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TAILORED FOR THE PLANET: A BIBLIOMETRIC DIVE INTO UNPACKING THE CONVERGENCE OF MASS CUSTOMIZATION AND SUSTAINABILITY

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ABSTRACT

Businesses are becoming more and more client-centered and there is consumer pressure to be green and sustainable. As industries strive to balance consumer-driven customization with the goals of resource efficiency, waste reduction, and environmental responsibility, the integration of these two paradigms has emerged as a critical quest. The main purpose of this study is to undertake a detailed bibliometric analysis to unravel trends, seminal works, influential countries, and authors along with emerging themes within this transformative convergence of mass customization (MC) and sustainability. The study extracted 263 documents from Scopus database and employed bibliometric methods, like co-authorship and keyword co-occurrence, to map the intellectual landscape of this interdisciplinary field. Key findings demonstrated a discernible trend in research activity with global relevance in this domain as top countries represent contributions from both developed and developing regions. Emerging directions revealed leveraging sustainable mass customization for maximizing competitive advantage and profitability, revolutionizing sustainable manufacturing using innovative designs with balancing the approach of MC to redefine production models and lastly supply chain dynamics is transforming for sustainable customized products, particularly with the advent of Industry 4.0 era. The integration of circular economy principles into customized production processes is also highlighted, with an emphasis on closed-loop systems and the design of products for longevity and recyclability. Challenges such as scalability, resource efficiency, and the adaptation of existing manufacturing systems to meet sustainability goals are also discussed. The study offers valuable insights to businesses to redefine their product development strategies by emphasizing eco-friendly goals, and efficient production processes fostering a competitive edge through agile supply chains, remanufacturing & refabricating and additive manufacturing technologies, such as 3d printing, modularities and so on. Policymakers can utilize the findings to inform decision-making and develop policies that promote sustainable practices.

Keywords: Mass Customization, Sustainability, Bibliometric Analysis, Scopus, Vosviewer, Biblioshiny

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1. INTRODUCTION

In recent years, there has been a notable shift in business operations, influenced by changing consumer preferences, technological breakthroughs, and social pressure to reduce environmental impact. These paradigm shifts have confronted manufacturing firms with the challenges of meeting customer expectations by offering highly customized products and adhering to rigorous sustainability standards. A key concept that has arisen in response is Mass Customization (MC), which addresses individual needs and preferences to stay competitive (Kotha, 1995). MC has become a strategic priority for many firms, especially in industries where standardized offerings are no longer adequate to meet consumer expectations (Wind and Rangaswamy, 2001). MC entails utilizing technology and managerial techniques in order to provide product diversity and customization through adaptability and prompt response (Davis, 1987; Pine, 1993). The main objective of MC is to create enough variation in goods and/or services so that almost everyone can find exactly what they want at a fair price (Broekhuizen and Alsem, 2002). Based on the extent of customer involvement, Gilmore and Pine (1997) have identified four MC approaches as illustrated in Figure 1. The evolving demands of customers for increased product variety, enhanced features, and superior quality have led to this shift (Kotler, 1989; Pine, 1993). Businesses have evolved into customer-centric enterprises as they can't prosper without considering the actual needs of their clients (Sheth et al., 2000).

Throughout the 21st century, marketing literature has extensively documented the organizational advantages of prioritizing customer-centric approaches (Pardo-Jaramillo et al. 2020). With the growing importance of strategic flexibility and customer centricity, MC has emerged as a significant area of research. Traditionally, this method had been associated mostly with assembly production, where advancements like automation, computer-integrated manufacturing, and flexible manufacturing systems were pivotal (Eastwood, 1996; Kotha, 1995). Nonetheless, the advent of Industry 4.0 enabled leveraging additive manufacturing techniques, such as 3D printing and modular production that broadened its scope to create customized items without the necessity for assembling components (Attaran, 2017; Bogue, 2013). This technology allows engineers to design products with optimized geometries and material usage, contributing to reduced material consumption and improved sustainability (Ahuja et al., 2015). By incorporating these engineering innovations, the use of MC can be seen as an economically viable business model, as firms can charge higher prices due to the increased willingness of clients to pay more for customized items (Pourabdollahian et al., 2014).

However, the significance of MC can extend beyond economic benefits, as it also aligns with contemporary sustainability concerns. As global attention is increasingly moving towards ecological and social responsibility, integrating business models with sustainability principles becomes paramount (Pourabdollahian et al., 2014). Businesses that want to ensure their long-term viability and retain the trust of their stakeholders must now incorporate sustainability into their business plans. In today's changing manufacturing landscape, the intersection of MC and sustainability has become a key focus, reflecting the collective drive towards more adaptive, and eco-conscious production practices. Unlike traditional business models, which primarily focus on economic factors, sustainable business models incorporate environmental and social considerations. Hora et al., (2016) proposed a structured framework by integrating different elements from both MC and sustainability in seven distinct Sustainable MC patterns, i.e., sustainable solution space development, sustainable configuration, recyclable products, produce only what you sell, sustainable usage, additional services and product stewardship.

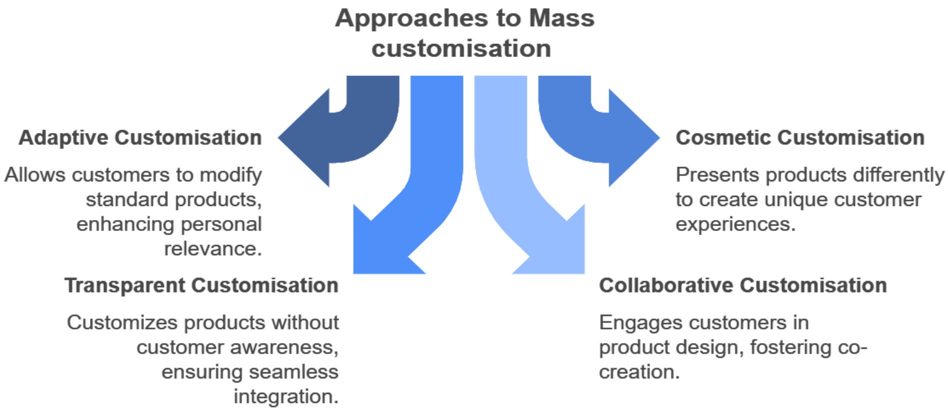

Figure 1. Approaches to MC based on Customer Involvement

Various studies have explored the linkage of these two concepts, illuminating both challenges and potential enablers. For instance, one of the key enablers of Sustainable MC is the use of advanced manufacturing technologies such as 3D printing and modular production that can reduce material waste and energy consumption by optimally utilizing resources (Attaran, 2017). Additionally, modular designs and closed-loop supply chains in MC facilitate improved product life cycle management and better reuse and recycling capabilities (Boër et al., 2018). However, a higher level of MC can also pose challenges to achieving sustainability such as complexity in supply chains and delivery logistics can have an increased carbon footprint if additive technologies are not utilized (Pulak, 2021). Furthermore, the complexity of customized products can pose a hindrance to disassembly and recycling unless modularity design is implemented to facilitate product modification and reuse. Despite all these challenges, the present trends of globalization, digitalization and sustainability emerged as key drivers for MC.

However, in spite of substantial advancements in the field of MC and sustainability and the potential of this convergence to reduce the environmental impact over the life cycle of the product, the existing literature exhibits a research gap regarding a holistic synthesis of these two paradigms. Previous studies often addressed this intersection through narrowly defined buzzwords "Smart Customization," "Agile MC," and "Sustainable MC" rather than substantive research. To fill this gap, the main purpose of this study is to undertake a detailed bibliometric analysis to unravel trends, and seminal works, along with emerging themes within this transformative convergence.

The research questions of the present study are:

RQ1. What are the publication and citation trends in the field of MC and sustainability?

RQ2. Who are the key contributors in terms of authors, journals, documents, affiliations and countries within the stated domain?

RQ3. What are the key topics and prominent themes studied in the scholarly literature on MC and sustainability?

RQ4. What are the future research directions based on thematic cluster analysis of publications pertaining to MC and sustainability?

2. MATERIALS AND METHODS

To explore the intellectual, conceptual, and collaborative dimensions of the intersection between MC and sustainability**,** this study employed a comprehensive bibliometric

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methodology. there has been a notable surge in the application of bibliometric analysis, owing to its ability to systematically uncover research trends, influential contributors, and emerging domains across large volumes of scholarly literature (Singh et al., 2023; Donthu et al., 2021). Given the growing intersection between personalization strategies and sustainable practices, it becomes essential to conduct a bibliometric analysis on mass customization and sustainability to uncover key trends, identify influential contributors, and map the evolution of this emerging research domain. To achieve research objectives, the study employed a systematic approach based on Jia et al. (2017).

2.1 Research Acquisition

As shown in Figure 2, To ensure a comprehensive and systematic coverage of relevant literature, the Scopus database was selected as the source for data acquisition. Scopus is recognized as one of the most extensive abstract and citation databases of peer-reviewed literature, encompassing a wide range of disciplines, including science, technology, medicine, social sciences, arts, and humanities (Leong et al., 2022). For this research, a literature search was conducted on 10 April 2025 using a search query to curate documents pertinent to the field by employing keywords which were selected based on prior studies (Baranauskas et al., 2020; Ciric et al., 2021; Nobanee et al., 2021). To ensure that only relevant documents were retrieved, the search was limited to the title, abstract and keywords fields. Initially, 426 documents were retrieved in total. The search string used for the study is given below:

(TITLE-ABS-KEY ("mass customization") OR TITLE-ABS-KEY ("mass customisation") OR TITLE-ABS-KEY ("mass-customization") OR TITLE-ABS-KEY ("mass-customization") AND TITLE-ABS-KEY ("sustainable development") OR TITLE-ABS-KEY ("sustainability") OR TITLE-ABS-KEY ("sustainab"))*

To maintain consistency and avoid linguistic bias, the search was limited to English-language journal articles and conference papers in the final stage of publication only. As such, the study excluded review papers, book chapters and editorials, along with documents written in a language other than English. This filtering stage resulted in a final dataset of 316 documents for conducting further analysis.

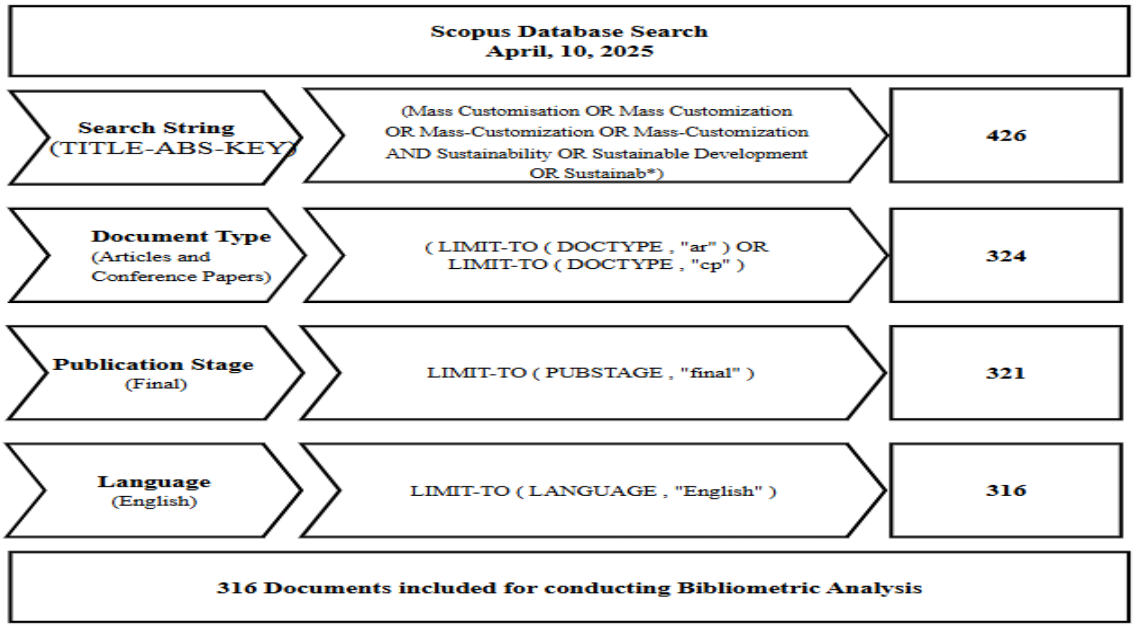

Figure 2: Data Extraction Protocols

2.2 Research Method

The present study adopted a bibliometric analysis approach by applying two core techniques—performance analysis and network analysis, to examine the landscape of research on mass customization and sustainability (Donthu et al., 2021). Performance analysis is used to identify the publication trends over time, highlight the most influential articles, authors, journals, institutions, and countries contributing to the field, and provide a temporal understanding of how the domain has evolved. Network analysis, on the other hand, is employed to uncover thematic structures and knowledge clusters through keyword co-occurrence mapping, enabling the identification of significant themes and interrelationships within the literature. For the visual and statistical analysis, we utilized two robust tools: VOSviewer (van Eck & Waltman, 2017) for constructing and visualizing bibliometric networks, and Biblioshiny for descriptive analysis, themes and word cloud generation.

3. RESULTS AND DISCUSSION

3.1 Descriptive Analysis of Data Characteristics

Table 1 showcases the data set characteristics, which comprise 316 documents (134 journal articles and 182 conference papers), originating from 185 different sources with an average growth rate of 6.7%, underscoring the importance of addressing contemporary challenges through holistic approaches that bridge MC and sustainability objectives. As depicted, with 1868 keywords plus and 973 authors' keywords along with 26.27% of international co-authorships, the field demonstrated an extensive scope of research themes and global collaborations.

Table 1. Dataset Characteristics

Timespan	1995:2025
Sources (Journals, Books, etc)	185
Documents	316
Annual Growth Rate %	6.7
Document Average Age	7.23
Average citations per doc	15.9
References	11021
DOCUMENT CONTENTS	
Keywords Plus (ID)	1868
Author's Keywords (DE)	973
AUTHORS	
Authors	920
Authors of single-authored docs	27
AUTHORS COLLABORATION	
Single-authored docs	30
Co-Authors per Doc	3.42
International co-authorships %	26.27
DOCUMENT TYPES	
article	134
conference paper	182

3.2 Publication and Citation Trend

Figure 3 depicts a discernible trend in the publication and citation count of documents focusing on MC and sustainability over a decade. The exponential rise in Mean Total Citations per Article (MeanTCperArt) after 2016 can be attributed to the introduction of the SDGs which provided momentum for research on emphasizing sustainability practices while

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maintaining customer-centric products. Nonetheless, fluctuations in publications are indicative of the complexity and dynamic nature of this interdisciplinary field requiring continuous adaptation to technological advancements, market trends, and societal demands. With 33 documents, 2024 seems to be the peak publishing year in the dataset. Over the decade, research on MC and sustainability has garnered more than 3500 citations. Notably, documents from 2020 had the highest MeanTCperArt at 23.5, with 24 papers, indicating that earlier studies had a significant impact and laid foundational work in this emerging area. Overall, the data indicates a surge in research output in recent years, affirming the rising relevance of integrating sustainability with personalized production approaches.

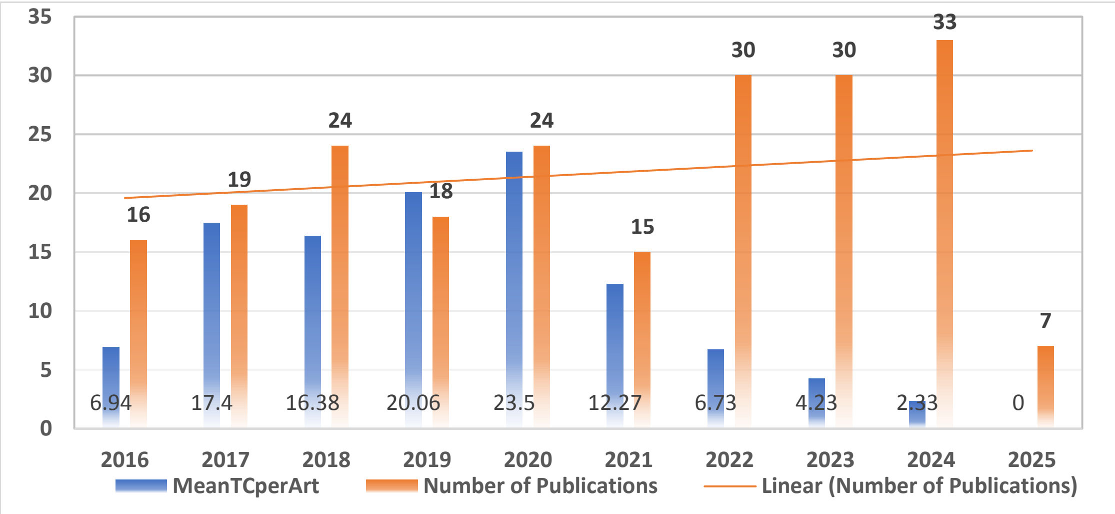

Figure 3. Trends in publishing activity related to Integration of MC with Sustainability

Source: Author's own

3.3 Leading authors

Table 2 presents the leading authors in the domain of convergence of MC with Sustainability. Hankammer S tops the list with 9 publications followed by Romero D, Canetta L and Medini K, contributing 7, 6 and 6 documents in the research area respectively. In terms of authors' influence, Hankammer S emerged as the most influential author in the field with 164 citations and the highest h-index, g-index, and m-index, with values of 7, 9, and 0.583, respectively who stareted publishing in the domain from 2014.

Table 2. Leading authors in the field of integration of MC with Sustainability

Author	NP	TC	h_index	g_index	m_index	PY_start
HANKAMMER S	9	164	7	9	0.583	2014
ROMERO D	7	51	5	7	0.333	2011
CANETTA L	6	66	5	6	0.278	2008
MEDINI K	6	73	5	6	0.357	2012
HORA M	5	49	3	5	0.3	2016
MARTÍNEZ-OLVERA C	4	69	3	4	0.429	2019
PEDRAZZOLI P	4	32	3	4	0.167	2008
ALTAN H	4	32	2	4	0.143	2012
BELLEMARE J	4	28	2	2	0.222	2017
FORMOSO CT	4	39	2	4	0.182	2015

Number of Publications (NP) total citations (TC)

Source: Biblioshiny

Hankammer S has significantly highlighted the underutilization of sustainability features in product configurations and offered strategies to improve user-interface design for sustainable choices. In a study by Hankammer et al. (2015), the authors analysed over 900 web-based configurations and found only 5% addressed sustainability in customization options. The findings highlighted that the food industry led with 20% by offering organic products, while apparel industry had only 8%, with mostly organic cotton. However, industries like accessories, automobiles, and sports equipment with no proper sustainable features, signifying a critical gap in integrating sustainability into MC interfaces. Furthermore, conducting case studies in electronics such as Google Project era, the author contended that despite commercial challenges, the use of modular smartphones can lead to product longevity and reduced waste.

3.4 Top countries

Table 3 discloses the top fifteen nations that contribute to the field of integration of MC with Sustainability. A total of 263 documents originated from 50 different countries representing a broad range of global perspectives. Evidently, Germany emerged as the leading country with a total of 47 published documents along with the highest citation count (1335). Followed by China, the United Kingdom and Italy publishing 37, 35 and 34 documents with a citation count of 357, 997 and 545 respectively. In terms of productivity, US stands out with the highest Average Article Citations (AAC) having a score of 36.9. Notably, Australia, the United Kingdom and Germany also boast the AAC at a score of 30.4, 28.48 and 28.4. India's productivity with an AAC score of 13.5, highlights its significant impact in the domain despite its fewer publications. Surpassing countries with higher publications like France, mexico, canada and many more, India's research demonstrates remarkable influence and relevance in this domain.

Table 3. Top countries in the field of integration of MC with Sustainability

Country	Documents	Total Citations	Average Article Citations
Germany	47	1335	28.40426
China	37	357	9.648649
United Kingdom	35	997	28.48571
Italy	34	545	16.02941
United States	32	1181	36.90625
France	22	296	13.45455
Sweden	20	795	39.75
Australia	17	518	30.47059
India	17	230	13.52941
Canada	16	207	12.9375
Mexico	12	129	10.75
Brazil	11	63	5.727273
Denmark	11	181	16.45455
Portugal	9	42	4.666667
Switzerland	9	86	9.555556

Source: Author's own

Figure 4 displays the global collaboration of each country where the blue colour denotes the presence of output specific to that nation, while the grey colour indicates no output. The country that produces the most in the area of MC and sustainability is indicated by the darker blue. The collaboration networks of the publishing nations are indicated by the red lines (Akter et al., 2021). Among the countries that actively collaborate with other are the USA,

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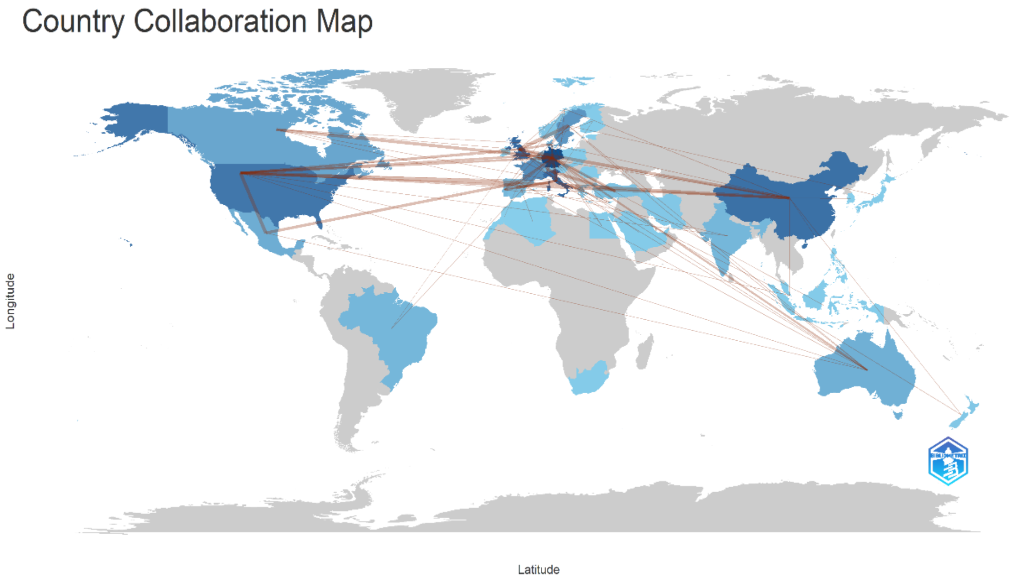
Germany, France, Sweden, UK, China, Switzerland, Mexico, Belgium, Canada and othes as indicated by the brown lines in the collaboration map. With a frequency of four, Germany & Italy, Germany & Switzerland, UK & Sweden and USA and France have the highest collaborations in the area of MC and sustainability.

Figure 4: Collaboration among Countries



Source: Biblioshiny

3.5 Top Most Cited Documents

The most cited documents in the field of integration of MC with Sustainability have been listed in Table 4. The data revealed that Kotha S (1995) is the top-cited document with 445 citations, Notably, the domain holds a substantial lead over the documents by Chen D et al. (2015), Bednar &Wech (2020), Kortmann et al. (2014) and Kohtala C (2015) with 382, 264, 255 and 221 citations respectively.

Kotha S (1995) examined how firms navigate the transition from mass production to MC, and highlighted the significance of integrating both approaches for sustaining a competitive edge in dynamic markets. Chen et al. (2015) investigated the sustainability implications of Direct Digital Manufacturing (DDM) by comparing its energy usage with traditional paradigms, including, mass production. The study highlighted the DDM's potential to enhance sustainable development despite encountering technical and social challenges, such as alterations in lifestyle affecting job markets and waste management practices. Bednar & Welch (2020) explored the evolving landscape of work and production in the context of technological advancements such as artificial intelligence, virtual reality, and integrated manufacturing systems. The findings suggested that a socio-technical systems approach is best suited to align smart technologies with both human and organizational needs. The study conducted by Kortmann et al. (2014) explored how strategic flexibility impacts operational efficiency indirectly through MC capability and innovative ambidexterity which can further lead to sustainable competitive positioning. Kohtala (2015) pointed out the significance of integrating sustainability into the design and implementation of distributed production systems. In the context of MC, the study highlighted the potential of mitigating pre-consumer waste by integrating closed-loop systems into product configurators, particularly in the fashion industry.

Table 4. Top most cited documents in the field of integration of MC with Sustainability

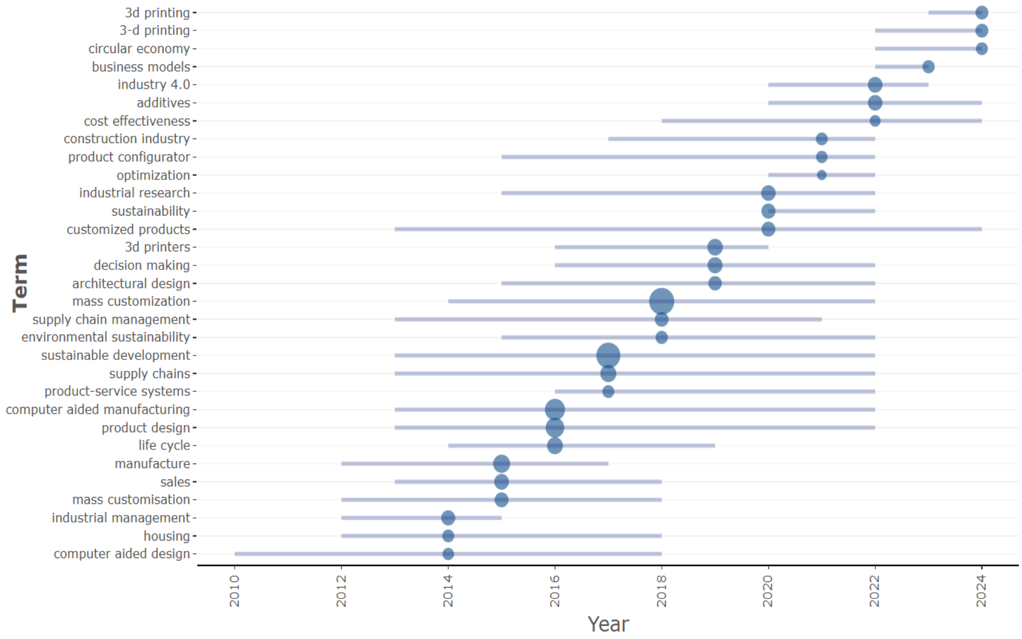
Author(s)	Title	Year	Cited by
Kotha S.	Mass customization: Implementing the emerging paradigm for competitive advantage	1995	445
Chen D.; Heyer S.; Ibbotson S.; Salonitis K.; Steingrímsson J.G.; Thiede S.	Direct digital manufacturing: Definition, evolution, and sustainability implications	2015	382
Bednar P.M.; Welch C.	Socio-Technical Perspectives on Smart Working: Creating Meaningful and Sustainable Systems	2020	264
Kortmann S.; Gelhard C.; Zimmermann C.; Piller F.T.	Linking strategic flexibility and operational efficiency: The mediating role of ambidextrous operational capabilities	2014	255
Kohtala C.	Addressing sustainability in research on distributed production: An integrated literature review	2015	221
Hienerth C.; Lettl C.; Keinz P.	Synergies among producer firms, lead users, and user communities: The case of the LEGO producer-user ecosystem	2014	133
Prause G.; Atari S.	On sustainable production networks for industry 4.0	2017	131
Matt D.T.; Rauch E.; Dallasega P.	Trends towards distributed manufacturing systems and modern forms for their design	2015	118
Ramakrishna S.; Zhang T.-Y.; Lu W.-C.; Qian Q.; Low J.S.C.; Yune J.H.R.; Tan D.Z.L.; Bressan S.; Sanvito S.; Kalidindi S.R.	Materials informatics	2019	111
Ülkü M.A.; Hsuan J.	Towards sustainable consumption and production: Competitive pricing of modular products for green consumers	2017	88
Pham D.T.; Thomas A.J.	Fit manufacturing: A framework for sustainability	2011	77
Ahuja B.; Karg M.; Schmidt M.	Additive manufacturing in production: Challenges and opportunities	2015	73
Gupta S.; Dangayach G.S.; Singh A.K.; Meena M.L.; Rao P.N.	Implementation of sustainable manufacturing practices in Indian manufacturing companies	2018	71
Trappey A.J.C.; Trappey C.V.; Hsiao C.-T.; Ou J.J.R.; Chang C.-T.	System dynamics modelling of product carbon footprint life cycles for collaborative green supply chains	2012	60
Leng J.; Jiang P.	Dynamic scheduling in RFID-driven discrete manufacturing system by using multi-layer network metrics as heuristic information	2019	58

Source: Authors' own

3.6 Trending Topics

Figure 5 illustrates the fascinating evolution in the field of MC and sustainability revealing trending and emerging topics from 2010-2024. The horizontal axis represents the year, while the vertical axis lists various terms. The size of the circles represents the frequency of these terms in research publications.

Figure 5. Emerging Topics in the field of MC and Sustainability



Source: Biblioshiny

The period 2010-2015 was dominated by foundational technologies such as computer-aided designs and manufacturing followed by the emergence of transformative technologies to integrate sustainable practices in manufacturing from 2015-2020. For instance, the use of 3D printing or additives to enable on-demand, customisable production with minimal waste and from 2020 to the present stage emphasizes sustainability and energy efficiency as core in driving strategic decisions, where industries are actively pursuing smart manufacturing integrated with circular practices such as resource recycling to ensure long term environmental and social benefits.

3.7 Leading journals

Table 5 enlists statistics regarding the leading journals in the field of integration of MC with Sustainability based on their publications and citation count. Sustainability (Switzerland) published by MDPI AG secures the top position for contributing 19 of the 263 documents (about 7.22%) with the highest number of citations (386), h-index, g-index and m-index thus representing the most influential source under the domain followed by Procedia Cirp by Elsevier with 17 publications (about 6.46%) and 293 citations. Intriguingly, the top ten leading journals together contribute more than 35% of all the documents in the dataset.

Table 5. Leading journals in the field of integration of MC with Sustainability

Source	Publisher	NP	TC	h_index	g_index	m_index
Sustainability (Switzerland)	MDPI AG	19	386	13	19	1.182
Procedia Cirp	Elsevier	17	293	10	17	0.833
Lecture Notes in Mechanical Engineering	Springer	14	36	4	5	0.8
Ifip Advances in Information and Communication Technology	Springer	12	75	5	8	0.313
Springer Proceedings in Business and Economics	Springer	9	33	3	5	0.3
Advances in Transdisciplinary	IOS Press	7	38	3	6	0.25

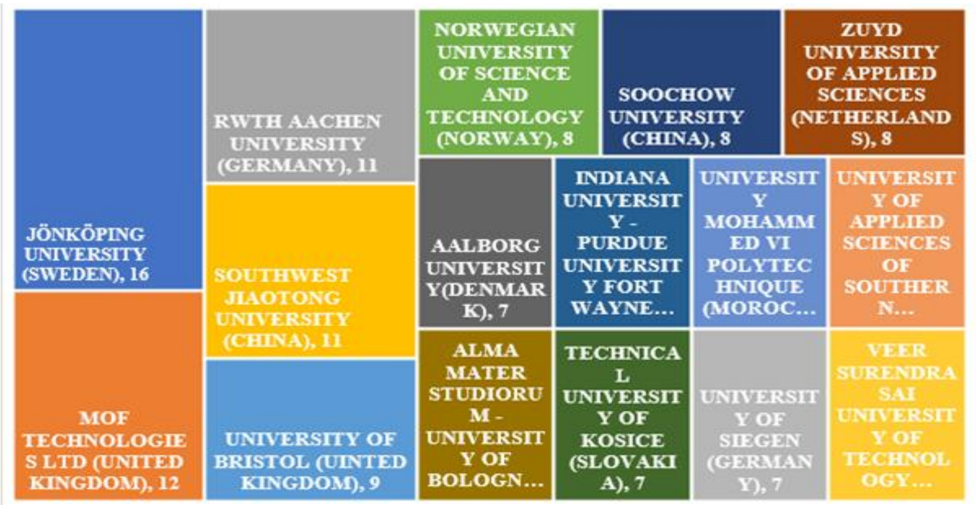
Engineering						
Journal of Intelligent Manufacturing	Springer	5	275	5	5	0.385
Journal of Cleaner Production	Elsevier	4	693	3	4	0.273
Journal of Manufacturing Technology Management	Emerald Publishing	4	146	3	4	0.167
Smart Innovation, Systems and Technologies	Springer	19	386	13	19	1.182

Source: Biblioshiny

3.8 Top Contributing Affiliations

Figure 6 provides a tree map of leading affiliations working in the domain of integration of MC with Sustainability. "Jönköping University" in Sweden emerged as the most prolific institution that has produced 16 documents, followed by "MOF Technologies Ltd" in the United Kingdom with 12 documents.

Figure 6: Tree Map of Top contributing affiliations in the field of MC and Sustainability



Source: Biblioshiny

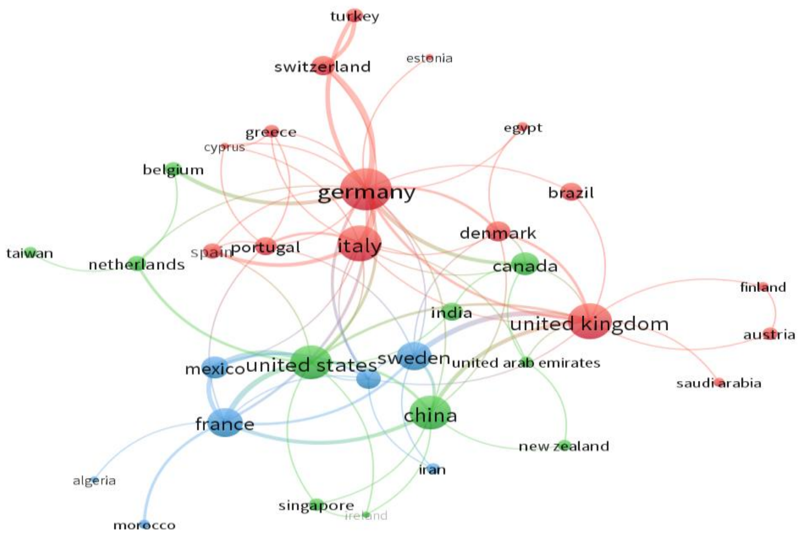
3.9 Analysis of Co-Authorship of Countries

The study employed co-authorship analysis at the country level (Figure 7) to gauge productivity, representing geographic collaboration and spatial distribution. When the minimum of two publication and five citations per country was set, out of 50 countries, 38 met the threshold. The extraction of three clusters has been depicted in Table 6 and Figure 7. It can be observed that authors from diverse geographical regions have collaborated to contribute to the development of knowledge related to MC and sustainability.

Table 6. Clusters of authors collaborating across nations

Clusters	Countries
Cluster 1- Red Cluster	Germany, Italy, the United Kingdom, Denmark, Switzerland, Austria, Brazil, Cyprus, Finland, Portugal, Saudi Arabia, Turkey, Estonia, Spain, Egypt, Greece
Cluster 2- Green Cluster	China, the United States, India, Canada, Belgium, Ireland, Netherlands, New Zealand, Singapore, Taiwan, United Arab Emirates
Cluster 3- Blue Cluster	Australia, Algeria, France, Iran, Mexico, Morocco, Sweden

Figure 7. Analysis of Co-Authorship of Countries



Source: Vosviewer

3.10 Analysis of Co-occurrence of Keywords

This section provides a visual representation of the author's keywords utilized in the extracted data concerning the integration of MC and sustainability. The co-word network map seeks to examine semantic relationships between keywords used in academic literature to discern the major research themes (Muritala et al., 2020). Out of the total number of keywords which was 2430, when a threshold of seven occurrences was set, 60 keywords met.

Table 7: Top fifteen Keywords in the field of integration of MC and Sustainability

Keyword	**Occurrences**	**Total Links**	**Total Link Strength**
Mass Customization	170	59	628
Sustainable Development	115	58	539
Sustainability	76	53	314
Computer Aided Manufacturing	61	53	286
Product Design	48	56	258
Manufacture	34	48	165
Mass Customisation	34	46	113
Industry 4.0	31	40	119
Supply Chains	28	38	144
Life Cycle	26	48	153
Additive Manufacturing	25	41	137
3d Printing	24	33	132
Decision Making	21	39	102
Competition	19	41	98
Sales	19	39	106

Source: Author's own

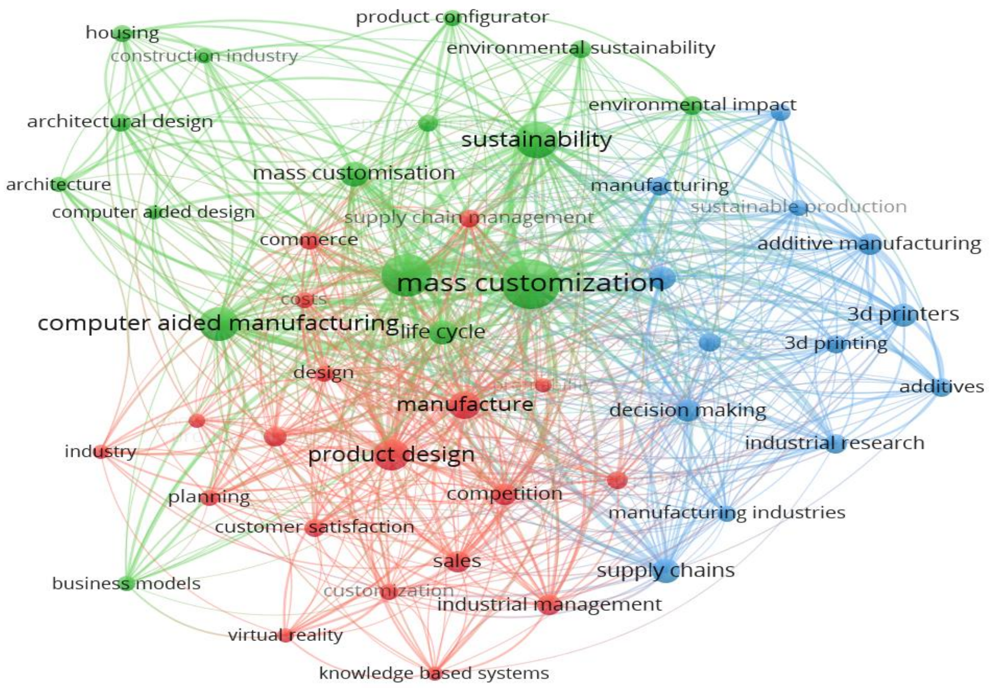
Table 7 reveals the top fifteen most prominent keywords in the domain, it can be observed that Mass Customization is the most significant keyword with an occurrence of 170 times with 628 link strength in total, followed by Sustainable development, Sustainability, Computer Aided Manufacturing and Product Design. Figure 8 depicts the Word cloud of the most frequently used keywords based on author keywords (AK) and keyword plus (KP) analysis. In relation to the theme of the paper, the analysis revealed a strong focus on technology enablers of MC, particularly computer-aided manufacturing and 3d printing. Further, the prominence of supply chain management reflects a critical role of sustainable supply chains in supporting MC which also aligns with the principles of circular economy.

Figure 8. Word cloud- based on AK and KP

Figure 9 represents the visual representation of the analysis of the co-occurrence of keywords concerning the domain of integration of MC and sustainability. As depicted, three distinct colors signify three significant thematic clusters, namely "Sustainable mass customization for Maximizing Competitive Advantage and Profitability" (Red Cluster) and "Revolutionizing Sustainable Manufacturing through Innovative Design and Mass Customization" (Green Cluster) and "Supply Chain Dynamics for Sustainable Customized Products in the Era of Industry 4.0" (Blue Cluster).

The *Red Cluster* is the largest cluster within the network which comprises 19 items. Some of the prominent keywords in this cluster are competition, product design, product development, innovation, customization, customized products, customer satisfaction, profitability, sales, etc. This cluster seeks to unveil how MC practices can be harnessed by businesses to gain a competitive edge in the market and enhance profitability while addressing environmental and social concerns. Firms navigate the transition from mass production to mass customization, and by integrating both approaches they can leverage a sustainable competitive edge in dynamic markets (Kotha, 1995). As highlighted by Kortmann et al. (2014), strategic flexibility impacts operational efficiency indirectly through MC capability and innovative ambidexterity which has an impact on sustainable competitive positioning. The *Green cluster* consists of 16 items. This cluster includes keywords such as mass customisation, mass customization, sustainability, sustainable development, environmental sustainability, environmental impact, computer-aided manufacturing, energy efficiency, architectural design, business models, etc. The cluster focuses on strategies for optimizing manufacturing practices to meet the evolving demands of sustainable development while fostering innovation and efficiency in production. (Pham and Thomas, 2011) highlighted the importance of integrating manufacturing efficiencies with marketing and product innovation strategies to meet the demands of MC and ensure long-term economic sustainability. The interlinkage between sustainability and MC lies in optimizing production methods to reduce waste, energy consumption, and carbon footprint (Tahmasebinia et al., 2020). For instance, integrating Product Service Systems (PSS) with MC, especially in service-oriented business models can lead to extended product use and providing more responsible consumption alternatives.

Figure 9. Co-word analysis



Source: Vosviewer

The Blue cluster includes 13 items. Some of the significant keywords in this cluster are 3d printers, 3d printing, additive manufacturing, industry 4.0, manufacturing, manufacturing industries, supply chains, sustainable manufacturing, sustainable production etc. The central idea of the cluster revolves around the integration of smart technologies in the Industry 4.0 era such as 3D printing and additives in manufacturing. It explores how these advancements drive sustainable manufacturing and supply chain practices. The study conducted by Prause and Atari (2017) explored the intersection of Industry 4.0, organizational development, networking, and sustainability to analyze the dynamics of modern manufacturing models and their adaptation to evolving network environments. Emerging technologies like 3D printing enable customized production without compromising efficiency and ensuring long-term sustainability. Solaimanni et al. (2021) compared additive and subtractive manufacturing for eyewear production to assess economic, environmental and social sustainability using simulation models. The results showed that additive manufacturing (layer by layer) gave higher sustainability in terms of all aspects by lowering inventory and operational costs, higher energy efficiency and reduced labour intensity.

Based on the above thematic analysis of research literature on the convergence of MC and sustainability, Table 8 outlines emerging areas, key enablers and challenges as supported by the literature.

Table 8: Emerging Areas

Emerging Themes	**Enablers**	**Challenge**	**Some Research Evidences**
Leveraging Additive Manufacturing (AM)	Weight reduction, Reduced time-to-market, mass customisation and personalisation, on-demand production, material efficiency	High initial investment, Limited build size, Skill gap, Material limitations	Sonar et al. (2022), Ahuja et al. (2015), Co & Culaba (2019)
Optimizing Supply Chains	Efficient Logistics, Agile and responsive supply chains, strong supplier relationships	Complexity of managing diverse product configurations, inventory management, Minimizing environmental impact of logistics	Nielsen et al. (2013), Solaimani et al., 2021
Circular Economy Implementation	Product Service Systems , Remanufacturing and refurbishment, Closed-loop supply chains	Designing for disassembly and recycling, Creating closed-loop supply chains, Minimizing environmental impact throughout the product lifecycle.	Bertassini et al. (2023), Hänsch et al. (2018)
Human-Centered Design and Co-creation	User experience design, Customer co-creation, Data-driven personalisation	Understanding diverse customers, Involving customers in the design process, Building strong customer relationships.	Hankammer et al. (2015), Bertassini et al. (2023), Boër et al. (2018)
Sustainability	Environmnetal impact assessment, social and ethical responsibility, Resource efficiency	Mitigating environmental impacts (LCA analysis), Ensuring social and ethical responsibility, Addressing impacts on labor and communities.	Briem et al. (2019), Sandrin et al. (2018)

4. CONCLUSION

This paper undertakes the bibliometric analysis on MC and sustainability on data extracted from the Scopus database. The trend in publications exhibited fluctuations across different years, with the highest number of publications recorded in 2024 (33), followed by 2023 and 2022 with 30 publications each. A decline is observed in 2021, where the number of publications reduced to 15, but there is a resurgence in 2023, reaching 30 publications reflecting a dynamic and evolving interest in the topic's significance, possibly driven by advancements in sustainable practices and a growing emphasis on customized, eco-friendly

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solutions. This research domain has a global reach, given that the 316 documents in the sample originate from 50 countries. Germany, China and the United Kingdom hold the top three positions in terms of publications. The study conducted by (Kotha, 1995) titled "Mass customization: Implementing the emerging paradigm for competitive advantage" stands out as the most influential with 445 citations which emphasized the need for firms in dynamic environments to leverage both mass production and mass customization to sustain a competitive edge, followed by the work of Chen et al., 2015 titled "Direct digital manufacturing: Definition, evolution, and sustainability implications" with 382 citations. Hankammer S, Romerso D, Canetta L and Medini K were most prolific authors in this domain. JÖNKÖPING UNIVERSITY in Sweden had the most relevant affiliation with 17 publications. "Sustainability (Switzerland)" has diffused the maximum number of documents (19) in the research area with a count of 386 citations. The co-occurrence analysis of keywords revealed three major clusters related to the study domain as "Supply Chain Dynamics for Sustainable Customized Products in the Era of Industry 4.0", "Sustainable mass customization for Maximizing Competitive Advantage and Profitability" and "Revolutionizing Manufacturing through Innovative Design and Mass Customization".

5. IMPLICATIONS

The bibliometric research has far-reaching practical implications for businesses as SMC is influencing company strategies, consumer behavior, and policymaking at large. Businesses can gain a competitive advantage by incorporating eco-friendly methods into product creation and providing customized solutions for environmentally sensitive customers. This requires adopting additive or layered manufacturing, implementing agile supply chains, co-designing and promoting circular economy practices such as remanufacturing and refurbishment technologies. Smart technologies such as AI and Blockchain can be utilized to improve the efficiency of supply chains and to assess the sustainability impacts. As highlighted by Hankammer, there is a need to focus on improving the user experience with sustainability options to make them more visible and accessible. Policymakers could employ the findings to develop policies that encourage sustainable behaviors in the MC arena, so promoting a broader environmental impact through regulatory measures. The study's social implications include liberalizing sustainable choices by making environmentally friendly products more available to a larger audience and encouraging mindful consumption through personalized choices. This development has the potential to enable individuals to make better-informed decisions, hence creating a collective demand for sustainable and ethically manufactured customized items.

6. LIMITATIONS AND FUTURE RESEARCH AGENDA

It is imperative to recognize certain practical limitations that may influence the scope and depth of the study. Firstly, due to the dynamic nature of research in this field, limiting the analysis to published articles and conference papers may have limited the comprehensiveness of the findings. Also, relying only on the Scopus database might have overlooked important contributions from other databases. The exclusion of non-English language publications could introduce a language bias, potentially neglecting valuable insights from diverse cultural and linguistic contexts. Moreover, the specificity of the search terms might overlook seminal works or recent trends that fall outside these parameters. Additionally, continuous developments and new publications may emerge after the completion of the analysis may potentially influence the completeness of the findings.

Future studies on the integration of MC and sustainability could explore a variety of approaches to increase understanding and fill gaps in the existing literature. According to the

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findings, while technology improvements and business strategies have received a lot of attention in this arena, there has been little research into the social and human components, such as customer behavior, cultural implications, and ethical considerations. Future research could be done to explore how societal values, norms, and behaviors influence the acceptance and effectiveness of SMC techniques. As highlighted by Henghamber due to the unique challenges and opportunities in different sectors like automotive apparel and electronics future research should focus on creating tailored key performance indicators to optimize sustainability. Furthermore, longitudinal studies that follow the progress of MC and sustainability trends over time would provide important insights into their dynamics and long-term consequences. Furthermore, a comparative study across industries, countries, and organizational contexts could provide a broader understanding of the motives, barriers, and best practices for attaining sustainable mass customization.

REFERENCES

1. Ahuja, B., Karg, M., & Schmidt, M. (2015). Additive manufacturing in production: challenges and opportunities. Laser 3D Manufacturing II, 9353, pp. 11–20.
2. Akter, S., Uddin, M. H., & Tajuddin, A. H. (2021). Knowledge mapping of microfinance performance research: a bibliometric analysis. International Journal of Social Economics,Vol. 48, No. 3, pp. 399-418.
3. Attaran, M. (2017). The rise of 3-D printing: The advantages of additive manufacturing over traditional manufacturing. Business Horizons, Vol. 60, No. 5, pp. 677–688.
4. Baranauskas, G., Raišienė, A. G., & Korsakienė, R. (2020). Mapping the scientific research on the mass customization domain: A critical review and bibliometric analysis. Journal of Risk and Financial Management, Vol. 13, No. 9, pp. 220.
5. Bertassini, A. C., Piller, F. T., & Gerolamo, M. C. (2023, June). Opportunities and challenges of mass customization for a circular economy: A literature-based analysis. In Proceedings of the Changeable, Agile, Reconfigurable and Virtual Production Conference and the World Mass Customization & Personalization Conference, pp. 24–32. Cham: Springer International Publishing.
6. Boër, C. R., Redaelli, C., Boër, D., & Gatti, M. T. (2018). Mass customization and personalization: A way to improve sustainability beyond a common paradox. In Customization 4.0: Proceedings of the 9th World Mass Customization & Personalization Conference (MCPC 2017), Aachen, Germany, November 20th–21st, 2017, pp. 237–250. Springer International Publishing.
7. Bogue, R. (2013). 3D printing: The dawn of a new era in manufacturing? Assembly Automation, Vol. 33, No. 4, pp. 307–311.
8. Briem, A. K., Betten, T., Held, M., Wehner, D., & Baumann, M. (2019). Environmental sustainability in the context of mass personalization – Quantification of the carbon footprint with life cycle assessment. International Journal of Industrial Engineering and Management, Vol. 10, No. 2, pp. 171.
9. Broekhuizen, T. L. J., & Alsem, K. J. (2002). Success factors for mass customization: A conceptual model. Journal of Market-Focused Management, Vol. 5, pp. 309–330.
10. Chen, D., Heyer, S., Ibbotson, S., Salonitis, K., Steingrímsson, J. G., & Thiede, S. (2015). Direct digital manufacturing: definition, evolution, and sustainability implications. Journal of Cleaner Production, 107, pp. 615–625.
11. Ciric, D., Lalic, B., Marjanovic, U., Savkovic, M., & Rakic, S. (2021, August). A bibliometric analysis approach to review mass customization scientific production. In

IFIP International Conference on Advances in Production Management Systems, pp. 328–338. Cham: Springer International Publishing.
12. Co, J. R. M., & Culaba, A. B. (2019, November). 3D printing: challenges and opportunities of an emerging disruptive technology. In 2019 IEEE 11th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM), pp. 1–6. IEEE.
13. Davis, S. (1987). Future Perfect. Reading, MA: Addison-Wesley Publishing Company.
14. Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: an overview and guidelines. Journal of Business Research, Vol. 133, pp. 285–296. https://doi.org/10.1016/j.jbusres.2021.04.070.
15. Eastwood, M. A. (1996). Implementing mass customization. Computers in Industry, Vol. 30, No. 3, pp. 171–174.
16. Gilmore, J. H., & Pine, B. J. (1997). The four faces of mass customization. Harvard business review, Vol. 75, No. 1, pp. 91-102.
17. Hankammer, S., & Steiner, F. (2015). Leveraging the sustainability potential of mass customization through product service systems in the consumer electronics industry. Procedia CIRP, 30, pp. 504–509.
18. Hänsch, A., Mohr, J., Steinberg, I., Gomez, S., & Hora, M. (2018). Opportunities and challenges of product-service systems for sustainable mass customization: A case study on televisions. In Customization 4.0: Proceedings of the 9th World Mass Customization & Personalization Conference (MCPC 2017), Aachen, Germany, November 20th–21st, 2017, pp. 265–284. Springer International Publishing.
19. Hora, M., Hankammer, S., Canetta, L., Sel, S. K., Gomez, S., & Gahrens, S. (2016). Designing business models for sustainable mass customization: a framework proposal. International Journal of Industrial Engineering and Management, Vol. 7, No. 4, 143.
20. Jia, H., Zhou, S., & Allaway, A. W. (2018). Understanding the evolution of consumer psychology research: A bibliometric and network analysis. *Journal of Consumer Behaviour*, *17*(5), 491-502.
21. Kohtala, C. (2015). Addressing sustainability in research on distributed production: an integrated literature review. Journal of Cleaner Production, 106, 654-668.
22. Kortmann, S., Gelhard, C., Zimmermann, C., & Piller, F. T. (2014). Linking strategic flexibility and operational efficiency: The mediating role of ambidextrous operational capabilities. Journal of Operations Management, Vol. 32, 7–8, pp. 475–490.
23. Kotha, S. (1995). Mass customization: Implementing the emerging paradigm for competitive advantage. Strategic Management Journal, Vol. 16, S1, pp. 21–42.
24. Kotler, P. (1989). From mass marketing to mass customization. Planning Review, Vol. 17, No. 5, pp. 10–13, 47.
25. Leong, L. Y., Hew, J. J., Wong, L. W., & Lin, B. (2022). The past and beyond of mobile payment research: A development of the mobile payment framework. Internet Research, Vol. 32, No. 6, pp. 1757–1782.
26. Muritala, B. A., Sánchez-Rebull, M. V., & Hernández-Lara, A. B. (2020). A bibliometric analysis of online reviews research in tourism and hospitality. Sustainability, Vol. 12, No. 23, 9977.
27. Nielsen, K., & Brunø, T. D. (2013). Closed-loop supply chains for sustainable mass customization. In Advances in Production Management Systems. Sustainable Production and Service Supply Chains: IFIP WG 5.7 International Conference, APMS

ISSN No: 2349-512X
Peer Reviewed & Refereed Journal (IF: 6.95)
Journal Website www.nrjsmm.in

2013, State College, PA, USA, September 9–12, 2013, pp. 425–432. Springer Berlin Heidelberg.

28. Nobanee, H., Al Hamadi, F. Y., Abdulaziz, F. A., Abukarsh, L. S., Alqahtani, A. F., AlSubaey, S. K., ... & Almansoori, H. A. (2021). A bibliometric analysis of sustainability and risk management. Sustainability, Vol. 13, No. 6, 3277.
29. Pardo-Jaramillo, S., Muñoz-Villamizar, A., Osuna, I., & Roncancio, R. (2020). Mapping research on customer centricity and sustainable organizations. Sustainability, Vol. 12, No. 19, 7908.
30. Pattnaik, D., Kumar, S., & Vashishtha, A. (2020). Research on trade credit – A systematic review and bibliometric analysis. Qualitative Research in Financial Markets, Vol. 12, No. 4, pp. 367–390. https://doi.org/10.1108/QRFM-09-2019-0103.
31. Paul, J., Lim, W. M., O'Cass, A., Hao, A. W., & Bresciani, S. (2021). Scientific procedures and rationales for systematic literature reviews (SPAR-4-SLR). International Journal of Consumer Studies, Vol. 45, No. 4, pp. O1-O16.
32. Pham, D. T., & Thomas, A. J. (2011). Fit manufacturing: A framework for sustainability. Journal of Manufacturing Technology Management, Vol. 23, No. 1, pp. 103–123.
33. Pine, B. J. (1993). Mass customizing products and services. Planning Review, Vol. 21, No. 4, pp. 6–55. https://doi.org/10.1108/eb054420.
34. Pourabdollahian, G., Steiner, F., Rasmussen, O. H., & Hankammer, S. (2014). A contribution toward a research agenda: identifying impact factors of mass customization on environmental sustainability. International Journal of Industrial Engineering and Management, Vol. 5, No. 4, 169.
35. Prause, G., & Atari, S. (2017). On sustainable production networks for Industry 4.0. Entrepreneurship and Sustainability Issues, Vol. 4, No. 4, pp. 421–431.
36. Pulak, M. F. H. (2021). Sustainability Key Performance Indicators for Mass Customization. West Virginia University.
37. Sandrin, E., Trentin, A., & Forza, C. (2018). Mass customization and environmental sustainability: A large-scale empirical study. In Customization 4.0: Proceedings of the 9th World Mass Customization & Personalization Conference (MCPC 2017), Aachen, Germany, November 20th–21st, 2017, pp. 251–264. Springer International Publishing.
38. Sheth, J. N., Sisodia, R. S., & Sharma, A. (2000). The antecedents and consequences of customer-centric marketing. Journal of the Academy of Marketing Science, 28, pp. 55–66.
39. Solaimani, S., Parandian, A., & Nabiollahi, N. (2021). A holistic view on sustainability in additive and subtractive manufacturing: A comparative empirical study of eyewear production systems. Sustainability, Vol. 13, No. 19, 10775.
40. Sonar, H., Ghosh, S., Singh, R. K., Khanzode, V., Akarte, M., & Ghag, N. (2022). Implementing additive manufacturing for sustainability in operations: Analysis of enabling factors. IEEE Transactions on Engineering Management, 71, pp. 3205–3219.
41. Tahmasebinia, F., ME Sepasgozar, S., Shirowzhan, S., Niemela, M., Tripp, A., Nagabhyrava, S., ... & Alonso-Marroquin, F. (2020). Criteria development for sustainable construction manufacturing in Construction Industry 4.0: Theoretical and laboratory investigations. Construction Innovation, Vol. 20, No. 2, pp. 379-400.
42. Van Eck, N. J., & Waltman, L. (2017). Citation-based clustering of publications using CitNetExplorer and VOSviewer. *Scientometrics*, *111*, 1053-1070.
43. Wind, J., & Rangaswamy, A. (2001). Customerization: The next revolution in mass customization. Journal of Interactive Marketing, Vol. 15, No. 1, pp. 13–32.