



<https://doi.org/10.64211/oidaijsd190418>

# Servitisation Innovation as a Catalyst to Sustainability and Circular Economy Transitions: A review and future research

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OIDA International Journal of Sustainable Development, Ontario International Development Agency, Canada.

ISSN 1923-6654 (print) ISSN 1923-6662 (online) [www.oidaijsd.com](http://www.oidaijsd.com)

Also available at <https://www.ssm.com/index.cfm/en/oida-intl-journal-sustainable-dev/>

**Abstract:** Servitization is a business transformation that allows organizations to transition from being product providers to offering integrated service solutions. Recent developments shows that it is necessary to incorporate the concepts like circular economy and servitisation, which evolved from the idea of integrating product service systems that proposes sustainable solutions to companies, conforming to the ESG (environmental, social and governance) and CSR (corporate social responsibility) directions. This transition is facilitated by digitalization, AI, and Industry 5.0 technologies, which are used to manage real-time customer data, predict downtimes, and prevent disruptions to ensure seamless service delivery. Also, servitization supports sustainability by encouraging resource efficiency, reducing waste, and extending product lifecycles through predictive maintenance and circular economy principles. This also involves adopting innovative business models, organizational structures, and workforce capabilities to align with the service-based model. Successful servitization requires co-creating value propositions with customers through efficient service integration. In this evolving landscape, it is crucial to examine the role of AI and advanced technologies in shaping the future of sustainable servitization, ensuring both business growth and environmental responsibility. Therefore, the primary objective of this research paper is to investigate the concept of servitization and its significance in the context of net zero emissions and green transitions, and to also study its impact on sustainable business practices and circularity. A systematic literature review approach using VOS viewer and Biblioshiny was used in this study. Building on these, further research can highlight the potential of servitization to contribute to more holistic and sustainable business practices.

**Keywords:** digital AI, industry 5.0, servitization, sustainable business practices, digitalization, decarbonization, circular economy, regulatory support, corporate social responsibility, environmental social governance.

## Introduction

Sustainability transitions are increasingly thought to impact 'Prosumption' (production and consumption) of goods and services (Q. Zhou et.al, 2024) and servitisation can be considered as a type of such transition at the logistic level. Servitization evolved from the idea of integrating product service systems that offer sustainable solutions, following the ESG (environmental, social and governance) and CSR (corporate social responsibility) viewpoints. The concept gained popularity in manufacturing and services as sustainable product-service systems focused towards dematerialization and refers to the process of manufacturing firms reallocating their business models from selling products to providing services that include the products. Alternatively, it involves a transformation of the traditional manufacturing-based business model into a service-oriented one. A linear approach to manufacturing is extremely resource intensive and unsustainable and poses a threat to humanity's sustenance. Further, recent research by Kohtamaki et al.(2024), focuses on the significant role of servitisation in capturing financial value and thereby remains motivated in sustainability

related issues. Heiskanen and Jalas (2003), initiated linking the concept of servitisation and sustainability and argued that in comparison to manufacturing, service businesses have better ecological performance.

The significance of servitization in accelerating the journey towards achievement of SDGs (Sustainable Development Goals) and global climate change targets is substantial. The shift towards servitization can help address some of the key challenges posed by global climate change phenomenon and help achieve the SDGs. Manufacturing companies can reduce waste and emissions and contribute to more sustainable business practices by providing services that enable customers to optimize the use of products. Moreover, servitization can lead to increased resource efficiency, lesser environmental impacts, and greater circularity in business models. However, implementing servitization can be challenging as it requires organizations to undergo internal restructuring and build an external ecosystem in order to offer a wide range of product-related services.

The damage done to the ecosystem by traditional linear manufacturing processes can be reduced by shifting towards sustainable practices like servitisation thereby driving towards decarbonization and digitalization trends. The process of reducing or eliminating carbon dioxide emissions from various sectors, while digitalization involves the integration of digital technologies into various aspects of business operations. Both trends are essential for achieving the SDGs and addressing the challenges posed by global climate change.

In the context of climate change phenomenon and the need for sustainable development, Servitization can be considered as a business model shift that is gaining popularity around the world. In India, the shift towards servitization is particularly relevant in the automobile sector, which is a major contributor to the country's greenhouse gas emissions. Servitization can impact both developed and developing countries in different ways. In developed countries, the shift towards servitization can help companies stay competitive in the face of global competition, increase revenue streams, and create new job opportunities. However, challenges like lack of infrastructure, limited access to technology and funding, and low levels of human capital may be prevalent in implementing servitization in emerging economies. Previous studies reveal that companies that embrace servitization can contribute to a more sustainable future and stay competitive in an increasingly globalized economy. The findings obtained from this study will be of immense significance to researchers, policymakers and scholars who are dedicated to promoting sustainable economic development.

Despite previous research, the following research questions remain unresolved which are the main focus of the study:

RQ1: What are the evolving trends and key discussions in the literature related to servitization, innovation, and technologies (SIT)?

RQ2: Which research publications related to SIT have highest number of citations?

RQ3: Who are the important contributors to SIT research in terms of authors, countries, institutions, and source titles?

RQ4: What are the most significant phrases or concepts found in SIT -related research articles?

RQ5: How is the current knowledge structure of SIT characterized, particularly regarding collaboration, networks, and shared events?

RQ6: What are the dominant themes in the field of SIT research?

RQ7: What role have servitisation played in promoting circular economy and sustainable business practices?

A bibliometric analysis was conducted to get answers to above mentioned research questions. Bibliometric analysis uses software to create clusters and themes of related subject areas. Bibliometric tools enable the identification of prominent authors, important publications, and citation patterns through scientific mapping and network analysis.

Bibliometric analysis allowed researchers to understand research trends and patterns surrounding the SIT by analyzing cross-national collaborations. These insights will certainly help future researchers in advancing current knowledge in the area of SIT. Also, the study's findings will help shape future research agendas by addressing the most contentious topics in SIT literature.

A systematic bibliometric method and a qualitative synthesis approach is used in this study, in contrast to the traditional narrative literature review, which majorly rely on subjective interpretation of selected studies. The current approach uses thematic evolution and collaboration networks to uncover intellectual structures (Snyder, 2019; Zupic & Čater, 2015). The study employs bibliometric tools such as Biblioshiny and VOSviewer which enables mapping of keyword occurrences and citation relationships, whereas the use of PRISMA ensures transparency and replicability (Aria & Cuccurullo, 2017; van Eck & Waltman, 2010). Subsequently, in addition to summarizing existing knowledge, this study also reveals research gaps and future directions that are difficult to capture using conventional review methods.

## Theoretical Background

Servitization concepts even though are not linked to circular economy and product service systems, it aligns with the principles of circular economy and product service systems value proposition wherein manufacturers transition from selling products to providing integrated solutions. This study further contributes to the academic argument by providing key insights relating to servitisation business models and the way they contribute to the extensive adoption of circular economy principles which is urgently needed for achieving the SDGs. This section sets the conceptual ground for servitisation and justifies how it can be positioned with respect to circular economy and integrated product service systems and further explores its role in various concepts.

### Servitisation, Circular Economy, Integrated Product Service Systems

The term servitisation was proposed in a study by Vandermerwe and Rada (1988) to describe a mechanism whereby top management thrust their businesses for value creation and gain competitive ground through service, thereby extending its scope from manufacturing to services, which infact differs from most recent definitions of servitisation which points to a product oriented manufacturing firm completely transferring to services offerings instead of products.

There has been few studies, which tried to link Product Service Systems (PSS) with sustainability, and in various studies the terms are utilized interchangeably. Literature classifies PSS to be more static as compared to servitisation which is more dynamic (Zhou et.al (2024)). Many arguments exist between linking servitisation and sustainability. A study by Abdelkafi et.al (2022) identified sustainable practices in servitisation and concluded that the link between servitisation and sustainability will depend on whether the life cycle of the product can be extended by the product service system. Some other researchers found that servitisation need not always support sustainability. However more focused studies focussing on servitisation, as well as sustainable and circular business models are needed to further understand servitisation and its impact. Hence the timing of the study can be termed very appropriate.

Circular economy revolves around the principles of concepts like life cycle analysis or cradle to cradle design, eco-efficiency, industrial ecology etc. Since this novel concept links environmental, economic and stakeholder considerations, it is attracting the attention of researchers exploring sustainable servitisation. The current researchers consider circularity as a crucial aspect towards the shift to improved financial performance by incorporating ESG factors into investment decisions (Mendoza et.al (2022), Alkaraan et.al (2022)). Thus sustainable business practices may support circular economy concepts by reducing pollution, improving resource usage and financial performance and optimising processes, which inturn form the cornerstone of servitisation concept. Kircheherr et. al. (2017) defines circular economy as a model that links economic development, environmental protection and financial sustainability. Further studies by Acerbi et al., (2022) opines that circular approaches helps organisations to maintain an internal commitment to circular values and to maintain external alignment with variety of stakeholders who may be part of different supply chains.

### Transition to Circular Business Models

Sustainable manufacturing practices including reuse, recycling, recovery and refurbishment helps many industries to slowly progress towards circular economy principles, which aligns with the servitisation concept. Servitisation concept entails that the ownership of the product rests majorly with the producer, which allows the producer to maintain the product for long term usage or elimination of waste. Reverse logistics concept inturn works with the above idea wherein the life span of an appliance is increased which maintains it for long term use and sustainability gains. Servitisation trails the doctrines of circular economy which allows waste to be eliminated from all energy and material logs and helps the system to improve using the principle of “remodel” or “reinvent” or “redesign”. Literature suggests that servitisation can play a crucial role in promoting sustainable practices which requires careful planning to ensure that sustainable services are effectively integrated into organisational practices (Sousa, & da Silveira (2019)). Some studies points out that servitization can lead to lower carbon emissions due to the potential for increased efficiency and resource utilization. In a study by Baines et al. (2013), it was found that servitization can enable firms to optimize resource use, reduce waste, and improve energy efficiency, resulting in a reduction in carbon emissions.

### Promotion of Sustainable Practices

As a business strategy, servitization involves providing services in addition to physical products and the approach has gained attention due to its potential to promote sustainable practices, like decarbonization that can help in achieving the global emission targets. In recent years, researchers have examined the relationship between servitization and decarbonization, with a focus on its impact on sustainability and the environment. Research indicates that servitization can play a significant role in promoting decarbonization by reducing carbon emissions through the provision of

sustainable services. It can facilitate the firms to shift from selling products to offering more sustainable services that consume fewer resources and generate less waste. There are increasing hurdles to servitization in promoting sustainable practices, including issues with implementing sustainable services, measuring sustainability performance, and aligning organizational culture and values with sustainability goals. Carbon emissions can be achieved by servitisation, thereby enabling firms to offer more sustainable solutions, such as through product leasing or sharing models. As evidenced by Sousa, & da Silveira (2019), careful consideration and planning are essential to ensure that sustainable services are implemented effectively, and hence future research should focus on identifying best practices and developing effective strategies for supporting sustainable servitisation. However, other studies have highlighted potential challenges associated with servitization, such as the potential for increased energy use in service delivery. A study by Gebauer et al. (2021) observed that servitization can lead to an increase in energy use due to the need for service delivery, which can offset any potential emissions reduction from product use. Since it is important to consider the potential trade-offs and barriers associated with this approach, further research is needed to obtain a detailed understanding of the impact of servitisation on decarbonization to identify strategies for augmenting the potential benefits associated with it.

Zhou et.al (2024) defined sustainable servitisation as: “An organisational transformation process via service introduction and advancement that aims to redefine sustainability-related value propositions according to changes in sustainability requirements. It represents a strategic decision and a long-term commitment, benefits from advancements in digital technologies, and typically results in introducing a new business model embedded with an emphasis on continuous improvement.”

### **Social and Environmental sustainability**

Servitization has gained attention in recent years to reduce environmental impacts by extending the lifetime of products and promoting circular economy. Research reveals that servitization can reduce environmental impacts by enabling manufacturers to optimize the use of their products, leading to reduced resource consumption and emissions during manufacturing and end of life (Paiola, 2021). However, the literature also points to the fact that servitisation sometimes provides comparatively fewer improvements like energy consumption, disclosures and environmental policies. (Mont, 2004). Also, service offerings can encourage the adoption of more sustainable practices by customers, such as through energy-efficient usage or restoration or refurbishment of products. Need for additional investments in service infrastructure and the potential displacement of traditional manufacturing jobs are some of its challenges. Moreover, an urgent need is felt to ensure that service offerings align with sustainability goals, rather than merely extending the lifetime of products that have negative environmental impacts. Some positive social impacts, such as the creation of new job opportunities, improved working conditions, and increased community engagement are also linked to servitisation. It is yet to gain commendable implementation benefits. Further research is needed to explore its potential for creating positive social impacts and to identify best practices for implementation.

### **Role of Digital Technologies and Data Analytics**

Digitalization and data analytics has significant implications on Servitisation, as explored by several studies. Servitization leads to a greater emphasis on data analytics, as service offerings typically involve the monitoring and analysis of customer usage data as observed by Kowalkowski et al. (2021). According to Saccani (2017), servitization encourages firms to develop more advanced digital capabilities, such as the use of sensors and machine learning algorithms, to improve service delivery and customer experience. However, earlier researchers have noted that servitization requires firms to collect and analyze large amounts of data, which can be expensive and time-consuming (Neely et al., 2017), and can act as a major challenge. Firms must ensure that they have the necessary skills and expertise to use data analytics effectively, which can be a significant barrier to its adoption (Baines et al., 2017). Hence research indicates that a significant impact on digitalization and data analytics is observed and firms are able to leverage these trends effectively to gain a competitive advantage. An exploratory study done by Langley (2022) investigates key concepts and challenges in transitioning towards digitally enabled servitisation in manufacturing industries and its clearer relation with circular economy. There was a need to develop a combined strategy, amalgamating technology driven servitisation along with traditional processes, due to quickly changing landscapes in digital technologies. There is an increasing reliance on IoT (Internet of Things) and far-edge data analysis solutions. It was further evidenced that data driven servitisation will lead to natural progress of many industries towards circular economy practices. However, a strong focus on data analytics and a significant investment in digital capabilities is required for successful adoption.

## Emerging Scenario in Developed and Developing Countries

Several studies have indicated that servitization can enhance the competitiveness of manufacturing firms, increase their profits, and improve their customer relationships. The shift towards service-based offerings can also create new business models and revenue streams for firms, leading to economic growth and job creation. Impact of servitization across various industrial sectors may vary and hence specific sectors must have their own tailored strategies.

In developing countries, comparatively fewer studies have been conducted. However, localized needs can be addressed by servitisation by providing business models offering innovative solutions. It can also help firms to differentiate among their competitors. Outsourcing can lead to loss of jobs. Significant investments in training and longer payback periods may act as barriers in firms of developing countries. This necessitates significant future research in these countries to understand and realize the benefits.

### Impediments

Significant challenges occur in transitioning to servitisation and circular business models. As evidenced by Langley (2022), data sharing risks, reliability and validity of the data, role of government, implementing digital product passports etc. may result in worse customer experience because of the absence of new ways of working. In developed countries, one of the primary barriers to servitization is the challenge of creating a service-oriented culture within manufacturing firms. Additionally, integration of services may need new business models. Need to invest in new technology and infrastructure to support the delivery of services may also act as another challenge. Regulatory and legal frameworks may not be supportive of service-based business models, and there may be limited access to skilled labor and managerial expertise, especially in emerging economies which can also act as a barrier.

### Policy Implications

Additional incentives like tax reductions could motivate businesses to explore the servitisation route as suggested by Abreu et al., 2021. However, responding to these regulatory requirements may bring additional benefits, such as tax reductions that could further motivate businesses to take a sustainable servitisation route (Abreu et al., 2021). As evidenced by Li et al., 2021b, businesses may sense or experience these changes in the environment via a change of practice from partners or supply chains and in some cases, from a change of social or buying behaviour from specific groups of end users who are orientating towards sustainability (Tan et al., 2017). Currently, the concept of servitization has gained significant importance from both academia and policymakers. While servitization can help address the challenges of aging populations and declining industries in developed countries, it can provide opportunities for economic diversification and job creation in developing countries. Some of the potential challenges and risks associated with servitization include the need for significant investments in technology and human capital, as well as the potential for job displacement and skill mismatches. Policymakers can play a crucial role in supporting servitization by creating an enabling environment through measures such as tax incentives, investment in education and training, and support for innovation and entrepreneurship. However, policymakers must develop appropriate policies and interventions to support it and carefully consider the potential challenges and risks associated with this transition. The government could create a regulatory framework that supports servitization and also the development of new business models that integrate services as well as products.

### Methods and Materials

PRISMA methodology used in this study details the steps for identifying, reviewing, and filtering relevant articles by utilizing a chosen database and specific search terms.

#### PRISMA Methodology

PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework was leveraged for filtering and selecting articles for bibliometric analysis. PRISMA is a common approach utilized in literature review research for data collection and analysis. This method assures reliability and transparency in generating qualitative research reports. It ensures the inclusion of all relevant materials.

The PRISMA approach allows the use of reliable databases, confirming access to high-quality resources and therefore, is considered beneficial in social science research. This systematic method employs keywords to clearly define the study's scope and boundaries, thereby avoiding inefficiencies and uncertainty regarding the relevance of selected works. PRISMA involves four distinct phases—identification, screening, eligibility, and inclusion—to systematically locate and refine relevant literature according to the research objectives (Page et al., 2021).

### **Database and Search Strategy**

This analysis was conducted on data extracted from the Scopus database, known for its extensive coverage of research across multiple disciplines, including social sciences, environmental studies, psychology, business, economics, marketing, technology, law, and engineering (Singh et al., 2021). Scopus database was chosen because it provides high-quality research publications that significantly contribute to the field of Servitization, Innovation and Technology (SIT).

Data was searched with keywords related to SIT leveraging Boolean operators. Search strings with relevant keywords were created to reflect the scope of the research, drawing from the thesaurus matches and database functions. Examples of search terms used include:

**TITLE:** servitization AND (tools OR innovation OR innovative OR 5.0 OR 4.0 OR automation OR 6g OR 5g OR edge OR smart OR technology OR twins OR machine OR robotics OR bpms OR technologies OR digital OR blockchain OR IoT OR AI OR intelligence OR AR OR VR OR cloud OR 3d OR analytics)

Articles published in English were only included in search. It was ensured that the keywords for searching articles relate with the research objectives to have comprehensive coverage of SIT-related topics (Page et al., 2021). The inclusion of these terms helped in extracting a wide range of relevant literature related to the study's topic.

### **Search Results and Screening**

The Scopus database generated 296 articles based on the specified search terms. To remove redundancy, dataset was checked for duplicate records. However, no duplicate records were found. A rigorous screening process was applied on the remaining papers using a predefined inclusion and exclusion criteria.

**Exclusion of Non-Research Papers:** Books, literature reviews, erratum and data papers were excluded from the study

**Language and Subject Criteria:** English-language publications focusing on social sciences, business, management, economics, and econometrics were included.

**Time Frame:** Articles published between 2013 and 2024 were considered for analysis (Page et al., 2022). Limiting the review to the last two decades ensures the inclusion of recent findings and relevant evidence, especially in rapidly growing research fields.

**Global Scope:** Publications from all regions were considered to ensure a varied and comprehensive review.

241 peer-reviewed journal articles were considered eligible for analysis after the review. A summary of the screening process and the resulting dataset is presented in Table 1.

By using the PRISMA methodology and Scopus database, this study ensures a strong and comprehensive review of the literature, providing valuable insights into the field of SIT research.

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**Table 1: Eligibility and elimination criteria**

Criterion	Eligibility	Elimination
Document type	Journal articles, book chapters, conference papers and Trade journals	Data papers, books, Erratum
Language	English	Non-English
Subject area	Engineering, Social Sciences, Computer Science, Environmental Science, Information Technology, Business, Management and Accounting, Mathematics, Economics, Econometrics and Finance, Decision Sciences	Agricultural and Biological Sciences, Neuroscience and Pharmacology, Toxicology and Pharmaceutics
Timeline	2013–2024	2013 and below
Coverage	Whole world	

### Eligibility and Inclusion Process

At this stage, papers related to "Servitization, Innovation & Technology" (SIT) were selected by the authors. A total of 296 papers were carefully examined, from the abstracts to the entire content, to assess the contributions of each study. Careful review of 296 papers resulted in selection of 241 articles for further analysis. The PRISMA model has been applied for clarity and transparency in the research methodology and each step of the selection process has been illustrated in figure 1.

### Bibliometric Methods

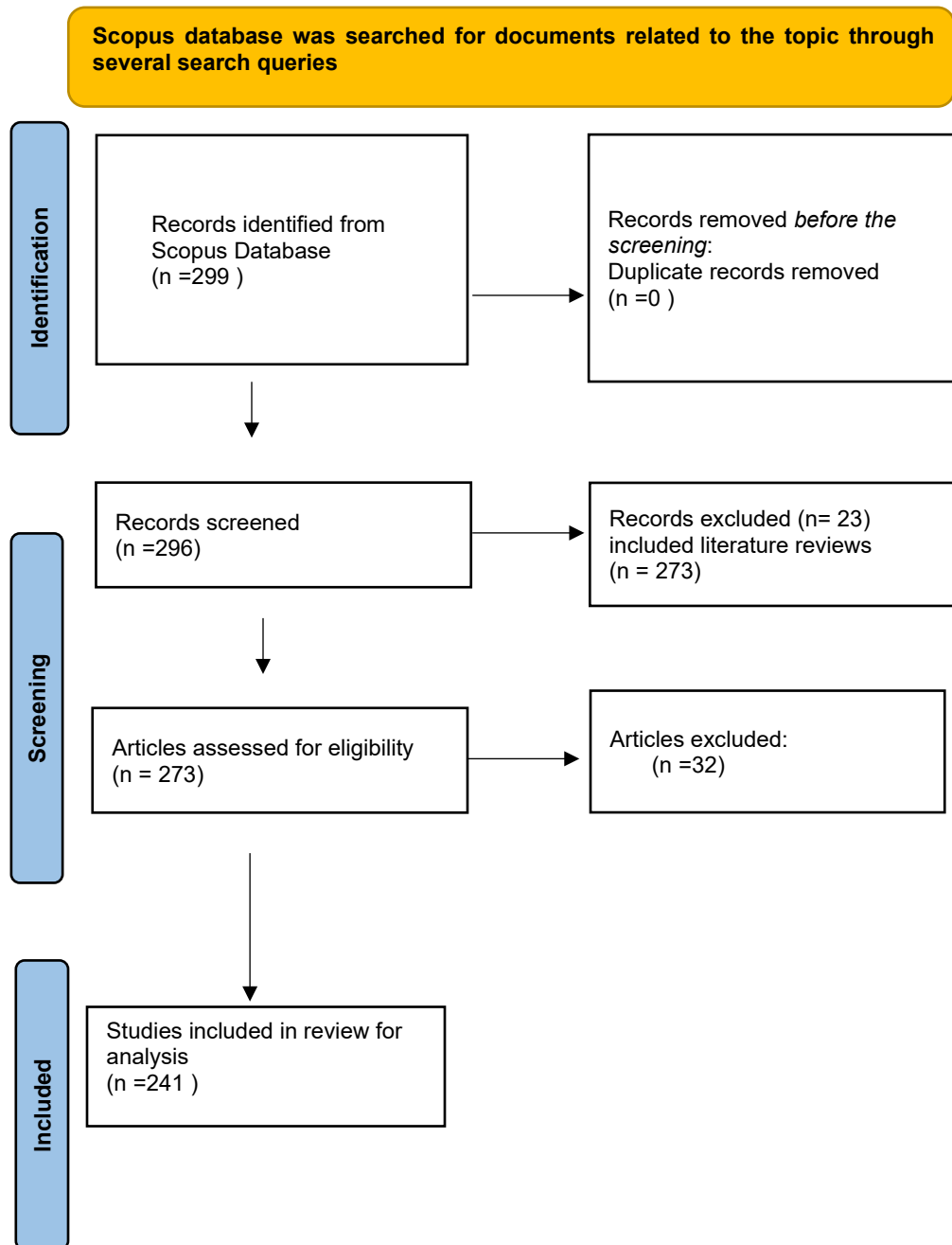
Bibliometric methods were employed to analyse the connections between important publications in SIT. Biblioshiny, an application built using the Shiny framework within the Bibliometrix R package was used as a key tool for scientific mapping and analysis (Aria & Cuccurullo, 2017).

The dataset was properly cleaned and prepared for compatibility with tools before analysis. The results were cross verified using VOSviewer, a complementary visualization and analysis tool to ensure robust findings. These tools enabled an in-depth analysis of the progression and developments in SIT research over the study period. The study used two main types of data analysis: descriptive analysis and network analysis to examine research trends and relationships.

A detailed examination of significant trends and changes in SIT from 2003 to 2023 was possible by the adoption of R-Studio software for analysis. With the help of bibliometric analysis and visualization tools, this study successfully captured the development and evolution of SIT research, providing valuable understandings into the field.

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Figure 1: PRISMA Model for selection of studies



Throughout the review process, several methodological safeguards were incorporated in order to mitigate the internal biases integral to qualitative and secondary-data based research. In order to minimize the selection bias during the identification, screening, eligibility and inclusion stages, a transparent and replicable PRISMA framework was adopted (Page et al., 2021). To reduce subjectivity and ensure methodological rigor, clearly defined inclusion and exclusion criteria were applied consistently (Tranfield et al., 2003).

Two independent bibliometric tools – Biblioshiny and VOSviewer were used for data extraction and synthesis in order to address interpretive and researcher bias, which also allowed cross-validation of findings (Aria & Cuccurullo, 2017; van Eck & Waltman, 2010). Confirmation bias was reduced by giving emphasis to citation patterns, co-occurrence

networks and thematic clusters rather than isolated interpretations of individual studies (Zupic & Čater, 2015). Reliability, transparency and trustworthiness of the qualitative synthesis were collectively enhanced by these measures.

A rigorous PRISMA-based screening and eligibility process was used to determine a final sample size of 241 peer-reviewed journal articles than arbitrary selection. Prior bibliometric research indicates that datasets exceeding 200 articles are sufficient to generate stable and reliable co-citation, collaboration, and keyword networks (Zupic & Čater, 2015; Donthu et al., 2021). The sample selected (2013-2024), represents diverse geographical regions and multiple disciplines, ensuring analytical robustness and thematic saturation, along with meaningful identification of dominant research themes, influential contributors, and evolving trajectories within the servitization, innovation and technology literature.

In order to assess their quality and potential risk of bias, a critical appraisal of the included studies was conducted, following the screening and eligibility phases of the PRISMA framework. Only peer-reviewed journal articles indexed in Scopus were retained, thereby reducing the likelihood of methodological weaknesses and publication bias (Kitchenham & Charters, 2007). In order to identify influential and theoretically grounded contributions (Paul & Criado, 2020), journal credibility, citation impact and methodological clarity were evaluated.

VOSviewer was used for cross-validation of thematic clusters and bibliographic coupling results (Aria & Cuccurullo, 2017; van Eck & Waltman, 2010), while Biblioshiny was employed to perform descriptive statistics, trend analysis, and network visualization. Research questions were systematically addressed using data extraction and synthesis. Bibliographic information—including authorship, publication year, journal source, citations, affiliations, keywords, and references—was extracted from the Scopus database and cleaned for consistency prior to analysis.

Instead of aggregating findings narratively, patterns and clusters were inductively derived from the data, ensuring analytical rigor and minimizing researcher bias. Identification of emerging themes, dominant topics, and intellectual linkages across the literature were identified by co-occurrence and co-citation analyses. Quantitative bibliometric mapping and qualitative thematic interpretation are combined in the synthesis (Waltman et al., 2010). Robust interpretation of knowledge structures and research trajectories in servitization, innovation and technology were facilitated by this integrative synthesis approach.

## Results and Discussions

The findings of the analysis on Servitization, Innovation and Technology (SIT), encompassing publications from 2013 to 2024 are included in this section. Data for this analysis was removed from the Scopus database on January 20, 2025 spanning a period of more than two decades. Selection of this dataset ensured a robust study as this dataset includes scholarly contributions from multiple disciplines, emphasizing works that have received considerable citations, indicating their academic influence and recognition. The analysis also reports distinguished authors, contributing countries and institutions, publication sources, locations, and keywords selected by the researchers. The annual publication growth rate in this field is 36.64%. A detailed summary of SIT related publications over the 2013–2024 period is provided in Table 2. It includes metrics such as the average publication year, mean citations per document, mean citations per year, author details, document types, content focus, and patterns of author collaboration. This all-inclusive dataset offers insights into the growth and scholarly impact of servitization, innovation and technology (SIT) research.

Descriptive of the data mentioned in Table 2 show that 120 journal sources contributed to the body of work related to SIT. It includes 241 articles and 613 author-selected keywords. The publications related to SIT involved 642 authors, with up to 9 authors contributing individually to 13 articles without collaboration (refer Table 2).

**Table 2: Data Overview**

Description	Results
<b>MAIN INFORMATION ABOUT DATA</b>	
Timespan	2013:2024
Sources (Journals, Books, etc)	120
Documents	241
Annual Growth Rate %	36.64
Document Average Age	3.29

Average citations per doc	30.59
References	12913
<b>DOCUMENT CONTENTS</b>	
Keywords Plus (ID)	879
Author's Keywords (DE)	613
<b>AUTHORS</b>	
Authors	642
Authors of single-authored docs	9
<b>AUTHORS COLLABORATION</b>	
Single-authored docs	9
Co-Authors per Doc	3.57
International co-authorships %	37.76
<b>DOCUMENT TYPES</b>	
article	161
book chapter	23
conference paper	57

### Annual Publication Trends

A detailed analysis of publication trends over a decade from 2013 to 2024, including metrics such as total publications (Total Publications/TP), total citations (Total Citations/TC), average citations per document (Citations/Document), and average citations per year (C/Y) (refer Table 3 and Figure 2). The findings specify that 2024 as peak year for servitization, innovation and technology (SIT) research, with 62 publications.

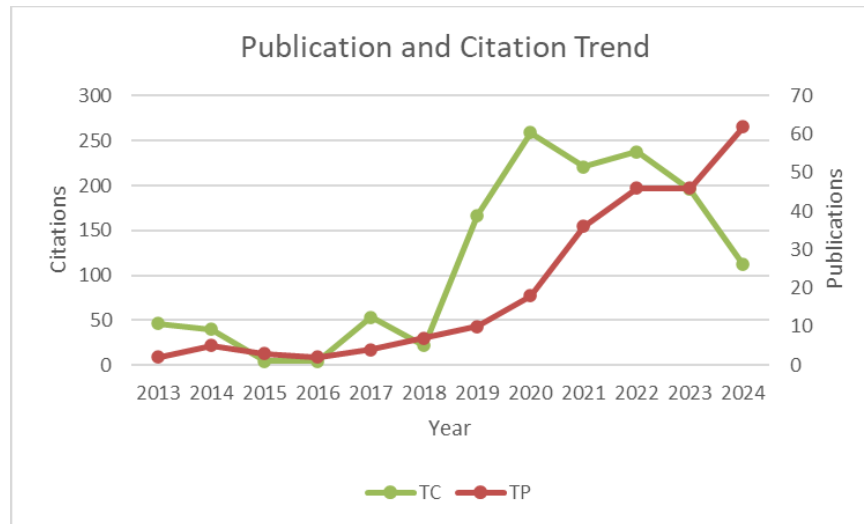
While variations can be observed in number of publications over the years, the overall progression depicts a substantial increase in both the volume of research and the number of citations during the study period. Notably, the two articles published in the year 2013 are most cited publications with average citation per document of 298, highlighting significant academic influence of these articles. Furthermore, a marked rise in the publication of SIT related articles is evident from 2021 onwards, coinciding with the post-COVID-19 era. This flow suggests an increased scholarly focus on the role of servitization, innovation and technology in the evolving global context.

**Table 3: Annual publication trend**

Year	TP	TC	C/D	C/Y
2013	2	596	298	13
2014	5	470	94	12
2015	3	40	13.33	11
2016	2	35	17.5	10
2017	4	475	118.75	9
2018	7	173	24.71	8
2019	10	1168	116.8	7
2020	18	1550	86.06	6
2021	36	1105	30.67	5
2022	46	950	20.65	4
2023	46	588	12.78	3
2024	62	224	3.6	2

Source: output Biblioshiny

TP Total publications, TC Total citations, C/D Citation per document, C/Y Citations per year

**Figure 2: Growth and publication impact per year**

### The Most Cited Articles

A detailed analysis of the most highly cited articles in the field of servitization, innovation and technology (SIT) are provided in Table 4 and Figure 3. Citation counts are key indicator of an article's impact and acceptance within the academic arena. The amount and frequency of annual citations typically correlates with an article's global citation count.

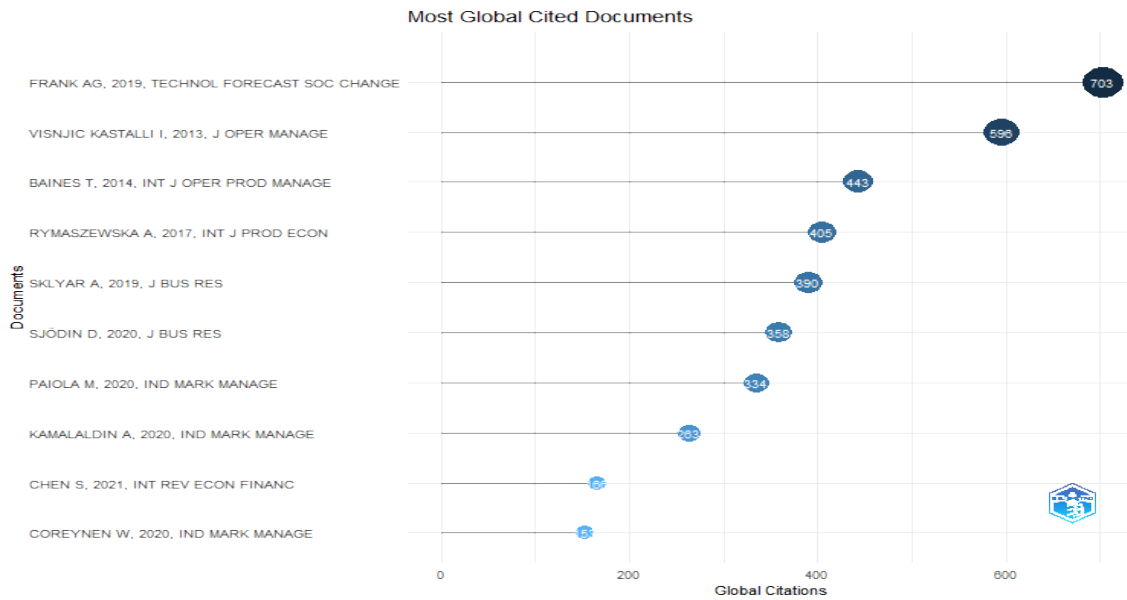
The study by Frank (2019) with 703 citations, published in *Technology Forecasting Social Change*, stands out as the most cited work. This study explores the connection between servitization and Industry 4.0 through business model innovation perspective. Article by Visnjic Kastalli (2013) published in *Journal of Operations Management*, is the second most cited article, with 596 citations. This study examines the challenges that manufacturing firms face while implementing servitization leading to decline in performance. The third most cited publication, with 443 citations, is by Baines (2014), published in *International Journal of Operations and Production Management*. This study investigates the organizational capabilities and basic technologies required for servitization.

These highly cited articles emphasize the varied yet critical themes within the domain of servitization, innovation and technology (SIT), including the challenges organizations face while adopting servitization and the way it influences performance and profitability of the firm.

**Table 4: Top 10 documents that have garnered significant citations**

Paper	Total Citations (TC)	TC per Year
FRANK AG, 2019, TECHNOL FORECAST SOC CHANGE	703	100.43
VISNJIC KASTALLI I, 2013, J OPER MANAGE	596	45.85
BAINES T, 2014, INT J OPER PROD MANAGE	443	36.92
RYMASZEWSKA A, 2017, INT J PROD ECON	405	45.00
SKLYAR A, 2019, J BUS RES	390	55.71
SJÖDIN D, 2020, J BUS RES	358	59.67
PAIOLA M, 2020, IND MARK MANAGE	334	55.67
KAMALALDIN A, 2020, IND MARK MANAGE	263	43.83
CHEN S, 2021, INT REV ECON FINANC	166	33.20
COREYNEN W, 2020, IND MARK MANAGE	153	25.50

**Figure 3: Most global cited documents**



**Most productive author**

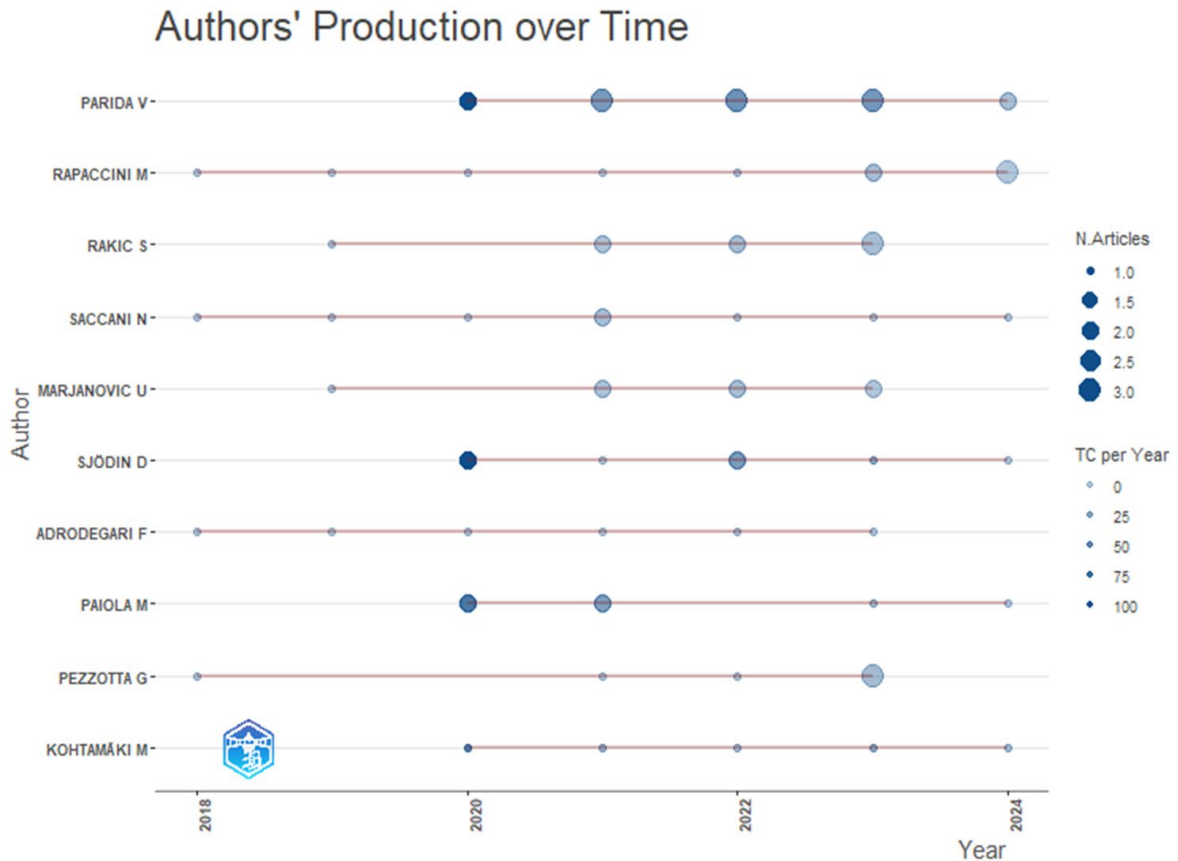
Table 5 highlights the top ten authors contributing to the field of servitization, innovation and technology, providing details on their total contributions. Figure 4 depicts the rankings of these prominent authors, focusing on articles with a primary emphasis on servitization, innovation and technology (SIT).

In the visualization, blue dots represent the number of publications, with larger dots indicating a higher number of articles. Furthermore, the density of the color corresponds to citation counts; darker shades signify greater citation numbers. The author productivity chart reveals that nearly all of the top authors have contributed on an average 7 articles to the field. Among them, Parida and Rapaccini have contributed 13 and 10 articles respectively.

**Table 5: Most productive author**

Author	TP	TC	YFP
PARIDA V	13	1142	2020
RAKIC S	8	116	2019
KOHTAMÄKI M	5	547	2020
MARJANOVIC U	7	93	2019
PAIOLA M	6	593	2020
SJÖDIN D	7	834	2020
ADRODEGARI F	6	35	2018
KOWALKOWSKI C	5	460	2019
PEZZOTTA G	6	58	2018
RAPACCINI M	10	64	2018

TP Total Publication, TC Total Citation, YFP Year of First Publication

**Figure 4: The evolution of an author's work over a period of time**

### Most productive country

Table 6 highlights the top ten nation's leading in servitization, innovation and technology, each with more than twenty publications. Notable contributors include China, Italy, Germany, Sweden and Spain, which have emerged as the most productive countries in this field.

Spanish scholars have contributed meaningfully to the discussion on servitization, addressing both its challenges and the enabling role of digitalization across various industries. Public-private innovation networks (PPINs) are one of the key themes in enabling successful servitization initiatives (Tahi et al., 2022). Competences in product innovation and digitalization act as critical enablers of this transformation (Vilkas et al., 2022). Technological innovation impacts servitization and this relationship is shaped by the presence of open innovation. Also, servitization is observed to mediate the impact of innovation on organizational performance (Martín-Peña et al., 2023). Therefore, we can say that technological advancement supported by open innovation enable servitization which in turn results in better organizational performance

Furthermore, digitalization is observed to strengthen the link between innovation and performance. Technologies such as artificial intelligence, big data analytics and Industry 4.0 are seen as powerful instruments for overcoming servitization related challenges and gaining a competitive edge (Abou-Foul et al., 2023; Ruiz-De-la-Torre & Sanchez-Bote, 2021). A good example is Gree, an air conditioning manufacturer that applied an innovative business model based on AI-powered smart solutions, enabling it to build an ecosystem of intelligent products and become a global leader in its sector (Chen et al., 2021). Another company in the retail sector, Mercadona, have applied co-innovation with customers and suppliers embedding servitization within its supply chain operations (Albors-Garrigos et al., 2023). Additionally, the SYNCHRO framework—which includes components such as stakeholder environment, co-creation outcomes, capability building, Industry 4.0 connectivity, internal restructuring, and organizational adaptation—offers a structured approach for firms to transition toward servitization, even when direct customer co-creation is restricted (Minaya et al., 2024).

Chinese researchers have made significant contributions to servitization literature by writing on servitization and its influence on organizational sustainability. It has been established by several studies that implementing servitization strategies improves innovation potential in manufacturing firms (Shi, 2013). The implementation of servitization often depends on whether a company follows an explorative (searching for new opportunities) or exploitative (making optimal use of existing assets) strategic track. Both strategies support the progression of digitalization during technological disruptions (Coreynen et al., 2020).

Further studies suggest that manufacturers can gain competitive advantage by combining product innovation with mass customization as it facilitates implementation of servitization-oriented business models (Mao & Wang, 2024). Digital transformation and innovation are said to have a positive impact on organizational performance (Xiao, 2023). Improvements have been observed by employment of both “basic digital services” (such as data-driven platforms) and more “advanced technologies” (like artificial intelligence). However, extreme slack resources may reduce the resolve to build collective service ecosystems, thus reducing the effectiveness of digitalization (Zhou et al., 2024).

Moreover, servitization and innovation play a mediating role in relationship of organizational transformation to ESG (Environmental, Social, and Governance) performance outcomes (Chen & Wang, 2024). Effective management of resources is critical for sustainable business model innovation and requires a transition from “acquisition and stabilization” to “enrichment and strategic deployment” (Zhang et al., 2024). The accelerated uptake of artificial intelligence is primary driver in this shift (Lin et al., 2024). Blockchain is emerging as a main enabler of servitization and sustainable development. Technologies such as decentralized applications (DApps) for 3D printing and blockchain-based smart contracts for secure identity verification are fostering new service delivery models (Zhao et al., 2022; Pustišek et al., 2022). Smart manufacturing systems are now integrating tools such as customer feedback mechanisms, service quality evaluation, idea generation processes, and end-to-end servitization frameworks (Lee et al., 2022).

The structure of an organization also influences how servitization drives innovation. While a formalized structure supports exploitative innovation, it may initially suppress explorative innovation. Over time, however, servitization appears to enable exploratory innovation as well, forming a U-shaped relationship (Wei et al., 2022). Additionally, insights gained from data analytics—when firms engage in bricolage, or creatively repurpose their current resources—can foster new product-service innovations (Chen et al., 2021). In labor-intensive manufacturing firms, it is the number of R&D staff and not overall employee count has a notable positive impact on servitization outcomes. This establishes the importance of R & D in process of servitization. (Ye, 2021).

German scholars have placed significant stress on digital servitization, particularly exploring the changing aspects within its ecosystems. Four key tensions—learning, belonging, organizing, and performing—are seen as closely interrelated. It is important for firms to evaluate how centralized or decentralized ecosystems, and the technologies used within them, either alleviate or intensify these tensions in order to implement digital servitization effectively (Tóth et al, 2022).

Digitalization has allowed organizations to develop integrated system using IoT platforms and combine both product-service functionalities and customer support and gain a competitive edge (Soellner et al., 2024). SMEs are also adopting sensor-based technologies as a vital step toward digital transformation. However, digitalization in small and medium enterprises can be challenging. **Employee upskilling, system upgrades**, and the introduction of organizational strategies can help these organizations implement digital servitization (Trabert et al., 2023). Digital technologies and digitalization play an important role in transforming business models and introduction of product-service systems that help in achieving servitization goals (Mosch et al.,2021; Harrmann et al., 2023; Jaspert et al., 2023).

European scholars have explored the intersection of servitization and Industry 4.0 technologies in their research. Organizations are forced to adopt smart manufacturing practices due to rapid technological advancements brought on by Industry 4.0, along with the shift toward service-oriented business models. This dual transformation leads to numerous challenges for firms steering both digital and service-based changes (Cimini, 2018). A vital part of this change involves enhancing competencies of employees to meet the demands of new systems and technologies (Paschou et al., 2018).

A conceptual model was proposed by Frank et al. (2020) that links various levels of servitization to Industry 4.0 capabilities. This model helps one understand the relationship between digital technologies and service integration. Training and empowering managers with an understanding of servitization strategies and their implications can enhance strategic decision-making processes in New Product Development (NPD) (Leotta et al., 2020). Effective

digital servitization requires strong collaboration between firms and their stakeholders, which is built on trust and transparency (Gandinetti et al., 2020).

A manufacturer has applied blockchain technology in servitization of ice cream machines. Manufacturers, refill suppliers, and operators were all part of an integrated value network enabled by decentralized technology (Balistri et al., 2020). Servitization can also involve retrofitting outdated equipment, which can possibly unlock new service openings but also brings several integration and operational challenges (Zambetti et al., 2020). Creating collaborative networks with external partners is necessary for servitization process to succeed. However, family-run businesses that operate in insular environments are hesitant to adopt these new approaches (Rondi et al., 2021). Firms can co-create value with customers either by managing data strategically ("datatization") or by leveraging digital tools and platforms ("digitalization") (Ciasullo et al., 2021).

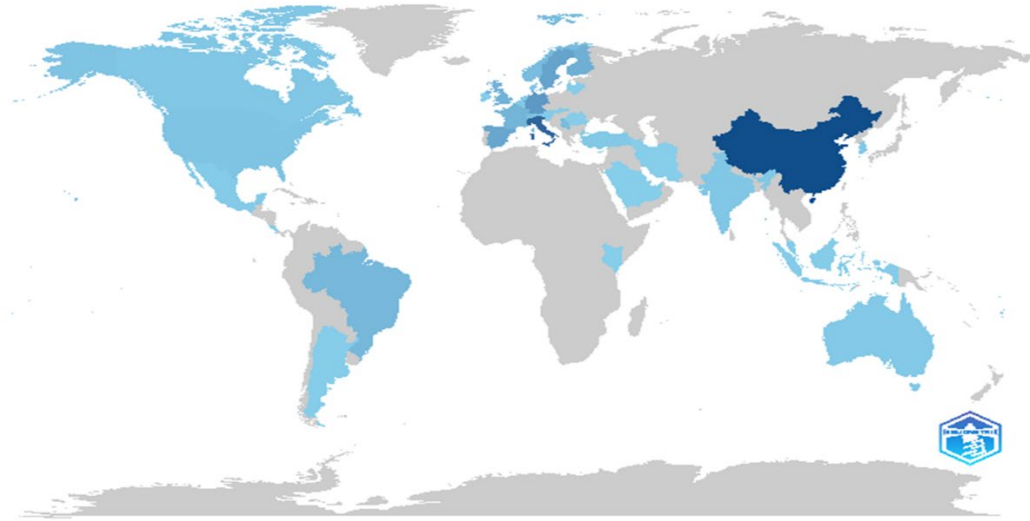
Servitization involves the design, deployment, and delivery of innovative service-based solutions. A notable example is Beta, a company that embraced digital servitization by leveraging Industrial Internet of Things (IIoT) technologies, highlighting how data and connectivity can drive advanced service innovation. Authors from different countries have studied different and varied aspects of servitization. Apparently, the use of **digital technologies** in relation to servitization is observed as a common theme globally. However, there are some unique aspects, which each country authors have focused. In **China**, there is a strong focus on connecting servitization to **Environmental, Social, and Governance (ESG)** principles making it a strategy for sustainable growth. **Spanish academicians** have published several use cases of servitization. They have given **real-world examples** underscoring the significance of **collaborative value creation** with customers and partners. **German researchers** have particularly focused on application of **Internet of Things (IoT)** technologies to enhance servitization, especially within industrial and manufacturing settings. Meanwhile, **Italian authors have** highlighted the role of **customer relationship building** and the use of **blockchain** for service innovation and delivery. As depicted in Fig. (Sankey diagram) Italian authors have covered almost all aspects of servitization in their writings.

**Table 6: Ten top countries that published on servitisation and technologies**

Region	Frequency
CHINA	185
ITALY	147
GERMANY	73
SWEDEN	58
SPAIN	54
FINLAND	41
UK	37
FRANCE	34
BRAZIL	30
NORWAY	24

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**Figure 5: Country-wise Publications (Darker shade denotes more publications)**  
**Country Scientific Production**



**Figure 6: Country-wise Production overtime**

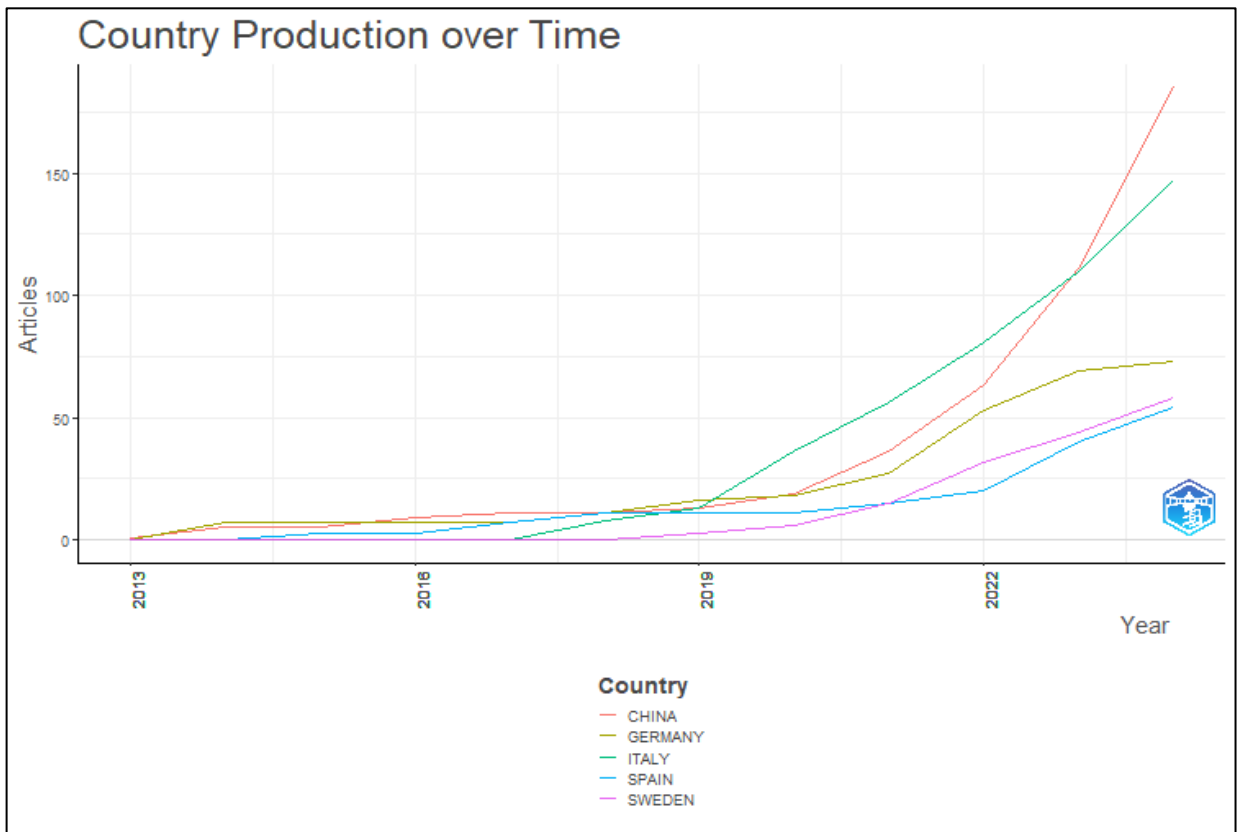


Figure 7: Sankey diagram depicting topics authors from countries writing on.

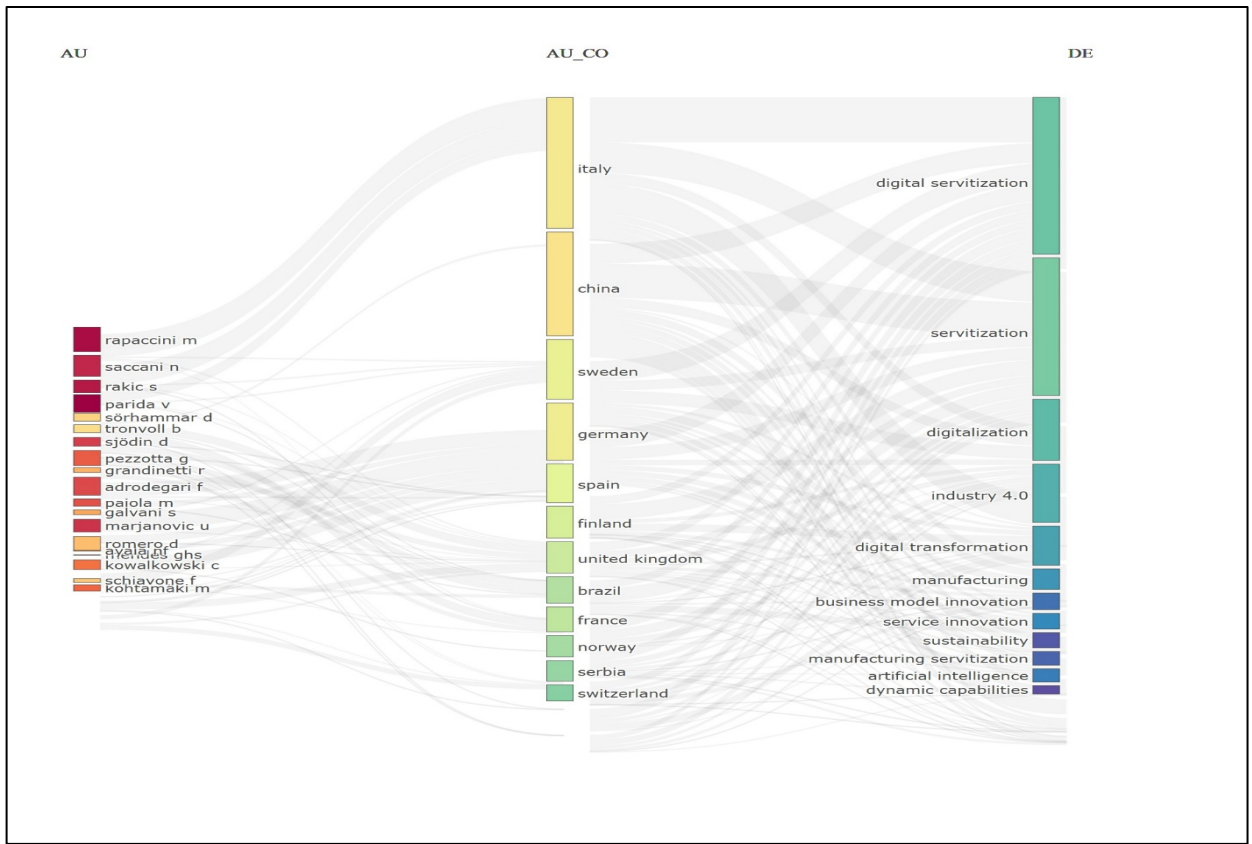


Table 7: Top affiliation that published SIT documents

Affiliation	Articles
LULEÅ UNIVERSITY OF TECHNOLOGY	30
UNIVERSITY OF NOVI SAD	23
UNIVERSITY OF BERGAMO	22
POLITECNICO DI MILANO	15
UNIVERSITY OF BRESCIA	14
CHALMERS UNIVERSITY OF TECHNOLOGY	13
UNIVERSITY OF PADOVA	11
UNIVERSITY OF VAASA	11
FEDERAL UNIVERSITY OF SÃO CARLOS	10
ASTON UNIVERSITY	9

**Affiliations with the Highest Productivity**

Table 7 identifies the institutions with the most substantial contributions to sevitzation, innovation and technology research, based on the total number of publications. For simplicity and clarity, only the top 10 institutions are listed. Among these, *Luleå University of Technology, Sweden* emerges as the most productive institution, with thirty articles, highlighting its significant role in advancing scientific discussions on sevitzation.

### Most Productive Publication Sources

A detailed analysis of publication sources, as shown in Table 8, identifies the journals with the highest output in the field of servitization, innovation and technology (SIT). This analysis highlights the publishing trends and provides insights into the most influential journals. The results show that the *Industrial Marketing Management*, published by Elsevier, lead the list with sixteen articles, establishing it as key sources for research on servitization.

### Most Frequently Used Keywords

The results in Table 9 highlight the most frequently used author keywords and indexed terms, appearing three or more times in the analyzed publications. The keyword “*Servitization*” with 97 occurrences and articles (8%), followed by “*Digital servitization*” and “*Digitalization*” with 94 and 36 occurrences respectively are the most prevalent keywords. Figure 8 presents a tree map visualization of the author keywords, providing additional insights into the thematic focus of the literature, including keywords beyond those listed in Table 9.

### Network Analysis

Network analysis, or science mapping, explores the structural and intellectual relationships within the field of SIT. This study utilized *Biblioshiny*, recognized as one of the most advanced tools for network analysis. This analysis provides an in-depth view of the interconnectedness of various components within the research landscape. Two key author networks stand out in the field: one led by Rapaccini, Saccani, Rakic, West, and others; focusing on the role of digitalization and Industry 4.0 technologies in enabling manufacturing firms to transition from traditional business to servitization; and another led by Parida, Kamalaldin, Sjodin, Zhang, and others, focusing on the integration of sustainability and circular economy in their business through technological advancements in manufacturing servitization (Figure 9).

### Collaboration Analysis

The co-authorship network in SIT research illustrates the collaborative patterns among authors from different countries. The collaboration rankings are based on the affiliations of the authors. Figure 10 present a global view of international research partnerships in this field. Countries with darker shades represent higher levels of collaboration, while lighter shades indicate less collaboration, and grey areas signify a lack of relevant publications from those nations. Thicker lines on the map denote stronger collaborative ties, providing a clear depiction of the global partnerships established within the field of employee mobility research.

**Table 8: Most productive sources on the article titles**

Source	h index	g index	m index	TC	NP	YFP
INDUSTRIAL MARKETING MANAGEMENT	12	16	2	1173	16	2020
JOURNAL OF BUSINESS RESEARCH	8	8	1.14285714	1184	8	2019
TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE	8	9	1.14285714	1046	9	2019
INTERNATIONAL JOURNAL OF OPERATIONS AND PRODUCTION MANAGEMENT	7	8	0.58333333	786	8	2014
JOURNAL OF BUSINESS AND INDUSTRIAL MARKETING	6	10	1.2	145	10	2021
TECHNOVATION	6	8	1.5	125	8	2022
IFIP ADVANCES IN INFORMATION AND COMMUNICATION TECHNOLOGY	4	7	0.57142857	59	11	2019
INTERNATIONAL JOURNAL OF PRODUCTION ECONOMICS	4	6	0.44444444	569	6	2017
JOURNAL OF CLEANER PRODUCTION	4	5	0.66666667	77	5	2020
JOURNAL OF MANUFACTURING TECHNOLOGY MANAGEMENT	4	7	0.57142857	86	7	2019

T.P. Total publications, N.P. Number of papers, T.C. Total citations, Y.F.P. Year of first publication



Figure 9: Collaboration network

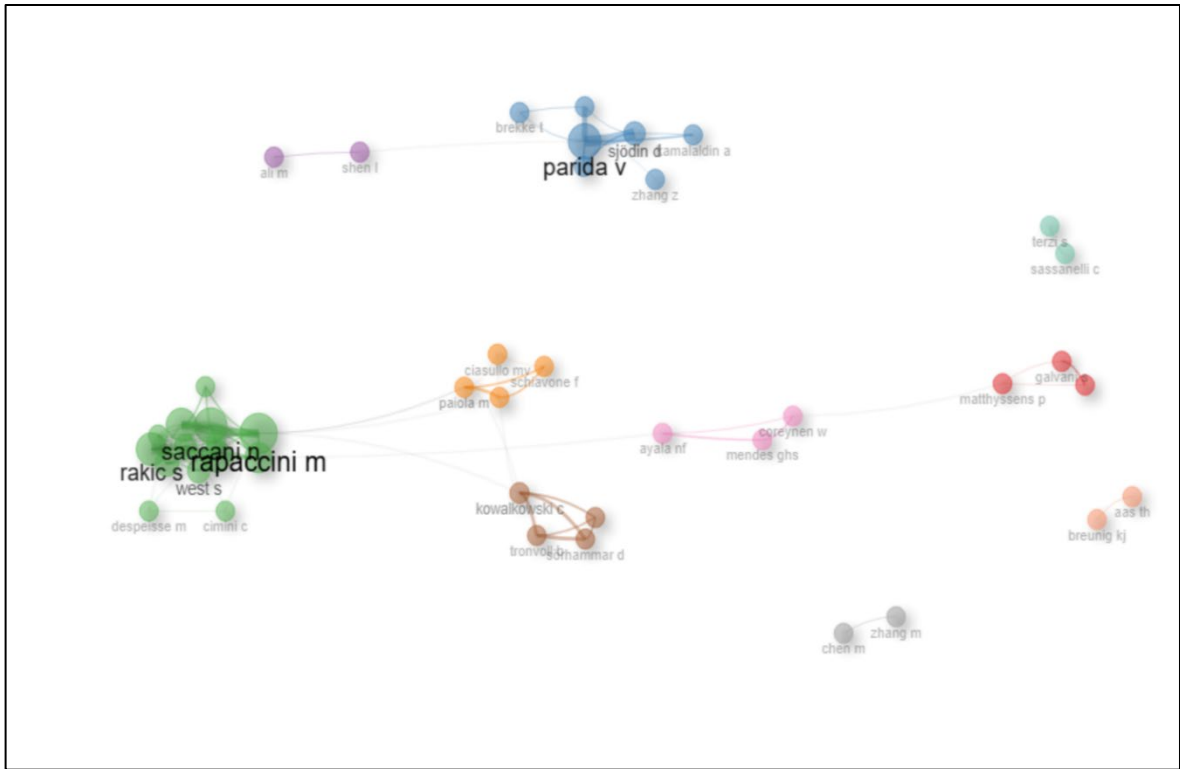
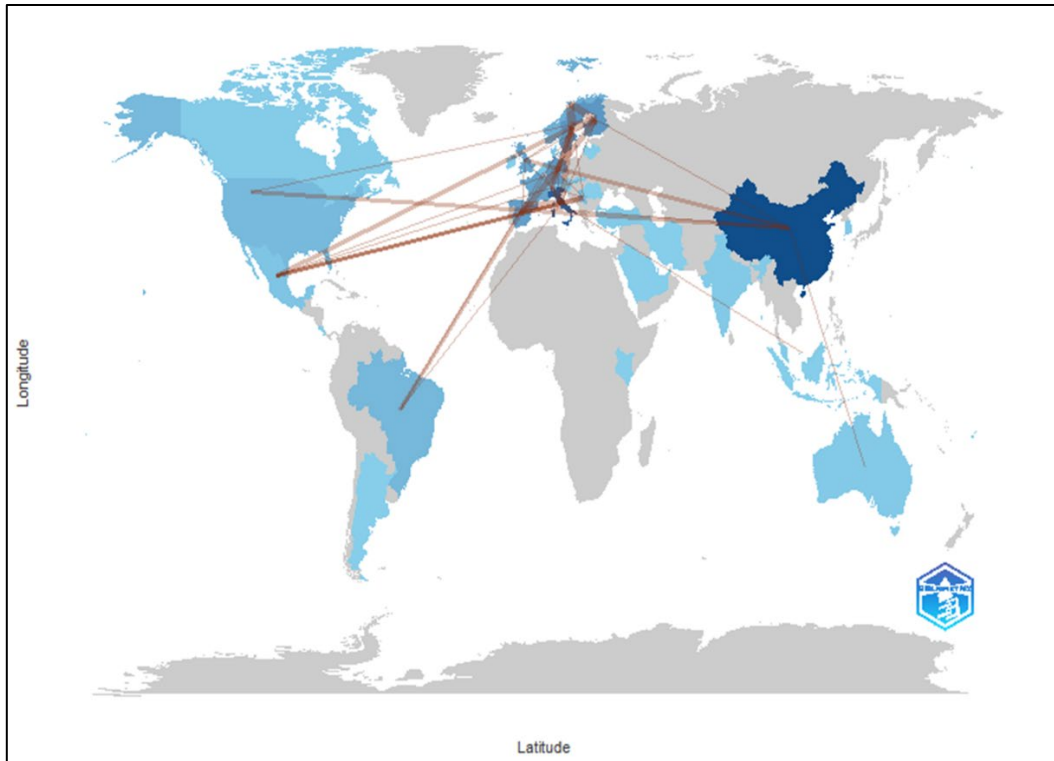
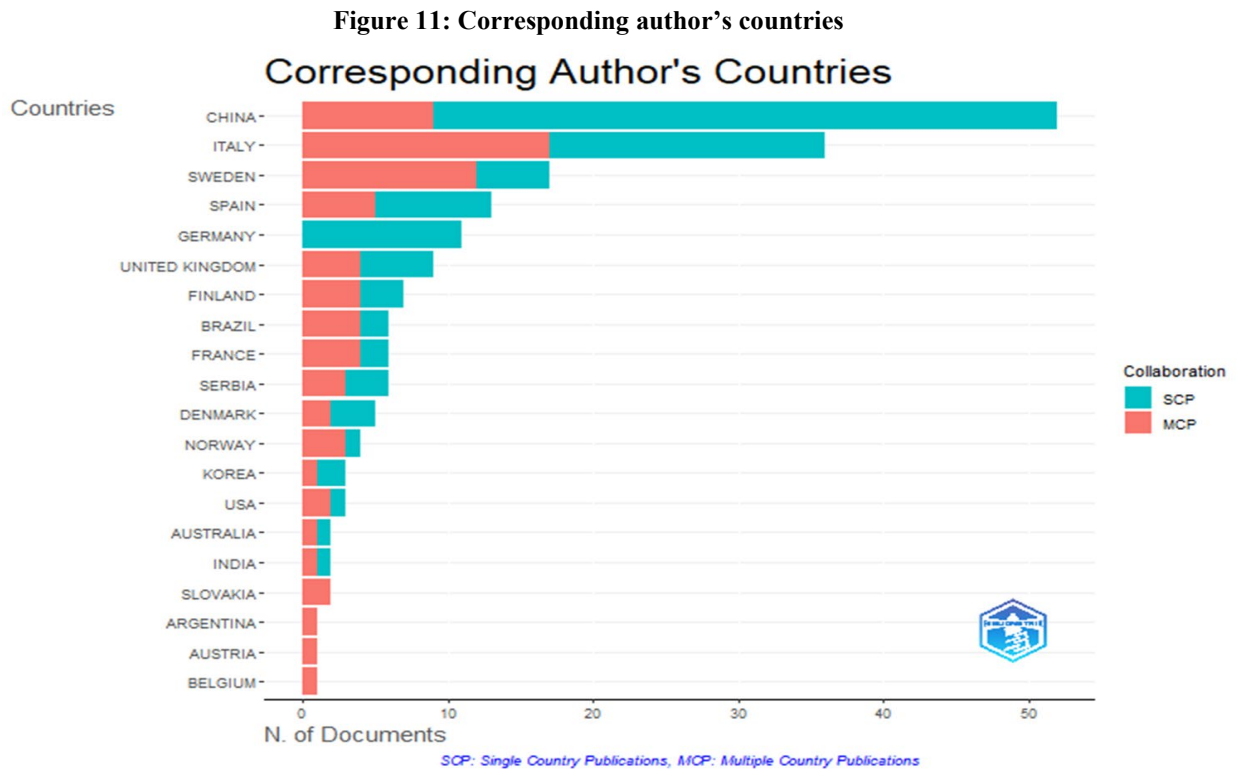


Figure 10: World map of countries' collaboration





As shown in Figure 7 & 11, international collaboration is most prominent among authors from China, Italy and Sweden. China researchers often collaborate with counterparts in countries such as the USA, the UK and Australia. Italy has most multi-country publications. Italian authors collaborate mostly with researchers from France, Serbia, Sweden and Switzerland.

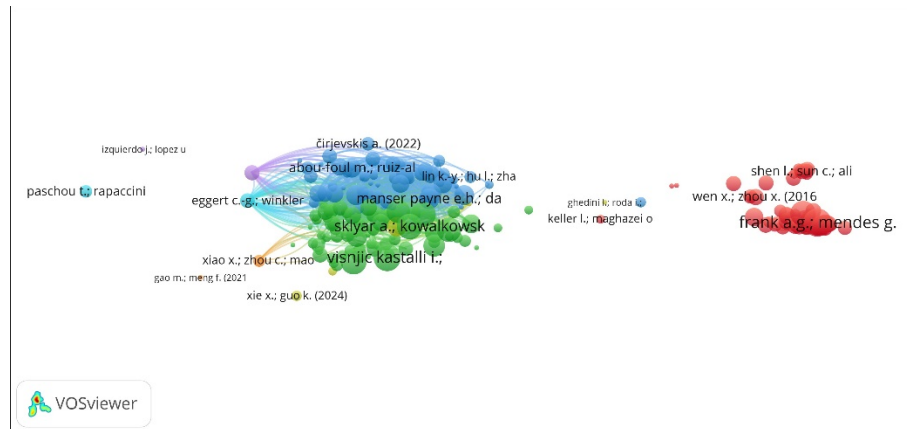
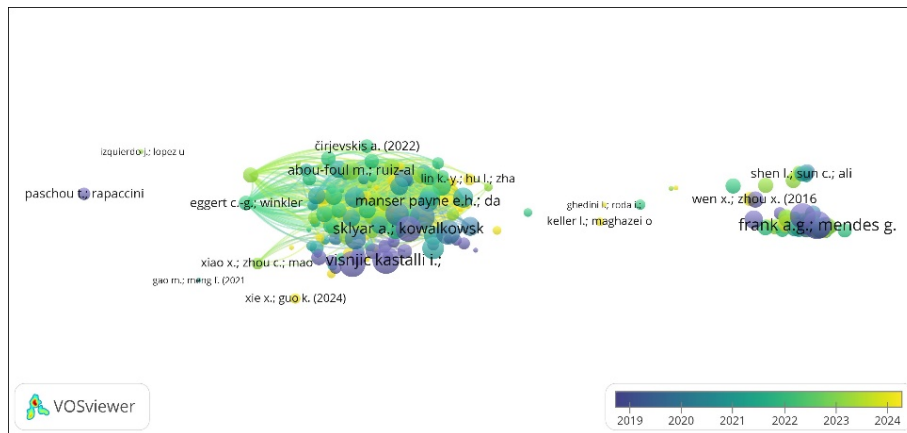
Figure 11 highlights countries with the highest number of corresponding authors, with Italy and China leading in this regard. Interestingly, Germany usually have Single Country Publications (SCPs) that means German authors usually do not collaborate with authors from other countries. Research publications originating from a single country are referred to as *Single Country Publications (SCP)*, whereas *Multiple Country Publications (MCP)* denote articles resulting from international collaborative efforts. The analysis indicates that SCPs are more prevalent than MCPs, underscoring a preference for national collaboration in this field.

### Co-Occurrence Network Analysis

This analysis evaluates the content of publications based on the assumption that frequently occurring keywords are interconnected and reflective of specific research themes (Donthu, 2021). The strength of the co-occurrence is represented by the thickness of the links between keywords, with thicker links indicating stronger associations (refer Table 10 in Appendix-1).

Figure 12 illustrates the results of a co-occurrence network analysis conducted using Biblioshiny. It has author keywords as the focal element. This analysis in biblioshiny created two clusters. Red cluster relates to emergence of servitization or product service system in manufacturing industry, organizational changes required for making a transition to servitization, role of digitalization in servitization, ecosystem required to make this transition and value co-creation. Blue cluster discusses about the new technologies, service innovation that can drive servitization and assist the organizations in achieving sustainability and circularity. Figure 10 shows co-occurrence network analysis conducted using VOSviewer software which is little different then biblioshiny as it has four main clusters. Apparently, the blue cluster of biblioshiny has been divided in several small clusters by Vosviewer as per the emergence of new technologies and utilization of these in servitization by the organizations e.g. red cluster in Figure 13 is about sustainability and innovation, green cluster related to digitilization and servitization, light blue cluster is about service innovation, dark blue cluster relates to internet of things and servitization, purple cluster is about industry 4.0



**Figure 14: Bibliographic Network visualization (Vosviewer)****Figure 15: Bibliographic overlay visualization (Vosviewer)**

### Thematic Evolution and Mapping

The thematic evolution highlights how central themes in Servitization, Innovation and Technology (SIT) research have developed over time, based on the analysis of author keywords. Figure 16 illustrates the progression of these themes through three distinct phases: 2013–2019, 2020–2023, and 2023–2024. During the initial phase (2013–2019), primary themes were product service systems, servitization and digitalization. Digitalization was discussed by authors, however in few publications (check the size of the box). However, in 2020–2023 era digital servitization took the center stage and was the most discussed theme in writings related to servitization. Themes such as circular economy, organizational change also emerged as a result of manufacturing organizations making transitions to servitization realized the need to change the structure and strategy in order to leverage advantages of servitization. Digital servitization has prominence in recent discussions also on servitization (2023–2024), circular economy again surfaced in the publications on this topic. Ecosystem is another major theme of 2023–2024 emphasizing the importance of ecosystem creation for successful transition to servitization by manufacturing firms.

Figure 17 provides a visual representation of the thematic map, divided into four quadrants, each corresponding to a measure of theme density and centrality (Aria et al.,2017). The upper right quadrant represents themes with high density and centrality, identifying them as evolving and crucial areas of research. The upper left quadrant includes themes with high density but low centrality, representing highly specialized and mature research areas. Themes in the lower left quadrant show low density and centrality, reflecting distinct but underdeveloped areas of study. Lastly, the lower right quadrant features foundational themes with high density but low centrality, forming the basis for ongoing research.

The thematic map demonstrates the interconnections among key areas such as servitization, digitalization, technologies and innovation. Themes in the lower left quadrant specifically address contemporary issues within SIT research, with an increasing focus on topics like technological innovation and organizational change required to make

a transition towards servitization. These emerging topics provide valuable perspectives for policymakers and organizations to consider in future studies. Notably, digitalization remains a central and fundamental theme, serving as a cornerstone for the majority of research on SIT.

Figure 16: Thematic evolution

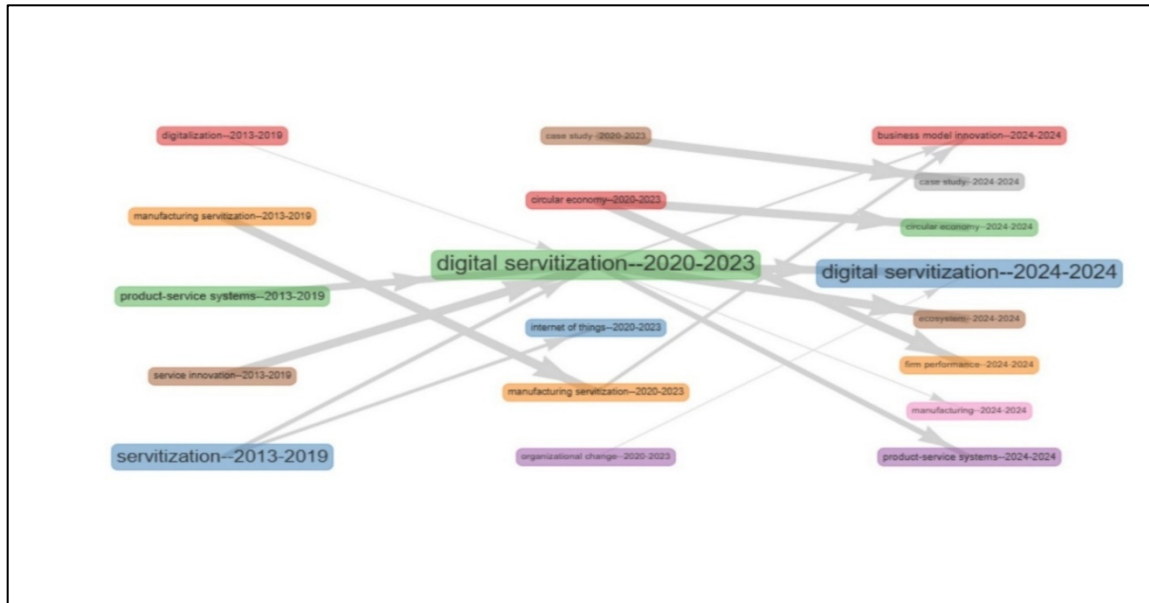


Figure 17: Thematic development of the article based on Keywords

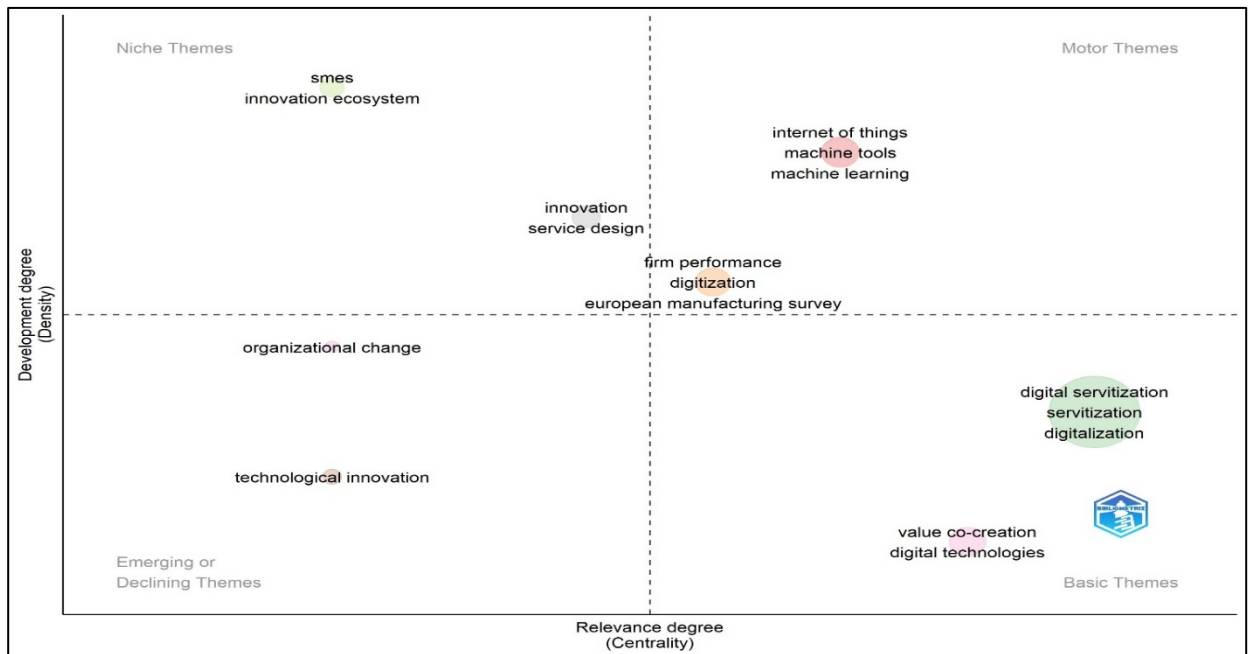


Figure 16 highlights several themes that are prominent in 2023-24, including **sustainability** and creation of **ecosystem** for successful servitization. In contrast, themes from 2022-2023 focused on leveraging **artificial intelligence** and **digital technologies** for servitization. During 2022 utilizing **industry 4.0 technologies** for servitization was the key area of interest.

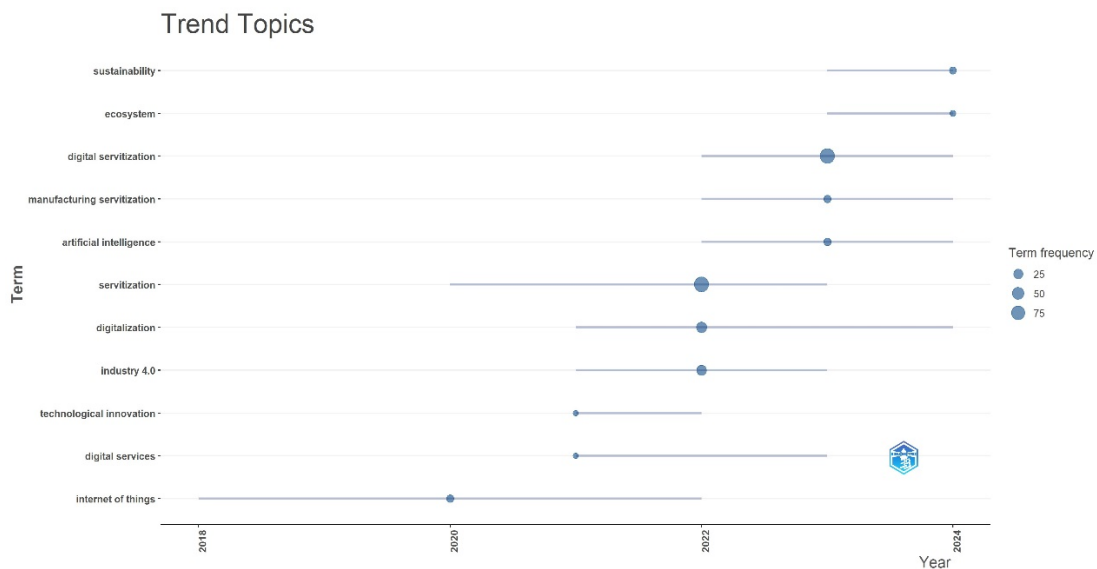
## Major Clusters

The underlying themes and sub-themes within the major clusters are detailed below.

Cluster 1 mainly focuses on the challenges and strategies related to ecosystem transformation in digital servitisation and firms must be able to manage data access challenges and must develop partnerships to create successful service networks and emphasises the ecosystem perspective on the interaction between firms, suppliers and customers. Cluster 2 deals with digital technologies as enablers in servitisation where firms must increase customer relationships and improve service offerings and focus on how technology enhances ecosystem-level transformation. Cluster 3 emphasises on the role of AI and automation in digital servitisation and focuses on the methods by which agile micro-service innovation helps firms adapt to AI driven automation that enables optimisation in servitisation. Cluster 4 is mainly business model oriented, which emphasises on strategic transformation, embracing value co-creation and new business frameworks. This is driven by internal organisational factors mainly attributed to cultural and managerial aspects which is impacted by top management commitment and organisational culture. Major themes are very limited with respect to Clusters 5, 6 and 7.

The cluster details are appended in Appendix.

**Figure 18: Trend topics based on the author keyword**



## Conclusions

According to the authors' assimilated knowledge, a bibliometric analysis on servitization, innovation and technology (SIT) is yet to be comprehended. Even though, servitization and digitalization are two important trends in modern business, there are potential benefits to combining these two trends, and some gaps in understanding of their impact. Since, emerging technologies have facilitated the process of servitization many organizations in different countries are working in this direction. Therefore, more literature reviews and case studies will improve the understanding of the subject. A bibliometric analysis of 296 papers published over a decade (from 2013 to 2024), from Scopus database was used for this investigative study. Annual publication and citation counts component measures research productivity, which is vital in assessing a researcher's contributions. The former evaluates productivity, and the latter the significance and core of the work (Donthu, 2021). Maximum number of research publications from Italy suggests the extensive initiatives taken by the government and companies regarding employee mobility and reduction in carbon emissions. In recent years a surge is seen in the number of publications on this topic.

The research highlights that Frank et al 's (2019) work has garnered the highest number of citations (709). The influence of a document is significantly impacted by the number of citations it receives. Therefore, identifying the most frequently cited articles is critical (Donthu, 2021). The findings of this study underscore several key contributions to the fields of SIT. Researchers have used citation analysis as a tool to assess significant outcomes and trace the

intellectual development on SIT.

The analysis of publications by author, nation, affiliation, and source title reveals considerable scholarly collaboration in the area of SIT, particularly among the most active writers. Parida (13, total publication) and Rapaccini (10, total publication) can be considered most productive authors in this area in comparison to others. Also, Parida (1142, total citation) is the most cited author making him an author with significant contribution for evolving the academic understanding of this field.

Keyword analysis, together with the use of common terms, tree maps, and trending topics, provides insights into the primary themes addressed in SIT research. This is especially valuable for researchers seeking to identify emerging trends in this domain. The analysis reveals that "digital servitization" is the most commonly used keyword by authors and "servitization" is most common word used by publication sources. Tree maps further augment literature exploration by offering a broader perspective on authors and indexed keywords. Furthermore, topics such as "organizational change," and "technological innovation" have emerged as trending areas of focus in the field. These findings assist researchers in refining their literature searches based on particular themes or keywords.

Publication trends in this area highlight that the scholars in China and Italy are the most active collaborators in SIT research, followed by researchers in the Germany and Sweden. These countries also engage in noteworthy international collaboration with nations like Slovakia, Argentina, and UK. Particularly, China has established strong collaborative relationships with other countries in this area. Researchers can leverage these insights to identify potential co-authors and collaborative networks in countries with vibrant research communities before publishing their work. The co-occurrence analysis of keywords further validates that "digital servitization" is the most used term, followed by "servitization". Bibliographic analysis resulted in 7 prominent clusters of authors.

A thematic evolution network analysis was conducted to know about the evolution of research themes over the past two decades. This approach, as suggested by Dervis (2019), recognizes periodic topic trends and tracks the progression of research themes over time. The analysis reveals a prominent transition from "servitization" to "digital servitization." to "circular economy" and "business model innovation". This shift characterizes a paradigm change-- a shift in focus from product service offerings to use to digital and emerging technologies to circular economy and sustainability.

The study minimized risks associated with selection, publication and interpretive biases by employing structured PRISMA protocol and relying on articles from peer-reviewed Scopus indexed sources and triangulating findings across multiple bibliometric tools (Page et al., 2021; Donthu et.al., 2021). This further strengthened analytical objectivity and enhanced dependability and confirmability of the results (Lincoln & Guba, 1985; Petticrew & Roberts, 2006). Hence the conclusions derived from the study are supported by strategies designed to enhance credibility and reduce internal bias.

By systematically mapping its intellectual structure, thematic evolution, and collaborative landscape, this study provides a comprehensive synthesis of servitization, innovation, and technology research landscape. The findings reveal a strong and growing convergence between digital technologies, service-oriented business models, and sustainability objectives. A shift from product-centric manufacturing toward integrated product-service ecosystems, was evidenced by dominant themes such as digital servitization, Industry 4.0 technologies, service innovation, and circular economy practices. Further, the results indicate technological innovation as an enabler and accelerator of servitization, supporting organizational performance, resilience, and ESG outcomes. Collaboration networks indicates concentrated scholarly influence in regions such as China, Italy, and Sweden, suggesting geographic leadership in shaping servitization discourse. The findings reflect increasing interdisciplinarity and global knowledge exchange at the institutional and author levels.

The study synthesises that servitization is no longer a standalone strategy but a systemic transformation driven by digitalization and sustainability imperatives. The findings offer, practical implications for managers seeking to design data-driven service models and for policymakers aiming to promote sustainable industrial transitions. In the academic arena, the study identifies relatively under explored themes namely, AI-enabled circular servitization and governance mechanisms, providing clear directions for future research.

### **Implications**

Thus, the study points to the fact that Servitization has the potential to drive digitalization and decarbonization by incorporating digital technologies to improve product design and service delivery while also driving innovation in product design. It can further help to reduce wastages and help firms to shift towards more sustainable business models by offering more sustainable services and reducing waste, which also helps the firms in their approach towards

SDG's. Overall, the impact of servitization on digitalization and decarbonization is likely to continue to grow in importance as firms seek to differentiate themselves and achieve competitive advantage in a rapidly changing business environment. The above study highlights the publication trends as well as evolving research areas in this field.

### Acknowledgement

This research did not receive any specific financial support from public, private, or non-profit funding bodies.

### Conflict Of Interest

The authors declare no conflicts of interest related to this study.

### Abbreviations

RQ	Research questions
TP	Total publication
TC	Total citation
C/Y	Citations per year
NP	Number of Publications
SIT	Servitization, Innovation and Technology

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## Appendix-1

Table 10: Bibliographic Clusters

S.No.	Label	URL	Cluster
1	hunke f.; engel c. (2018)	doi.org/10.1007/978-3-030-00713-3_17	1
2	de souza m.; trento l.r.; dauer m. (2020)	doi.org/10.1007/978-3-030-23816-2_94	1
3	marjanovic u.; rakic s.; lalic b. (2019)	doi.org/10.1007/978-3-030-30000-5_63	1
4	paschou t.; rapaccini m.; peters c.; adrodegari f.; saccani n. (2020)	doi.org/10.1007/978-3-030-43616-2_44	1
5	maamar z.; faci n.; yahya f. (2021)	doi.org/10.1007/978-3-030-73203-5_14	1
6	vladorchuk a.; schaffhauser-linzatti m.; mikolasik m.; ivanochko i. (2021)	doi.org/10.1007/978-3-030-76632-0_17	1
7	rakic s.; visnjic i.; gaiardelli p.; romero d.; marjanovic u. (2021)	doi.org/10.1007/978-3-030-85902-2_17	1
8	pezzotta g.; saccani n.; adrodegari f.; rapaccini m. (2021)	doi.org/10.1007/978-3-030-85902-2_21	1
9	anderson m.; west s.; harrison d. (2021)	doi.org/10.1007/978-3-030-85906-0_15	1
10	sassanelli c.; de carolis a.; terzi s. (2022)	doi.org/10.1007/978-3-030-94399-8_35	1
11	pezzotta g.; arioli v.; adrodegari f.; rapaccini m.; saccani n.; rakic s.; marjanovic u.; west s.; stoll o.; meierhofer j.; holst l.; wiesner s.a.; bertoni m.; romero d.; pirola f.; sala r.; gaiardelli p. (2022)	doi.org/10.1007/978-3-031-16411-8_37	1
12	charissis v.; khan m.s.; harrison d.k. (2022)	doi.org/10.1007/978-3-031-22131-6_40	1
13	sassanelli c.; sarbazvatan s.; demetriou g.; greyl l.; mosca g.; terzi s. (2023)	doi.org/10.1007/978-3-031-43666-6_11	1
14	pezzotta g.; arioli v.; adrodegari f.; rapaccini m.; saccani n.; rakic s.; marjanovic u.; west s.; stoll o.; wiesner s.a.; bertoni m.; romero d.; pirola f.; sala r.; gaiardelli p. (2023)	doi.org/10.1007/978-3-031-43666-6_12	1
15	slavic d.; marjanovic u.; pezzotta g.; turcin i.; rakic s. (2023)	doi.org/10.1007/978-3-031-43666-6_8	1
16	beducci e.; acerbi f.; de carolis a.; terzi s.; taisch m. (2023)	doi.org/10.1007/978-3-031-49339-3_15	1
17	ciasullo m.v.; douglas a.; romeo e.; ferrara m. (2024)	doi.org/10.1007/978-3-031-65115-1_2	1
18	keller l.; maghazei o.; gróf c.; netland t.h. (2024)	doi.org/10.1007/978-3-031-71622-5_17	1
19	galimberti m.; Chávez c.a.g.; despeisse m.; cimini c.; west s. (2024)	doi.org/10.1007/978-3-031-71637-9_18	1
20	kavanaugh j.; ramachandran s.; puri r. (2023)	doi.org/10.1007/978-981-19-7071-9_6	1
21	wen x.; zhou x. (2016)	doi.org/10.1007/s00170-014-6348-8	1
22	minaya p.e.; avella l.; trespalacios j.a. (2023)	doi.org/10.1007/s10843-023-00333-6	1
23	albors-garrigos j.; de miguel molina m. (2023)	doi.org/10.1007/s10843-023-00336-3	1
24	brekke t.; lenka s.; kohtamäki m.; parida v.; solem b.a.a. (2024)	doi.org/10.1007/s11846-023-00641-0	1

25	kamp b.; ochoa a.; diaz j. (2017)	doi.org/10.1007/s12008-016-0345-0	1
26	grubic t. (2018)	doi.org/10.1016/j.compind.2018.05.002	1
27	wang j.; wang w.; wu h.; liu y. (2023)	doi.org/10.1016/j.eneco.2023.106706	1
28	song y.; niu n.; song x.; zhang b. (2024)	doi.org/10.1016/j.eneco.2024.107875	1
29	mao n.; wang m. (2024)	doi.org/10.1016/j.heliyon.2024.e38312	1
30	rymaszewska a.; helo p.; gunasekaran a. (2017)	doi.org/10.1016/j.ijpe.2017.02.016	1
31	qi y.; mao z.; zhang m.; guo h. (2020)	doi.org/10.1016/j.ijpe.2020.107747	1
32	mosch p.; schweikl s.; obermaier r. (2021)	doi.org/10.1016/j.ijpe.2021.108141	1
33	vendrell-herrero f.; para-gonzález l.; mascaraque-ramírez c.; freixanet j. (2024)	doi.org/10.1016/j.ijpe.2024.109228	1
34	bustinza o.f.; molina l.m.; vendrell-herrero f.; opazo-basaez m. (2024)	doi.org/10.1016/j.ijpe.2024.109411	1
35	jia y.; cui l.; su j.; wu l.; akter s.; kumar a. (2024)	doi.org/10.1016/j.ijpe.2024.109434	1
36	wei f.; feng n.; yang s.; zhao q. (2020)	doi.org/10.1016/j.jclepro.2020.121431	1
37	gonzález Chávez c.a.; bryolf s.; despeisse m.; johansson b.; rönnbäck a.ö.; röslér j.; stahre j. (2024)	doi.org/10.1016/j.jclepro.2023.140401	1
38	vaillant y.; lafuenta e. (2024)	doi.org/10.1016/j.jclepro.2024.142078	1
39	spadafora m.; rapaccini m. (2024)	doi.org/10.1016/j.jclepro.2024.142178	1
40	bressanelli g.; saccani n.; perona m. (2024)	doi.org/10.1016/j.jclepro.2024.142512	1
41	paiola m.; grandinetti r.; kowalkowski c.; rapaccini m. (2024)	doi.org/10.1016/j.jengtecman.2024.101846	1
42	zhao h.; liu j.; hu x. (2022)	doi.org/10.1016/j.ocecoaman.2022.106195	1
43	legault p.; de santa-eulalia l.a.; mosconi e.; bordeleau f.-e.; francoeur c.; cadieux n.; anholon r.; rekik z. (2019)	doi.org/10.1016/j.promfg.2019.03.061	1
44	zambetti m.; khan m.a.; pinto r.; wuest t. (2020)	doi.org/10.1016/j.promfg.2020.05.144	1
45	gonzález Chávez c.a.; unamuno g.; despeisse m.; johansson b.; romero d.; stahre j. (2023)	doi.org/10.1016/j.rcim.2022.102520	1
46	frank a.g.; mendes g.h.s.; ayala n.f.; ghezzi a. (2019)	doi.org/10.1016/j.techfore.2019.01.014	1
47	paiola m.; schiavone f.; khvatova t.; grandinetti r. (2021)	doi.org/10.1016/j.techfore.2021.120963	1
48	münch c.; marx e.; benz l.; hartmann e.; matzner m. (2022)	doi.org/10.1016/j.techfore.2021.121361	1
49	schiaivone f.; leone d.; caporuscio a.; lan s. (2022)	doi.org/10.1016/j.techfore.2021.121441	1
50	leminen s.; rajahonka m.; wendelin r.; westerlund m.; nyström a.-g. (2022)	doi.org/10.1016/j.techfore.2022.122070	1
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