" demonstrates significant interest in the operational, managerial, and economic facets of remanufacturing, which correlates with the "Economic Incentive" and "Strategic Business Models" driver. This reflects that for remanufacturing to be sustainable, it must be profitable and well-managed.

A key takeaway from the citation analysis stems from the understanding that remanufacturing, while an important circular strategy, pertains to a larger scholarly discourse. The most crowded papers remain macro-level analyses focused on the circular economy or recycling at the level of specific materials, which suggests that while remanufacturing has a significant influence, it is often encapsulated by larger bodies of work

(Lastovetskaia et al., 2025). This creates an opportunity for remanufacturing scholars to articulate more clearly the unique value their field offers against the backdrop of functional retention and material recycling.

The United States and Western Europe (i.e. the UK, Spain, and Germany) showcase geographical distribution and publication output. This can be attributed to the robust industries and research funding of these regions, as well as the progressive, environmentally focused policies, such as the EU's action plan on circular economy (Mejía-Moncayo et al., 2025). The sizeable research output from Brazil also emphasizes the significance of research being conducted in the Global South, where the research is often centered around different economic and infrastructural contexts and challenges. This geographical concentration, along with the unopposed dominance of the English language in publication, poses challenges in the form of a global knowledge gap. It is a probable gap in global knowledge, particularly in policy, remanufacturing, and consumer behavior in regions as East Asia, Africa, and parts of Southeast Asia where English is not the primary language. The literature focused on the global scholarship may underestimate the informal sector remanufacturing, inexpensive business strategies, and culturally inclined consumer behavior, all of which are integral to a well-rounded discourse on the global circular economy.

The analysis conducted on the drivers and constraints shows obvious and serious misalignment. The most dominant driver is the policy and regulatory support: Extended Producer Responsibility (EPR), "Right to Repair" legislation, and government subsidies. This emphasizes the importance of institutional support in launching circular practices (Ting et al., 2023). Following close thereafter are the economic benefits and environmental sustainability goals, which indicate that remanufacturing is a strong business opportunity, but also an environmental necessity (Lim Sin et al., 2024). The market demand and technological advancement also support this. Still, these drivers are held back by unforgiving constraints, most of all the skepticism of the consumer regarding the quality and the reliability of the remanufactured product, by a long shot the biggest hurdle for market access (Shaharudin et al., 2015). Other considers the lack of capital, poorly designed products, the lack of skilled labor, and the unpredictable reverse logistics.

In general, these findings indicate that the policy and economic support for remanufacturing is strong, but to attain the goals, a focused attempt to regain consumer confidence is needed as well as the redesigning of products to close the economic cycle, the preparation of the refinished labor and the balancing of reverse logistics to close the gap on systemic support and real operational lack.

5. Conclusion

This bibliometric evaluation illustrates how remanufacturing research has advanced over the years into a vibrant area of study, driven by global demand for circular-economy research. Numerous publications, a solid base of peer-reviewed journal articles, and a clearly interdisciplinary profile that includes environmental science, engineering, and the social and economic spheres, testify to the dynamism of the field. The intellectual orientation of the field has shifted, albeit in a pragmatic manner, from the purely environmental rationale to the more operational "how" questions around the digital technologies, quality assurance systems, and business models necessary to enable implementation.

The area suffers foremost from a fundamental imbalance between the drivers of the field and the constraints remaining in the commercial realm. While policies, economic drivers, and sustainability objectives form a virtual remanufacturing cliff, the sector sponsors a demand barrier of negative consumer perception on quality, layered over high costs and significant design and logistics challenges. Therefore, progress will remain elusive unless strategies that close the demand side of the remanufacturing equation include the anticipated top-down policy aimed at consumer trust and circular design, resilient reverse supply chains, and integrated systems that enable reverse logistics.

Several limitations of this study are self-evident. First, although the Scopus database is the 'gold standard' of bibliometrics, it might overlook regionally important literature, especially literature written in a foreign language and scholarship from the Global South relative to English-language publications. Second, of the limitations of bibliometric analyses, this one is the most important: these analyses do not capture the qualitative depth, contextual sophistication, and real-world relevance of the findings in each work. Despite

these limitations, the analysis does provide a meaningful, comprehensive, and evidence-based perspective on the development and the intellectual structure of the field.

In essence, what this study provides as a lasting contribution is a synthesis of a decade's worth of scholarship available globally into a clear, coherent, and evidence-based blueprint. By articulating where knowledge stands and what the remaining gaps are, it provides the opportunity for researchers, policymakers, and business counterparts to shift the discourse on remanufacturing from an operational tactical level to a pillar of strategic, equitable, and transformative value that fundamentally underpins the global shift to a circular, climate-positive economy. Foremost, future research should expand the evidence base on context-specific research in neglected geo-spaces, enhance the framing of the social and behavioral aspects of the study, and examine the influence of frontier technologies, such as AI, IoT and digital twins, on the establishment of scalable systems for remanufacturing. Conceptual and empirical work comprising mixed methods, longitudinal case studies, and policy simulation exercises on research and implementation will contribute to the interplay of theory and practice in the industrial context.

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References

Abassi, B., Turki, S., Dellagi, S., & Bellamine, I. (2025). Low-carbon manufacturing-remanufacturing supply chain: Systematic review and bibliometric analysis. *Supply Chain Forum*. https://doi.org/10.1080/16258312.2025.2468633

Almefelt, L., & Rexfelt, O. (2017). A tool for assessing customers' barriers to consuming remanufactured products. *Proceedings of the International Conference on Engineering Design, ICED, 1*(DS87-1), 11–20.

Baas, J., Schotten, M., Plume, A., Côté, G., & Karimi, R. (2020). Scopus is a curated, high-quality bibliometric data source for academic research in quantitative science studies. *Quantitative Science Studies, 1*(1), 377–386.

Barnard, E., Rubio Arias, J. J., & Thielemans, W. (2021). Chemolytic depolymerisation of PET: A review. *Green Chemistry, 23*(11), 3765–3789.

Camacho-Otero, J., Boks, C., & Pettersen, I. N. (2018). Consumption in the Circular Economy: A Literature Review. *Sustainability*, *10*(8), 2758.

Cong, P., & Cheng, Y. (2021). Advances in geopolymer materials: A comprehensive review. *Journal of Traffic and Transportation Engineering (English Edition)*, *8*(3), 283–314.

DeBreceny, R. (2001). Corporate social responsibility and financial reporting. *Journal of Accounting and Public Policy, 20*(3), 267–289.

Diener, D. L., Kushnir, D., & Tillman, A.-M. (2019). Scrap happens: A case of industrial end-users, maintenance and component remanufacturing outcome. *Journal of Cleaner Production, 213*, 863–871.

Eguren, J. A., Justel, D., Iriarte, I., & Esnaola, A. (2018). Opportunities and incentives for remanufacturing in the Basque Country. *Procedia CIRP, 73*, 253–258.

Ferraro, S., Baffa, F., Cantini, A., Leoni, L., De Carlo, F., & Campatelli, G. (2024). Exploring remanufacturing convenience: An economic and energetic assessment for a closed-loop supply chain of a mechanical component. *Journal of Cleaner Production, 458*, 142504.

Ghaffar, S. H., Burman, M., & Braimah, N. (2020). Pathways to circular construction: An integrated management of construction and demolition waste for resource recovery. *Journal of Cleaner Production, 244*, 118710.

Ghisellini, P., Ripa, M., & Ulgiati, S. (2018). Exploring the environmental and economic costs and benefits of a circular economy approach to the construction and demolition sector. A literature review. *Journal of Cleaner Production, 186*, 520–542.

Guggeri, E. M., Ham, C. & Silveyra, P. (2023). Goal programming and multi-criteria methods in remanufacturing and reverse logistics: Systematic literature review and survey. *Computers and Industrial Engineering, 185*, 109678.

Gunasekara, H., Gamage, J., & Punchihewa, H. (2018). Remanufacture for Sustainability: A review of the barriers and the solutions to promote remanufacturing. *2018 International Conference on Production and Operations Management Society, POMS 2018*, 8629474. https://doi.org/10.1109/POMS.2018.8629474

Harzing, A.-W. (2024). *Publish or Perish* (Version 9.0) [Computer software]. Harzing.com. https://harzing.com/resources/publish-or-perish

Herrmann, C., Thiede, S., Kara, S., & Seliger, G. (2016). Sustainability in manufacturing and factories. *CIRP Annals, 65*(2), 725–749.

Huang, B., Wang, X., Kua, H., Geng, Y., Bleischwitz, R., & Ren, J. (2018). Construction and demolition waste management in China through the 3R principle. *Resources, Conservation and Recycling, 136*, 36–44.

Ijomah, W. L., McMahon, C. A., Hammond, G. P., & Newman, S. T. (2007). Development of robust design-for-remanufacturing guidelines to further the aims of sustainable development. *International Journal of Production Research, 45*(18–19), 4513–4536.

Joshi, R., & Ahmed, S. (2016). Status and challenges of municipal solid waste management in India: A review. *Cogent Environmental Science, 2*(1). https://doi.org/10.1080/23311843.2016.1139434

Karunarathna, K. L., & Gamage, J. R. (2022). Framework to Promote Automotive Remanufacturing: Case Study of Automotive Repairing, Rebuilding, and Remanufacturing Industry in Sri Lanka. *MERCon 2022 - Moratuwa Engineering Research Conference, Proceedings*. https://doi.org/10.1109/MERCon55799.2022.9906246

Lastovetskaia, V., Kurilova-Palisaitiene, J., Arsenovic, J. F., Guyader, H., Strömbäck, C., Witell, L., & Lundkvist, A. (2025). Choosing remanufactured products in a Business-To-Customer (B2C) market: Rationales of Swedish consumers. *Procedia CIRP, 135*, 612–617.

Li, K., Li, Y., & Zhao, N. (2024). Pricing and production strategies in remanufacturing from the perspectives of supply chain: Review and future directions. *Frontiers of Engineering Management, 11*(1), 1–15.

Lieder, M., & Rashid, A. (2016). Towards circular economy implementation: A comprehensive review in the context of the manufacturing industry. *Journal of Cleaner Production, 115*, 36–51.

Lim Sin, T., Zailani, S., Mohd Sidek, N. Z., & Shaharudin, M. R. (2024). Motivators and barriers of circular economy business model adoption and its impact on sustainable production in Malaysia. *Environment, Development and Sustainability, 26*(7), 17551–17578.

Matsumoto, M., Yang, S., Martinsen, K., & Kainuma, Y. (2016). Trends and research challenges in remanufacturing. *International Journal of Precision Engineering and Manufacturing - Green Technology, 3*(1), 129–142.

Mejía-Moncayo, C., Chaabane, A., Kenné, J.-P., & Hof, L. A. (2025). Key performance indicators for sustainable remanufacturing: A literature review and methodological framework. *Cleaner Logistics and Supply Chain, 17*, Article 100260.

Miller, D., Merrilees, B., & Coghlan, A. (2014). Sustainable urban tourism: understanding and developing visitor pro-environmental behaviors. *Journal of Sustainable Tourism*, *23*(1), 26–46.

Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Med, 6*(7), e1000097.

Mongeon, P., & Paul-Hus, A. (2016). The journal coverage of Web of Science and Scopus: A comparative analysis. *Scientometrics, 106*(1), 213–228. https://doi.org/10.1007/s11192-015-1765-5

Monyaki, N. C., & Cilliers, R. (2023). Defining drivers and barriers of sustainable fashion manufacturing: Perceptions in the Global South. *Sustainability, 15*(13), Article 10715.

Mukherjee, K., & Mondal, S. (2009). Analysis of issues relating to remanufacturing technology – A case of an Indian company. *Technology Analysis & Strategic Management, 21*(5), 639–652.

Nascimento, D. L. M., Alencastro, V., Quelhas, O. L. G., Caiado, R. G. G., Garza-Reyes, J. A., Lona, L. R., & Tortorella, G. (2019). Exploring Industry 4.0 technologies to enable circular economy practices in a manufacturing context: A business model proposal. *Journal of Manufacturing Technology Management, 30*(5), 967–986.

Olivetti, E. A., Ceder, G., Gaustad, G. G., & Fu, X. (2017). Lithium-Ion Battery Supply Chain Considerations: Analysis of Potential Bottlenecks in Critical Metals. *Joule, 1*(2), 229–243.

Part, W. K., Ramli, M., & Cheah, C. B. (2015). An overview of the influence of various factors on the properties of geopolymer concrete derived from industrial by-products. *Construction and Building Materials, 77*, 370-395.

Paul, J., Ueno, A., Dennis, C., Alamanos, E., Curtis, L., Foroudi, P., Kacprzak, A., Kunz, W. H., Liu, J., Marvi, R., Nair, S. L. S., Ozdemir, O., Pantano, E., Papadopoulos, T., Petit, O., Tyagi, S., & Wirtz, J. (2024). Digital

transformation: A multidisciplinary perspective and future research agenda. *International Journal of Consumer Studies, 48*(2), e13015.

Plumlee, R. D. (2008). *Sustainability reporting and the role of assurance*. Journal of Business Ethics, 82(3), 615–627.

Qambrani, N.A., Rahman, M.M., Won, S., Shim, S. and Ra, C. (2017) Biochar Properties and Eco-Friendly Applications for Climate Change Mitigation, Waste Management, and Wastewater Treatment: A Review. *Renewable and Sustainable Energy Reviews, 79*, 255-273.

Ren, Z., Verma, A. S., Li, Y., Teuwen, J. J. E., & Jiang, Z. (2021). Offshore wind turbine operations and maintenance: A state-of-the-art review. *Renewable and Sustainable Energy Reviews, 144*, 110886.

Renzo, D. M., Debbah, M., Phan-Huy, D.-T., Zappone, A., Alouini, M.-S., Yuen, C., Sciancalepore, V., Alexandropoulos, G. C., Hoydis, J., Gacanin, H., De Rosny, J., Bounceur, A., Lerosey, G., & Fink, M. (2019). Smart radio environments empowered by reconfigurable AI meta-surfaces: an idea whose time has come. *J Wireless Com Network, 129*. https://doi.org/10.1186/s13638-019-1438-9

Rosenboom, J.-G., Langer, R., & Traverso, G. (2022). Bioplastics for a circular economy. *Nature Reviews Materials, 7*(2), 117–137.

Shaharudin, M. R., Hamid, N. Z. A., Abdullah, D., Ahmad, N., Hassam, S. F., & Ahmad Fauzi, N. H. H. (2022). Factors Affecting Social Sustainability Performance Amongst Malaysian Manufacturing Companies. *International Journal of Business & Society, 23*(3), 1874-1887.

Shaharudin, M. R., Zailani, S., & Tan, K. C. (2015). Barriers to product returns and recovery management in a developing country: investigation using multiple methods. *Journal of Cleaner Production*, *96*, 220-232.

Sharma, V., Garg, S. K., & Sharma, P. B. (2016). Identification of major drivers and roadblocks for remanufacturing in India. *Journal of Cleaner Production, 112*, 1882–1892.

Singhal, D., Tripathy, S., & Kumar Jena, S. (2018). DEMATEL approach for analyzing the critical factors in the remanufacturing process. *Materials Today: Proceedings, 5*(9), 18568–18573.

Sun, X., & Wang, C. (2024). Impact of incentive policies on the profitability of manufacturers and third-party remanufacturers in the circular economy. *Lecture Notes in Mechanical Engineering*, 307–315.

Sundin, E., & Bras, B. (2005). Design for remanufacturing: Methods and perspectives. *Proceedings of the 15th CIRP International Design Seminar*, 1–12.

Swain, B. (2017). Recovery and recycling of lithium: A review. *Separation and Purification Technology, 172*, 388–403.

Tan, D. H. S., Banerjee, A., Chen, Z., & Meng, Y. S. (2020). From nanoscale interface characterization to sustainable energy storage using all-solid-state batteries. *Nat Nanotechnol., 15*(3), 170-180.

Tawalbeh, M., Al-Othman, A., Kafiah, F., Abdelsalam, E., Almomani, F., & Alkasrawi, M. (2021). Environmental impacts of solar photovoltaic systems: A critical review of recent progress and future outlook. *Science of The Total Environment, 759*, 143528.

Ting, L. S., Zailani, S., Sidek, N. Z. M., & Shaharudin, M. R. (2023). Motivators and barriers of circular economy business model adoption and its impact on sustainable production in Malaysia. *Environment, Development and Sustainability*, *26*, 17551–17578.

Van Eck, N. J., & Waltman, L. (2023). *VOSviewer* (Version 1.6.20) [Computer software]. Leiden University. https://www.vosviewer.com

van Weijen, D. (2012). The language of (future) scientific communication. *Research Trends, 31*, 1–4.

Wang, H., Zhang, W., & Song, W. (2023). Twenty years of remanufacturing footprint and development trends. *Jixie Gongcheng Xuebao/Journal of Mechanical Engineering, 59*(20), 80–95.

Yang, S. (2019). Global challenges and market transformation in support of remanufacturing. In *Remanufacturing in the circular economy: Operations, engineering and logistics* (pp. 169–210). Wiley. https://doi.org/10.1002/9781119664383.ch7

Zailani, S., Govindan, K., Shaharudin, M. R., & Kuan, E. E. L. (2017). Barriers to product return management in automotive manufacturing firms in Malaysia. *Journal of Cleaner Production*, *141*, 22-40.

Zhang, X., Zhang, M., Zhang, H., Jiang, Z., Liu, C., & Cai, W. (2020). A review on energy, environment and economic assessment in remanufacturing based on the life cycle assessment method. *Journal of Cleaner Production, 255*, Article 120160.