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Problems and Potentials of Shared Manufacturing in the Context of Industrial Ecosystems: A Bibliometric Analysis

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Abstract

Shared Manufacturing has emerged as a transformative paradigm in the manufacturing industry that can potentially disrupt the sector. In particular, the formation of ecosystems could serve as an incubator for sharing approaches. New business models linked to demand-based resource allocation could increase the manufacturer's competitiveness and can even help to achieve sustainability goals. While sharing approaches have already emerged in some sectors, the impact on manufacturing has been inhibited so far.

This bibliometric analysis aims to provide a high-level overview of the research landscape on hurdles and potentials related to Shared Manufacturing in ecosystems. The findings provide researchers with entry points for a problem-centered approach to the topic, serving as an initial starting point for a more in-depth work and examination. In this way, further research can address the challenges and liberate the full potential of Shared Manufacturing.

Keywords: Sharing Economy, Shared Manufacturing, Ecosystems, Bibliometric Analysis

1. Introduction

Collaboration and resource sharing are increasingly crucial for companies to remain competitive, and are additionally an enabler of Industry 4.0 (Camarinha-Matos et al., 2017). One manifestation of the Sharing Economy is sharing production capacities, also known as Shared Manufacturing (Yu et al., 2020). Sharing machine capacity in a network promises vast competitive advantages, leading to decreased idle times and increased utilization ratios (Camarinha-Matos et al., 2017). Both developments mean an increase to the cost-benefit share especially for manufacturers with small and medium lot sizes. They often possess machines with standardized processes, like CNC or lathe machines, whose reconfigurability exceeds individual products, so that they manufacture incomplete lots. Additionally, due to network effects, default network risks can be reduced drastically. Furthermore, safety stocks can be decreased due to the higher availability of machinery assets, leading to more working capital being freed up (Domagała et al., 2023). Creating additional revenue streams while maintaining less safety stock offers persuasive business opportunities. As rapid technological change and innovative business models potentially threaten business continuity, Shared Manufacturing could be an opportunity for companies to turn former threats into opportunities (Niemimaa et al., 2019).

Providing third parties temporary access to own machinery fits perfectly within the definition of the Sharing Economy, although no uniform definition has yet been established (Codagnone & Martens, 2016). Sharing Economy principles also contribute to achieve several sustainability goals and represents one of the main reasons why customers use collaboration platforms, along with economic benefits, social experience and quality of life (Boar et al., 2020). Although Shared Manufacturing offers the promise of combining sustainability and economic benefits, there is still a lack of examples that demonstrate its viability on a large scale. Hence, this paper focuses on the identification of hurdles and potentials of Shared Manufacturing by answering the following research question: *What are the most significant hurdles or potentials addressed in Shared Manufacturing in industrial ecosystems in the context of Industry 4.0?*

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In order to answer the research question, the paper is structured as follows: First, we briefly outline related work and identify the research gap. Then, we conduct a bibliometric analysis, which is enriched by a multi-stage keyword filtering process. Here, we extract potentials and hurdles connected to Shared Manufacturing from the raw data. The derived keywords undergo a quantitative examination, being reduced to a logically clustered data set, which is then qualitatively contextualized based on the literature. Subsequently, we discuss the findings of our bibliometric analysis and derive topic clusters indicating challenges and opportunities relating to Shared Manufacturing. Finally, we reflect our results in the discussion and draw a conclusion for further research.

2. Related Work

This chapter proceeds as follows: First, we present relevant literature on Sharing Economy. Afterward, we fit the term 'industrial ecosystem' into the context of a Sharing Economy. Finally, we contextualize the findings to outline the need for further analysis.

As early as 2008, Vachon and Klassen (2008) pointed out the relevance of collaboration in the context of sustainability and the performance of supply chains. They also pointed out the positive impact of collaboration on environmental performance or, for instance, on costs and quality (Vachon & Klassen, 2008). The term 'Sharing Economy' yet remained to be introduced. This happened in the year of 2010 by Botsman and Rogers (2010), who are often mentioned as the originators of the concept of a 'Sharing Economy' (Teubner, 2014). However, the term lacks a clear definition to date and is used in a broad matter (Codagnone & Martens, 2016). Additionally, some terms in the domain are applied interchangeably, such as *Collaborative Economy*, and are closely related to the *Circular Economy* (Codagnone & Martens, 2016).

A holistic definition approach is made by Klarin and Suseno (2021), summarizing the *Sharing Economy* as the "[...] commercial and non-commercial sharing of goods and services that is coordinated via online platforms without the transfer of ownership" (Klarin & Suseno, 2021, p.2). In contrast to the original meaning of sharing, the Sharing Economy is explicitly a non-zero-sum game (Teubner, 2014). It allows the exploration of new business models (such as pay-per-use) to generate additional revenues and thus compensates for economic fluctuations (Curtis, 2021).

Shared Manufacturing, as interpreted by Yu et al. (2020), is a manifestation of the Sharing Economy, involving peer-to-peer use of manufacturing capacity through temporary access to machines and thus being distinct from other forms of social manufacturing (Yu et al., 2020). Although the authors' interpretation is fitting well, the paper lacks of a comprehensive or detailed literature review to substantiate the definition, and the hurdles or potential hurdles are addressed rather parenthetical.

Analogous to biological ecosystems, Korhonen (2001) has identified four principles for industrial ecosystems: 'roundput', 'diversity', 'locality' and 'gradual change'. Different actors work together in these ecosystems to produce different products through local resource use and recycling (Korhonen, 2001). The paper's findings are presented as ecosystem analogies and via metaphorical comparison of associated principles. This procedure helps to interpret and contextualize similarities in opportunities and challenges across ecosystems.

In order to identify challenges and potentials, Suuronen et al. (2022) have conducted a systematic literature review for digital business ecosystems in the manufacturing industry. They identified eight benefits, eight challenges and nine preconditions, some of which can be applied to Shared Manufacturing. However, the paper is limited to platform and digital-based ecosystems and does not grasp the general potentials or hurdles.

Building upon the findings of a bibliometric analysis, Klarin and Suseno (2021) derived four research directions associated to Sharing Economy in which sustainability and collaborations are relevant focus areas. Taking an emphasis on Industry 4.0 in general, Tambare et al. (2021) derived six categories from literature addressing challenges in the context of Industry 4.0. They refer to standardization, collaboration, cyber security, system integration, communication, and environment. The specific area of Shared Manufacturing still needs to be analyzed against this background, as further potential and hurdles may arise from linking the intersecting areas.

In the context of growing sustainability demands, exploring the potential of collaborative production to improve resource efficiency is becoming increasingly important. Focusing on industrial ecosystems with their potential to improve resource allocation and minimize waste offers a promising approach for sustainability efforts. However, it is critical to note that there is still a distinct lack of current literature-based work specifically addressing logistics barriers in the context of Shared Manufacturing, underscoring the urgent need for such research to address this research gap.

The methodology used to answer the research question is discussed in the next chapter.

3. Methodology

Since the scope of literature on Shared Manufacturing and industrial ecosystems contains over thousands of papers, the use of a bibliometric analysis is recommended by Donthu et al. (2021). The procedure is illustrated in Figure 1 to get a first impression of the numerous discussed topics. The method is applied to extract relevant hurdles and potentials from the literature, giving a first indicator for potential research gaps and demands.

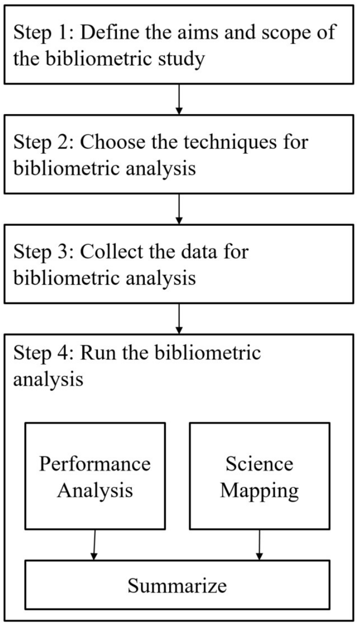

Figure 1. Steps of the bibliometrics process in accordance to (Donthu et al., 2021).

Following the process, the first step is to define the objective and the scope of the analysis. In a second step we selected appropriate techniques for bibliometric analysis. Donthu et al. (2021) present an overview of methods for bibliometric analysis and a comprehensive set of sequential instructions that resulted in a toolkit for conducting bibliometric analyses. After the relevant data is collected, our bibliometric analysis covers two subsections: performance analysis and scientific mapping. *Performance analysis* is a widely used descriptive method found in most reviews that shows the performance of various research components in the field, which is used to determine the relevance of the field (Donthu et al., 2021). Hence, it intends to give a short overview of the data set and helps to evaluate its representativeness and topicality. *Science mapping* is used to explore the relationships between the research constituents, which is important for the contextualization of the keywords (Donthu et al., 2021).

In the following, the steps shown in Figure 1 will be explained. The scope of this paper is derived from the research question as it focuses on the identification of hurdles and potentials when Shared Manufacturing is implemented in the context of industrial ecosystems in the era of Industry 4.0. As data sources, Scopus, the Association for Computing Machinery (ACM) and Web of Science (WoS) served as the basis for the subsequent analysis. Using multiple data sources helps reduce biases that can arise from each platform's indexing policies. Additionally, these platforms ensure a high quality of the paper (e.g. peer-reviewed, high-ranked conferences and journals, books).

The respective search terms in platform-specific notation are shown in Table 1, focusing on the linkage of Sharing Economy, ecosystems and problems or hurdles since the proclamation of Industry 4.0 by the German Government in 2011 (Kagermann & Wahlstern, 2011). The data from the different sources are merged in Citavi as it provides functionalities for immediate detection and removal of duplicates across the results of the databases.

The number of *total publication (TP)* is analyzed during the *performance analysis*. The TP is used to quantify the total volume of publications on the topic, where increasing or decreasing publishing rates can be identified. Thus, the topic's relevance can be visualized. In addition, the TP is determined with regard to their source (or original database) and is deducted over time. In the process of consolidating data from multiple sources, we have eliminated redundancies in our dataset. Consequently, it is not possible to clearly assign a keyword to a specific source as the distinctions between the sources have been blurred. Additionally, the TP over time is analyzed regarding the type of publication. Hence, time delays might be explained due to the publishing format. Also, the types of publications in the data set are analyzed. The process of determining power assignment is performed by using frequency tables on the merged data set.

The *science mapping* examination is based on *co-word-analysis*, providing a first insight into relevant keywords that can be interpreted as relevant research topics. Within this search, the keywords were derived from the documents' metadata. Therefore, a multi-stage keyword selection process, comparable to the process used by (Nobre & Tavares, 2017), is applied, whereby hurdles and potentials are extracted from the raw data. A bibliometric analysis was performed and a manual keyword selection and filtering process was implemented to improve relevance and specificity, particularly by excluding non-specific terms such as

Table 1. Database Queries and Results.

Database	Search String Composition	Results
Scopus	TITLE-ABS-KEY ((shar* AND (“Econom*” OR “Manufact*” OR “Industr*”)) AND (“ecosystem*” OR “network*”) AND (“hurdle” OR “Challeng*” OR “potential*” OR “requir*” OR “inhibit*” OR “problem*” OR “limit*” OR “benefit*” OR “obstacl*”)) AND PUBYEAR > 2010 AND PUBYEAR < 2024	$17,543$
Web of Science	TS = ((“shar*” AND (“Econom*” OR “Manufact*” OR “Industr*”)) AND (“ecosystem*” OR “network*”) AND (“hurdle” OR “Challeng*” OR “potential*” OR “requir*” OR “inhibit*” OR “problem*” OR “limit*” OR “benefit*” OR “obstacl*”)) AND PY > 2011-01-01 < 2024	$11,106$
ACM	[All: shar*] AND [[All: “econom*”] OR [All: “manufact*”] OR [All: “industr*”]] AND [[All: “ecosystem*”] OR [All: “network*”]] AND [[All: “hurdle”] OR [All: “challeng*”] OR [All: “potential*”] OR [All: “requir*”] OR [All: “inhibit*”] OR [All: “problem*”] OR [All: “limit*”] OR [All: “benefit*”] OR [All: “obstacl*”]] AND [E-Publication Date: (01/01/2011 TO 12/31/2023)]	248
	Total Amount	28,897
	Without Duplicates	25,836

names and countries.

The keyword-based search process applied in this paper is illustrated in Figure 2. In the first step, a thesaurus file is used to standardize notations (e.g. merging similar words with a different spelling). A keyword occurrence threshold is then applied, set at 30, to ensure that the data set is reduced to relevant and meaningful keywords for further processing. The occurrence quantifies the frequency of keywords in the data set. In the final step, keywords that apply to problems and potentials are selected, and irrelevant keywords are removed.

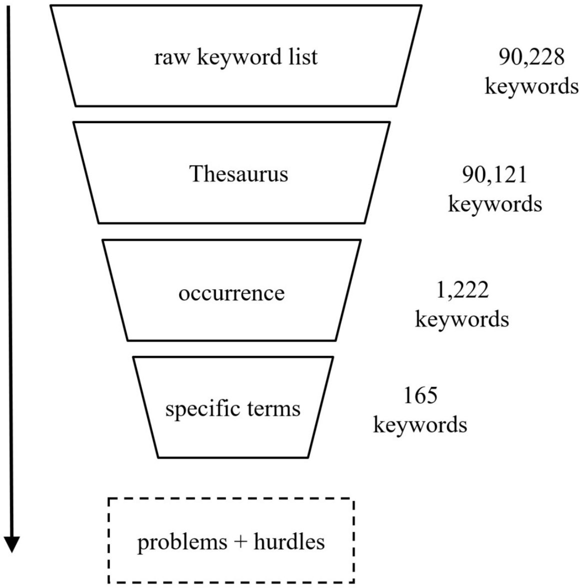

Figure 2. Keyword filtering process as suggested by (Nobre & Tavares, 2017).

After filtering the keywords, the *smart local moving algorithm* proposed by (Waltman & van Eck, 2013) is used to generate and display co-words and clusters in VOSviewer visually. The Smart Local Moving algorithm focuses on modularity-based community detection in large networks, resulting in high modularity values at a manageable computational cost (Waltman & van Eck, 2013). Hence, it helps to uncover inherent structures and relationships in the data.

Lastly, and in order to interpret the central threshold of keywords, further restrictions were applied. For a detailed analysis we generated a second co-word network, including only the top 20 percent keywords, measured based on the total number of occurrences. A sample size of 20 percent was chosen to strike a balance between obtaining reasonably accurate results and avoiding an unwieldy sample for the author (Edwards, 1999). In order to enhance the accuracy of the classification, the assignment was refined through iterative collaboration, following a consensus-building approach. The result analysis of the bibliometric process, which is performed in the third and fourth steps following (Donthu et al., 2021), is described in more detail in the next chapter.

4. Results

In this chapter, the results of the analysis described in the previous chapter are being presented in correspondence to the applied search string, starting with the *performance analysis*.

Considering the distribution of all papers, a total of 25,836 articles were analyzed. They can first be categorized by the databases from which they originated. Scopus provided 17,543 documents, 11,106 could be identified from Web of Science, and another 248 documents were found at ACM.

As can be seen in Figure 3, nearly half of the identified papers can be classified as journal articles (JOUR: 49.8%, #12,868). Both categories

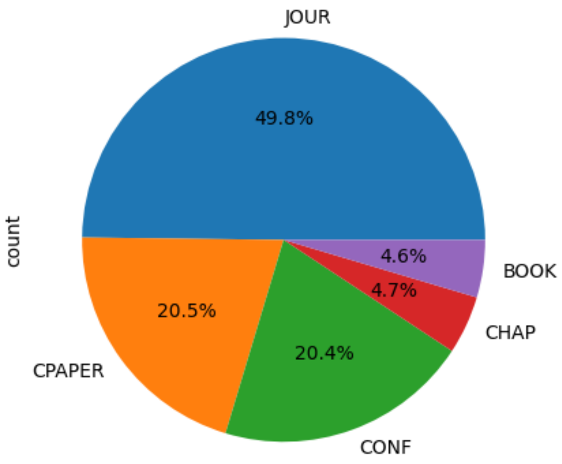

Figure 3. Document types in the analysis.

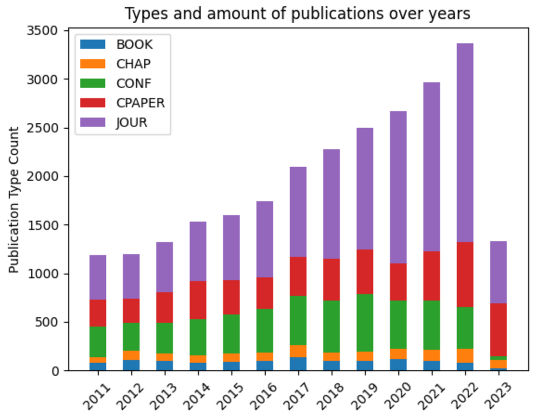

Figure 4. Publications per year.

of conference articles, CONF (20.4%, #5,267) and CPAPER (CPAPER: 20.5%, #5,306), contribute about one-fifth to the final set of results. CONF encodes a conference proceeding, while CPAPER represents a conference paper. Thereby, conference-related literature sums up to 40,9%. Complete books (BOOK: 4.5%, #1,189) and individual book chapters (CHAP: 4.7%, #1,206) complete the investigated pool of documents.

In a next step, the analysis of the development of publications over time is illustrated. Following Figure 4, a continuous slope is visible in the number of publications per year. For 2023, the number of documents is lower, as this represents the currently available quantity and does not yet represent the full year. From 2011 to 2022 alone, the volume of publications has multiplied almost three times, from 1,184 to 3,364 publications per year. The proportion of journal publications compared to conference-related publications is increasing, which may be due to time delays in journal publication, still indicating an increased interest in the topic over the last twelve years.

The second part of the bibliometric analysis is the *science mapping*. Figure 5 displays the identified hurdles and potentials of Shared Manufacturing in industrial ecosystems. The weight of the keywords represents their total number of occurrences, while the color indicates the corresponding cluster. It can be seen that that five clusters can be derived from the keyword set.

Located in the upper half, the *yellow cluster* contains mainly energy-related or power-related terms, with *electricity transmission* as the main keyword. In the bottom half of the yellow cluster, close to the centre of the network, production- and finance-oriented terms like ‘optimization’, ‘costs’, ‘scheduling’, ‘investments’ and ‘profitability’ are incorporated.

In the *red cluster*, technical terms are bundled that imply *economic and social effects*, with the *Internet of Things* as the most common term. The technical terms are primarily concentrated in the lower left-hand section, offering keywords related to specific technologies of Industry 4.0, such as ‘blockchain’, ‘big data’, ‘5g’, ‘artificial intelligence’, ‘industrial robots’, and ‘sensor networks’. In a broader context, infrastructural terms linked to these technologies are mentioned, e.g. ‘complex networks’, ‘data sharing’ and ‘information sharing’, security’ and ‘network architecture’.

The *green cluster* focuses on the connection of environmental and economic terms while also considering the human (social) perspective. Its most frequently occurring terms are therefore *economics* and *human*. In a broader view, also terms related to sustainability are frequent, such as *sustainable development*, addressing all three dimensions of a sustainable mindset in the sense of the triple bottom line (John Elkington, 2013).

Between the red and green cluster, the *blue cluster* mainly contains management and economic terms, such as ‘competition’, ‘knowledge management’, ‘performance’ or ‘supply chains’.

Focusing primarily on traffic-related terms such as transportation or roads, the *purple cluster* finds itself located at the center between the yellow, red and green clusters. The most significant term is *commerce*, which is also located nearly at the center of the network.

To summarize, the red cluster bundles technology-related terms with economical and social implications resulting from the increasing use of technologies, while the green cluster focuses on the relationship between the three sustainable development categories. Additionally, the yellow cluster is primarily concentrated on terms associated with the context of

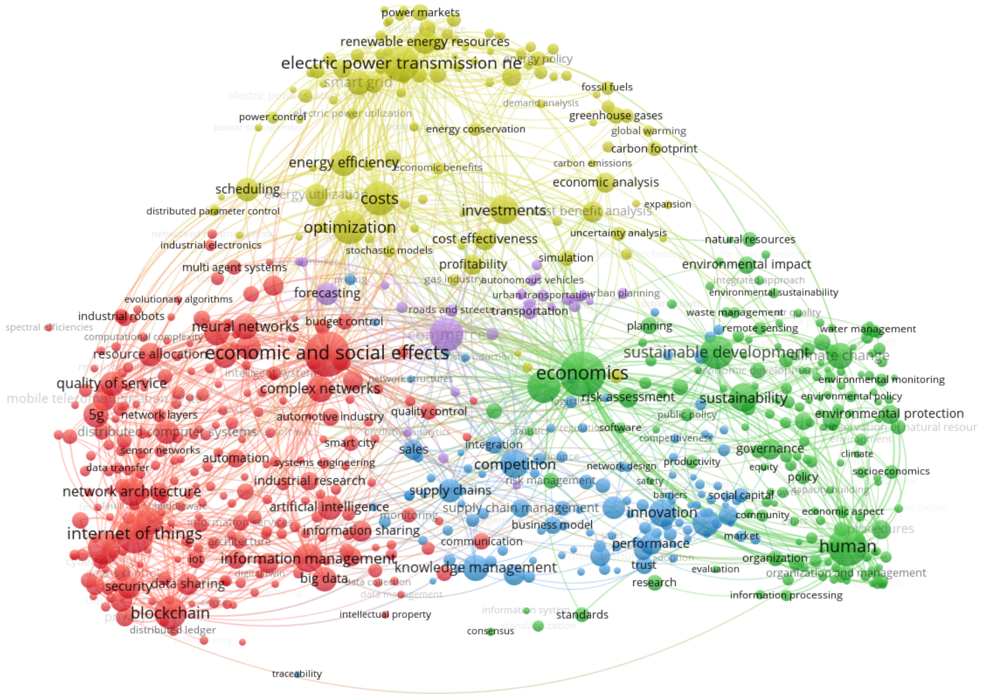

Figure 5. Hurdles and potentials in a network visualization.

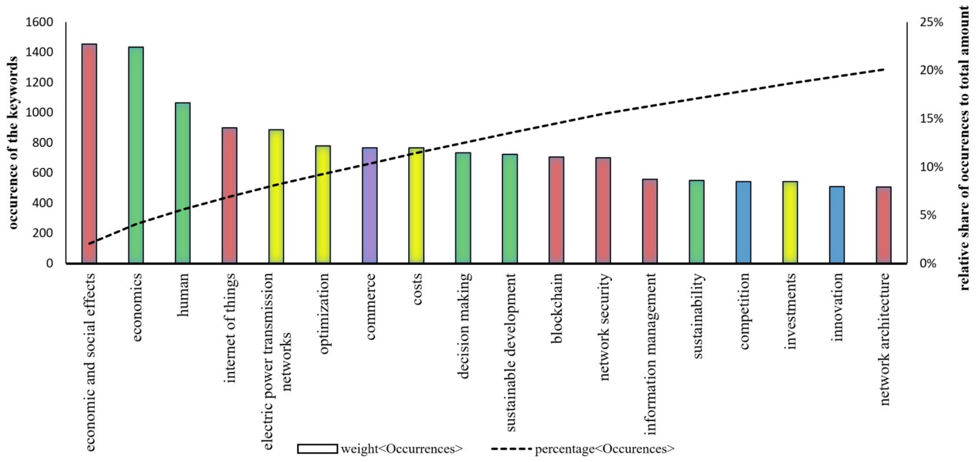

Figure 6. Keywords with respective occurrence in relation to the total amount of keywords.

production and energy. The blue cluster, driven by the management aspects of a Sharing Economy, is in tension between enabling technologies (and the associated technical and information technology-infrastructural challenges) and the economic, human-social, and ecological aspects.

In order to carry out an in-depth analysis, a stricter selection of keywords is applied. Therefore, the first 18 keywords are analyzed, adding up to 20% of the total sum of keyword occurrences. A visualisation is presented in Figure 6.

Economic and social effects and *economics* are the two most occurring keywords, with around 1,400 hits per term. They add up to four percent of the data set with 2,891 mentions. All five distinct clusters are still represented in the reduced map. As shown in Figure 5, *economics* and *economic and social effects* represent the center of the visualization. The green and red clusters continuously concentrate the most keywords within them. The green cluster inherits the keywords *economics*, *sustainable development*, *sustainability*, *human* and *decision making*. The red cluster contains

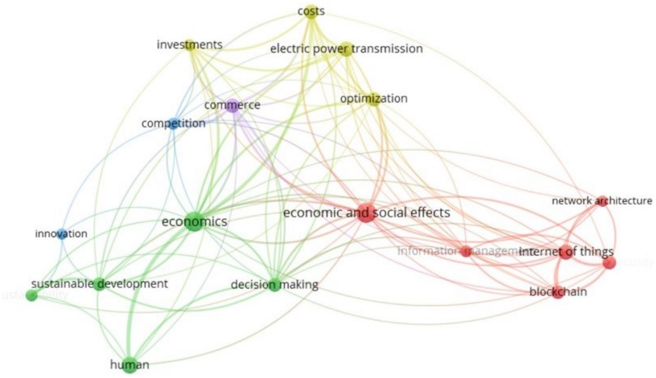

Figure 7. Selection of the top 20% of all keywords.

economic and social effects, *information management*, *network architecture*, *internet of things*, *blockchain* and *network security*. The more technologically oriented keywords form a conglomerate on the right margin in the cluster. The yellow cluster, which is still positioned at the top, consists of heterogeneous terms like *costs* and *investments*, but also inherits the term *electric power transmission network*. Commerce forms its own cluster (purple), which is positioned in the center of the yellow, blue, and green clusters. Finally, the blue cluster includes the keywords *competition*, *management*, and *innovation*. An interpretation of the keywords based on the literature is provided subsequently.

5. Discussion

In the following discussion, the keywords presented in Figure 6 and Figure 7 are successively incorporated into an overall picture, based on pertinent literature. This inductive approach provides an initial understanding of problems and hurdles.

'Economics' counts as one of the social sciences, with a focus on production, distribution and consumption of goods and services (Krugman & Wells, 2013). *Economics* itself includes two significant sections, studying the micro perspective as well as the macro perspective. In the context of *macroeconomics*, production ecosystems can benefit from Shared Manufacturing approaches, as local misfits of capacity can be balanced within the network, so that local peaks are levelled among all participants (Domagała et al., 2023). As mentioned, the Sharing Economy is a non-zero-sum game, providing advantages to all network partners (Teubner, 2014). By leveling the network load, machine utilization rates are improved. Additional positive effects are strengthened local economies due to deeper cooperation and the development of resilience, as regions build a shared capacity pool to manage (individual) crises (Ashby, 2016; Vachon & Klassen, 2008; Yu et al., 2020). On a *microeconomics level*, companies can develop new business models and tap into new sources of revenue. On the other hand, hurdles regarding the standardization of processes, intellectual property and liability could hinder those potentials. The potential for *social effects* lies in the collective solving of problems through strategic cooperation (Cheng et al., 2008; Vachon & Klassen, 2008). Redundant development can be avoided, although this may also lead to increased competition (Vachon & Klassen, 2008). Additionally, more efficient and flexible production systems could raise concerns about job stability or income inequality (Domagała et al., 2023).

As Shared Manufacturing is immensely enabled through new, innovative digital technologies in the context of Industry 4.0, a good spare of the top 18 keywords focuses on the topic's digital, technological, and infrastructural side. The bigger picture, represented by the term *Internet of Things*, is a vision where all entities in a digital network can communicate directly and autonomously (including intelligent machines) (Ochoa et al., 2017). The idea of self-aware production equipment that negotiates orders independently is a natural complement to the Sharing Economy approach. Thus, the load in the network is distributed decentralized and in an automated way, comparable to cloud computing (Domagała et al., 2023; Xu, 2012). To achieve such a highly and deeply developed system, an underlying, well-designed, technological *network architecture* has to be in place, providing safe and standardized *information management* and data exchange (Xu, 2012). Security concerns are one of the main challenges of data sharing. *Network security* has to be assured in multiple ways, considering technological and governance aspects. A promising technology, detaining trust and addressing the described problems is the *blockchain* technology.

In the context of ongoing and ever-faster digitalization, automatization and autonomization, the role of the *human* is constantly changing. The competence requirements are rapidly enlarging, developing from domain experts to managers of technical systems, which massively support and enable *decision making* (Sorko S. R. et al., 2016).

Strongly associated with the keywords 'human' and 'economics' are the items *sustainability* and *sustainable development*. The manufacturing and logistics sector is sensitive to sustainable operations, and there is already a broad understanding of the impact the sectors have on sustainability, as processes are sometimes energy-intensive or involve

Table 2. Findings - Hurdles and Potentials.

Cluster	Potentials	Hurdles	Corresponding keywords
red, green, yellow, purple	new business models, new sources of revenue	missing process standardization, intellectual property, indistinct liability	economics, economic and social effects, commerce, costs
red, green, yellow	improved machine utilization, capacity balancing, network resilience effects, strengthened local economies	initial costs and investments	economics, economic and social effects, optimization, costs, decision making, investment
red, green, yellow	minimize transportation distance, optimize lot size, consolidation, economies of scale, sustainable development		economics, economic and social effects, costs, optimization, sustainable development, sustainability
green, blue	new dynamic of cooperation (e.g. coopetition), paradigm shift, innovation	increased competition, changing competence requirements, changing role of the human	innovation, competition, economic and social effects, human, decision making
red	technological enablers	security concerns, need for underlying architecture	internet of things, blockchain, network architecture, network security, information management
yellow	reducing the risk of energy shortages	overall need of reliable power supply	electric power transmission networks

high emissions, while customer preferences are shifting toward greater sustainability and environmental friendliness (Domagała et al., 2023). A *sustainable development* can be achieved by utilizing the Sharing Economy, and sustainability is one of the main goals that the Sharing Economy promotes (Boar et al., 2020). Sustainable actions can be channeled through a shared approach, for example by allocating production jobs close to the customer to minimize transportation distances, by assigning jobs to machines that are started anyway but whose lots are not complete, or by consolidating cargoes on logistical vehicles (Boar et al., 2020; Domagała et al., 2023). Resource sharing can lead to economies of scale and reduce the environmental and social impacts of production, as machine resources can be utilized at optimal load ranges (Sonntag, 2000).

All the aforementioned aspects are closely linked to new management approaches, changing from a ‘single-business paradigm’ to a ‘shared-network paradigm’, representing a high level of disruption and requiring a large amount of *innovation*. Additionally, a whole new dynamic has to be established, as enterprises which once were in *competition* now join forces. Thus, a situation of coopetition (competition and cooperation at the same time) will arise in Sharing Economy networks (Chatterjee et al., 2023). Hand in hand with such disruptions, the benefit has to be quantified and compared to the necessary *investments* and on-going *costs*. *Commerce* seems to be the main product category for Sharing Economy approaches, generating revenue streams which can be contrasted with the costs. Furthermore, the ever more *optimization* of existing collaboration forms as well as the *optimization* of Shared Manufacturing approaches is a highly discussed hurdle.

Finally, *electric power transmission networks* are highly discussed in the analyzed set of literature. Reliable power grids serve as a prerequisite for production due to the need for a stable production environment. Additionally, power reliability is becoming increasingly relevant. Renewable energies can lead to temporary bottlenecks in network sections, resulting in third-party contracting processes being used to harmonize the network. Thus, processes have to be adapted and optimized to given boundary conditions. Through the upcoming focus on green energy and the need for harmonizing elements could be an enabler for Shared Manufacturing, as shortages could be reduced by (cross-)regional scheduling. The resulting hurdles and potentials are summarized in Table 2 according to the respective clusters and keywords.

In contrast to Tambare et al. (2021) findings, which focused on Industry 4.0, the present results diverge in their classification of sustainability as a potential or hurdle. Tambare et al. (2021) referred to sustainability as a challenge without specifying it further, whereas we consider it as a potential in the context of Shared Manufacturing due to its focus on resource efficiency. The impact on the business model, especially the collaboration aspects, have also been stated by Suuronen et al. (2022). In contrast, the profit-sharing obligation and the ”winner takes it all” situation were presented as hurdles that hinder the decentralized and mostly usage-based payment model of Shared Manufacturing (Suuronen et al., 2022). As potentials are clearly defined, researchers can explore them in more detail to exploit opportunities for innovation and progress. Likewise, addressing hurdles helps to acknowledge boundary conditions and to pursue targeted problem-solving.

The categorization results are limited by the methodology, which is why the following section discusses the limitations and provides an outlook for further research.

6. Limitations and Outlook

The research question in this paper was to identify the most significant problems or hurdles that Shared Manufacturing (as a manifestation of the Sharing Economy) faces in industrial ecosystems. Therefore, related literature has been identified and subsequently analyzed in the context of a bibliometric analysis. The process was conducted in accordance to (Donthu et al., 2021).

In addition, a multi-level filtering keyword analysis in accordance to the process used by (Nobre & Tavares, 2017) has been executed. Following the filtering, 165 keywords respectively problems or hurdles remained. Further, 18 Keywords which sum up to 20% of the total 165 keywords and their according occurrence have been analyzed and contextualized in depth. Most of the analyzed papers are articles, with Scopus being the largest source. Therefore, 28,897 documents with 90,228 keywords in total were examined. Journals, conference papers and proceedings were the predominant publication source, accounting for 90.7% of the total. In addition, the number of published papers has steadily increased, with an outlier in 2023, as the year is still ongoing. The keywords 'economic and social effects' and 'economics' were mentioned most frequently, with more than 1,400 mentions each. Later on, it has been stated out that the terms in the network visualization in Figure 7 represent two-thirds of the triple bottom line, while other keywords take the ecological dimension into account. The identified *hurdles* are often connected to the future role of humans, technical hurdles and competitive apprehensions. On the other hand, the *potentials* lie in resilience structures, competitiveness and diversification opportunities. Overall, Shared Manufacturing is enabled by digital technologies, leading to changes in the role of people and in business models. In addition, sustainability and the availability of local resources are becoming increasingly important. Potentials and risks are often interwoven, making a clear classification difficult. Depending on their characteristics, they can turn into either advantages or disadvantages. Therefore, the developed sketch serves only as a first step for further work.

The validity and meaningfulness are closely linked to the chosen methodological approach as well as the basis of analysis. Since bibliometric analysis is time sensitive and heavily depending on the data provided from the databases, impacts due to the choice of platforms cannot entirely be ruled out. In order to reduce this bias, multiple databases where used. Furthermore, the analysis depends on the data provided by the databases and thus on the availability and completeness of the data sets. Biased or erroneous data sets can lead to inaccurate or unreliable results. The risk of large impacts has been diminished by manual reviews of the data sets to ensure that there are no large-scale errors in the data. Moreover, the bibliographic analysis provides only quantities, but gives no insight into the content, while the discussion is subjective and thus biased. Hence, this paper mainly refers to the literature in the discussion part to lessen the subjectivity and to substantiate the arguments with literature-based evidences. Therefore, a bibliometric analysis does not constitute a comprehensive analysis of the problem area, but provides a first review. Further research has to be conducted in order to gain an in-depth understanding of the problem space. Suitable methods include expert interviews or systematic literature review, whereby the latter can be performed on basis of the identified keywords.

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References

Ashby, A. (2016). From global to local: Reshoring for sustainability. https://doi.org/10.1007/s12063-016-0117-9

Boar, A., Bastida, R., & Marimon, F. (2020). A systematic literature review. relationships between the sharing economy, sustainability and sustainable development goals. https://doi.org/10.3390/su12176744

Botsman, R., & Rogers, R. (2010). *What's mine is yours: The rise of collaborative consumption* (1. publ). Harper Business.

Camarinha-Matos, L. M., Fornasiero, R., & Afsarmanesh, H. (2017). Collaborative networks as a core enabler of industry 4.0. In L. M. Camarinha-Matos, H. Afsarmanesh, & R. Fornasiero (Eds.), *Collaboration in a data-rich world* (pp. 3–17). Springer International Publishing.

Chatterjee, S., Chaudhuri, R., Mikalef, P., & Sarpong, D. (2023). Coopetition in the platform economy from ethical and firm performance perspectives. https://doi.org/10.1016/j.jbusres.2022.113576

Cheng, J.-.-H., Yeh, C.-.-H., & Tu, C.-.-W. (2008). Trust and knowledge sharing in green supply chains. https://doi.org/10.1108/13598540810882170

Codagnone, C., & Martens, B. (2016). *Scoping the sharing economy: Origins, definitions, impact and regulatory issues*. Institute for Prospective Technological Studies Digital Economy Working Paper. https://doi.org/10.2139/ssrn.2783662

Curtis, S. K. (2021). Business model patterns in the sharing economy. https://doi.org/10.1016/j.spc.2021.04.009

Domagała, J., Górecka, A. K., & Roman, M. (Eds.). (2023). *Sustainable logistics: How to address and overcome the major issues and challenges*. Routledge Taylor & Francis Group.

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. https://doi.org/10.1016/j.jbusres.2021.04.070

Edwards, S. (1999). Citation analysis as a collection development tool: A bibliometric study of polymer science theses and dissertations. *Serials review*, *25*(1), 11–20.

John Elkington. (2013). Enter the triple bottom line. In *The triple bottom line* (pp. 1–16). Routledge. https://doi.org/10.4324/9781849773348-1

Kagermann, H., & Wahlstern, W. (2011). Industrie 4.0: Mit dem internet der dinge auf dem weg zur 4. industriellen revolution.

Klarin, A., & Suseno, Y. (2021). A state-of-the-art review of the sharing economy: Scientometric mapping of the scholarship. https://doi.org/10.1016/j.jbusres.2020.12.063

Korhonen, J. (2001). Four ecosystem principles for an industrial ecosystem. https://doi.org/10.1016/S0959-6526(00)00058-5

Krugman, P. R., & Wells, R. (2013). *Economics* (3rd. ed., international ed.). Worth Publ; Macmillan.

Niemimaa, M., Järveläinen, J., Heikkilä, M., & Heikkilä, J. (2019). Business continuity of business models: Evaluating the resilience of business models for contingencies. https://doi.org/10.1016/j.ijinfomgt.2019.04.010

Nobre, G. C., & Tavares, E. (2017). Scientific literature analysis on big data and internet of things applications on circular economy: A bibliometric study. https://doi.org/10.1007/s11192-017-2281-6

Ochoa, S. F., Fortino, G., & Di Fatta, G. (2017). Cyber-physical systems, internet of things and big data. https://doi.org/10.1016/j.future.2017.05.040

Sonntag, V. (2000). Sustainability — in light of competitiveness. https://doi.org/10.1016/S0921-8009(00)00141-5

Sorko S. R., Rabel B., & Richter H. M. (2016). The future of employment – challenges in human resources through digitalization.

Suuronen, S., Ukko, J., Eskola, R., Semken, R. S., & Rantanen, H. (2022). A systematic literature review for digital business ecosystems in the manufacturing industry: Prerequisites, challenges, and benefits. https://doi.org/10.1016/j.cirpj.2022.02.016

Tambare, P., Meshram, C., Lee, C.-C., Ramteke, R. J., & Imoize, A. L. (2021). Performance measurement system and quality management in data-driven industry 4.0: A review. https://doi.org/10.3390/s22010224

Teubner, T. (2014). Thoughts on the sharing economy. *Multi Conference on Computer Science and Information Systems, MCCSIS 2014*, 322–326.

Vachon, S., & Klassen, R. D. (2008). Environmental management and manufacturing performance: The role of collaboration in the supply chain. https://doi.org/10.1016/j.ijpe.2006.11.030

Waltman, L., & van Eck, N. J. (2013). A smart local moving algorithm for large-scale modularity-based community detection. https://doi.org/10.1140/epjb/e2013-40829-0

Xu, X. (2012). From cloud computing to cloud manufacturing. https://doi.org/10.1016/j.rcim.2011.07.002

Yu, C., Xu, X., Yu, S., Sang, Z., Yang, C., & Jiang, X. (2020). Shared manufacturing in the sharing economy: Concept, definition and service operations. https://doi.org/10.1016/j.cie.2020.106602