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FACING CUSTOMIZATION IN THE BUILDING INDUSTRY

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Abstract: *The adoption of modular construction and the increasing integration of digital technologies are transforming the building industry. This literature review is focused on the customization in AEC industry considering the mass customization approach and several innovations such as product configurator that could enhance customization performance. The study employs a comprehensive search strategy using the Scopus database, incorporating multiple search logics to capture a wide range of relevant publications. The search concentrated on three main areas: product configurators in the building construction industry, variety and customization of construction projects and mass customization within on-site construction.*
Our findings reveal an important trend in the adoption of innovations supporting digital-based customization and the growing integration of product configurators and building information modeling (BIM) technologies, with notable applications in 3D printing and digital twin technologies. Despite significant advancements in off-site modular construction, there remains limited exploration of on-site practices to enhance operational performances in the construction of customized buildings. This review shows the potential of these technologies to transform the building industry towards enhanced flexibility and sustainable construction practices. Finally, the study outlines further research opportunities related to better addressing customization in the building industry.

Key Words: ***Product configurators, Customization, Personalization, Individualization, On measure, Engineer to order, Custom made, Variety, AEC, Architect, Construction, Building industry, Family building, Industrial building, Commercial building, Multistorey building, House, Apartment, Mass customization, Mass personalization, Industrial construction, Off-site construction, On-site construction, Traditional construction, Modular construction, Platform, Additive manufacturing, 3D printing, Building information modeling, BIM, Building information systems***

1. INTRODUCTION

The architecture, engineering, and construction (AEC) industry is changing rapidly, thanks to the fast-paced integration of new-age technologies and methodologies. Traditional construction practices, which has always been rigid, expensive, and wasteful, are being made to be flexible, economical, and sustainable. Some of the biggest innovations, which are helping to bring forward a new era of customization for building projects and contribute to increased productivity, are modular construction, product configurators, BIM, and 3D printing.

Factory-made sections are transported to the site for final assembly in a process called modular construction. This not only decreases construction time and cost but also increases quality control and reduces environmental impacts (Neelamkavil 2009). The digitalization process in this system comes with additional perks, ensuring minute customization for specific clients.

Product configurators are expert systems that assist users in creating custom product definitions (Forza and Salvador 2006, Hvam et al. 2008). These systems restrict how different components and properties may be combined, ensuring feasibility and compliance with design standards (Al Fisher et al. 2022, Cao et al. 2021). Also in the building industry, product configurators may enhance mass customization (Campo-Gay et al. 2022), a manufacturing approach that links the advantages of mass production in terms of economies of scale with the benefits of custom-made products (Mohamed and Carbone 2022). And through the user-friendly interfaces, clients are able to personalize their own building projects according to their needs and desires without affecting production standards or cost efficiency.

BIM has transformed the way AEC firms design buildings by providing a 3D model that displays the geometry, location, and relationships between the rectilinear and spatial elements within the building. BIM serves as a shared knowledge resource, forming a reliable basis for decisions made throughout the facility's lifecycle, from conception onward (Abbasnejad et al. 2020, Vernikos et al. 2014). When integrated with product configurators, BIM enhances the accuracy and

speed of the customization process, enabling real-time stakeholder collaboration and reducing the potential for errors and rework (Farr et al. 2014).

Additive manufacturing, or 3D printing, is another technology that is changing the way we think and work in the construction industry. This process produces three-dimensional elements in a layer-by-layer method using various materials, including concrete, metal, and plastic (Egan 2023, Quah et al. 2023). The advantages of this technology include rapid prototyping, reduced material waste, and the ability to produce highly customized and intricate designs that would be difficult or impossible to achieve with traditional construction method. 3D printing in construction provides new possibilities of design, speed of construction and environmentally friendly building solutions (Onutu et al. 2023).

Despite these advances, there remains a significant gap in the utilization of tailor-made technologies in on-site construction practices. While off-site modular construction has seen significant growth, on-site customization, which accounts for a substantial portion of industry, has clearly been under-explored, presenting both a challenge and an opportunity for the industry (Zhou et al. 2021, Viana et al. 2017, Schoenwitz et al. 2017). Closing this gap could provide the level of flexibility and responsiveness that could propel the industry towards sustainable construction.

Digital twin technology in construction has further added a new customization and manageability layer. A digital twin makes the virtual representation of reality, specifically a building, through the use of real-time monitoring and simulation (Rafsanjani and Nabizadeh 2023, Kim et al. 2023). By doing so, the technology allows for precise and efficient customization of building operations, thus providing a potential way to fill the gap between off- and on-site customization (Tuhaise et al. 2023).

This literature review has focused the customization in AEC industry considering the mass customization approach and a number of innovations that could support a more performing customization such as product configurator. The search strategy is a highly inclusive search that uses multiple search logics to capture a wide spectrum of publications that are pertinent. It is structured around three areas: product configurators in building production, variety and customization in construction projects, and on-site construction mass customization. Results from this review show important trends and gaps in the adoption of these technological tools and methodologies, signalling the need of further empirical studies and practice-based framework to support their broader implementation. The methodology used to carry out this literature review is outlined in the following sections, as are the research findings, and the potential implications of these for the future of the building industry. Our intention in highlighting this revolution is to shed light on how advancements in customization tech can change the face of building construction and improve flexibility, efficiency, and sustainability in practice.

2. LITERATURE REVIEW METHOD

A literature review summarizes the research landscape in a particular subject field, supporting the identification of specific research questions. It is a critical analysis of existing research that is significant to the work we are about to carry out (Rowley and Slack 2004). Replicability and reproducibility will be aided by clearly reporting the research method used (Munafò et al. 2017). In the subsequent part of this section, we explain the search strategy and procedure of selecting the articles.

2.1. Search strategy

The literature review is aimed at surveying existing studies on product configurators and mass customization within the building construction sector. Three different search logics were used to create the search strategy, which aimed to allow for as broad a search as possible for an extensive variety of literature:

1) Product configurators in construction:

The objective is to identify literature discussing the application and impact of product configurators within the building construction industry. Search string: (configurat*) AND (AEC OR architect* OR construction OR "building industry" OR "family building" OR "industrial building" OR "commercial building" OR "multistor* building" OR house* OR "apartment building").

2) Variety and customization of construction projects and mass customization:

The objective is to explore literature on the customization of construction projects and the concept of mass customization. Search string: (customi* OR personali* OR individuali* OR "on measure" OR "engineer* to order" OR "custom made" OR variety) AND (AEC OR architect* OR construction OR "building industry" OR "family building" OR "industrial building" OR "commercial building" OR "multistor* building" OR house* OR "apartment building") AND ("mass customi*" OR "mass personali*" OR "industrial construct*" OR "off-site construction" OR "modular*" OR "platform" OR "additive manufacturing" OR "3d print*" OR configurat* OR BIM OR "build* information system*").

3) Variety and customization of on-site construction projects and mass customization:

The objective is to investigate literature specifically addressing on-site construction customization and mass customization techniques. Search string: (customi* OR personali* OR individuali* OR "on measure" OR "engineer* to order" OR "custom made" OR variety) AND (AEC OR architect* OR construction OR "building industry" OR "family building" OR "industrial building" OR "commercial building" OR "multistor* building" OR house* OR "apartment building") AND ("mass customi*" OR "mass personali*" OR "industrial construct*" OR "on-site construction" OR "traditional construction" OR "modular*" OR "platform" OR "additive manufacturing" OR "3d print*" OR configurat* OR BIM OR "build* information system*").

2.2. Article selection process

In the article selection process, high-quality and relevant studies were included by a 3-stage step: publication identification, filtering by quality, and filtering by content.

1) Publication identification:

The search was conducted in the Scopus database, known for its extensive coverage of peer-reviewed literature across various disciplines (Falagas et al. 2008). Keywords were searched in titles, abstracts, and keyword sections to capture all relevant studies. Articles published up to March 2024 were included to ensure the review incorporates the most recent research findings. Only English-language papers were included to maintain consistency in understanding and analysis.

2) Filtering by quality:

Journal articles from all quartiles (Q1 to Q4) were included. Publication of journals from all quartiles can provide a more comprehensive review, capturing a broad spectrum of research quality and perspectives (Falagas et al. 2008). We also included other types of publications not limited to journal articles, but also books, book chapters, conference papers, and conference reviews. We included studies published after 2020 or earlier that had been cited at least once to capture those which were up to date and had impact.

3) Filtering by content:

Given the huge number of publications retrieved we first filtered publications considering the title and subsequently considering the abstract. In both cases we have been conservative, i.e. if we were not sure whether to retain or not a publication, we decided to retain it.

Criteria 1 (Title screening). Exclude titles that do not describe involvement in one of the AEC industry's innovative practices or AEC emerging technologies. For instance, articles having to do with traditional construction methods only, but none dealing with digital transformation or innovation may not be that much relevant to the research query. Retain titles explicitly mentioning technological innovations or methodologies poised to revolutionize the AEC industry, such as the application of product configurator, BIM, and additive manufacturing. Titles should suggest a forward-looking perspective on construction practices, highlighting integration with smart technologies or novel construction methodologies like modular and off-site construction. Retain titles considering customization.

Criteria 2 (Abstract screening). Exclude abstracts that, while discussing technologies such as product configurators or digital fabrication techniques, fail to connect the discussed technologies with tangible outcomes or implications for the AEC industry. Papers should not only mention these technologies but also demonstrate their practical integration into current or future construction practices.

2.3. Publication selection

Using these search criteria, the initial search across three logics yielded 129,441 articles (see Table 1). These were further filtered based on publication quality, narrowing the selection to 102,609 articles. Following the application of exclusion criteria at different stages further narrowed it down to 171. After removing duplicate titles across the logics, the final selection comprised 140 unique articles that were fully read and analyzed.

3. RESULTS

This literature review has focused the customization in AEC industry considering the mass customization approach and several innovations that could support a more performing customization such as product configurator.

The analysis covers the frequency of research topics, the temporal distribution, the geographical distribution of research, the source journals and conferences, the journal quality and citation, the research methodologies, and the barriers and challenges.

3.1. Frequency analysis of research topics

The frequency analysis of the retained publications (see Figure 1) reveals that BIM, mass customization, product configurators, and 3D printing are the most frequently researched topics.

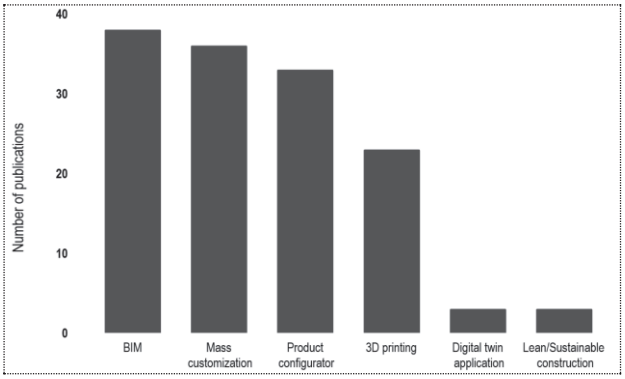

Figure 1. Distribution of research by topics

The analysis reveals distinct trends in the building industry:

BIM related topics (27.94%): The high prevalence of BIM related publications underscores its critical role in modern construction practices. BIM facilitates fully integrated data sharing and collaboration among project stakeholders, enhancing the precision and efficiency of building projects.

Mass customization based on modularization and product platform (26.47%): Reflecting a significant industry shift, mass customization allows for tailored solutions that meet specific client requirements while maintaining production efficiency. This approach merges the benefits of mass production with the need for individual customization, driven by evolving clients demands.

Product configurators (24.26%): These tools are pivotal in the customization process, enabling efficient production by allowing clients participation in defining product specifications that conform to design standards. Product configurators streamline the customization

process, ensuring compatibility and feasibility in building projects.

3D printing (16.91%): As a transformative technology, 3D printing allows the rapid prototyping and construction of complex structures with enhanced material efficiency, and design flexibility. Its application in on-site construction presents opportunities for addressing specific site conditions and clients needs more directly.

In summary, the frequency analysis indicates a strong focus on BIM, mass customization, product configurators, and 3D printing, highlighting their respective impacts and potential for transforming construction practices.

Table 1. *Overview of article search and selection process*

Step	Activities performed and criteria used	Search logic	Articles and others	Conference and books	Total
Initial search	- Keywords were searched in titles and abstracts in Scopus database - Included conference papers/reviews, books, and book chapters - Excluded non-English papers	1	44,417	41,217	129,441
		2	10,020	11,765	
		3	10,154	11,868	
Publication quality selection	- Retaining articles from all quartiles (Q1 to Q4) in the Scimago database - As regards books, book chapters, conference papers, conference reviews, if published after 2020 then include them, otherwise include only if cited at least once	1	37,684	29,568	102,609
		2	8,582	8,849	
		3	8,700	9,226	
Title screening	Criteria 1: - Exclude if does not consider AEC industry's innovative practices or AEC emerging technologies - Retain if mentions innovations important for the AEC industry - Keep if suggests a forward-looking perspective on construction practices - Retain if considers customization	1	67	56	547
		2	142	179	
		3	55	48	
Abstract screening	Criteria 2: - Exclude if only discussing product configurators or digital fabrication techniques without tangible outcomes or implications for the AEC industry - Retain if demonstrating practical integration of these technologies into current or future construction practices	1	34	10	171
		2	74	22	
		3	15	16	
Duplicate removal and full text reading	- Identify and eliminate duplicate papers from the selected list after combining the search logics - Perform comprehensive reading, extract insights and evaluate results and conclusions related to customization in AEC industry - Document key findings and significant points from each paper for further analysis and the writing of the paper	-	103	37	140

3.2. Temporal distribution

The temporal distribution analysis (see Figure 2) reveals several key trends in the research landscape over the years. Notably, publications on BIM saw steady and significant growth, implying increasing interest due to its potential to transform construction management and project delivery.

Similarly, there has been a significant rise in publications on 3D printing in recent years, illustrating that this is a developing technology driven by its application in additive manufacturing for complex and customizable construction. Mass customization and product configurators have shown fluctuating but sustained interest, reflecting the industry's ongoing needs for efficiency and better customization.

Digital twin applications, a relatively new field, indicate a shift towards advanced digital replicas of physical assets within the industry.

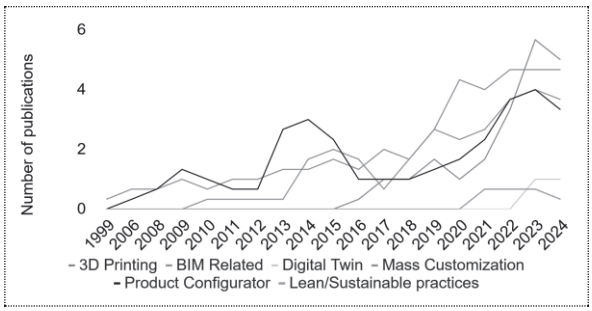

Figure 2. Temporal distribution of construction technology topics

3.3. Variety and customization: on-site and off-site

The increasing demand for tailored solutions and innovative approaches in the building industry is evident. This demand is reflected in the growing number of academic publications related to various innovative technologies, as shown in Figure 2. The figure illustrates a significant upward trend in research on BIM, 3D printing, digital twin technologies, mass customization, product configurators, and lean/sustainable practices over the past two decades. This increase in research activity underscores the industry's focus on adopting and integrating these technologies to meet the evolving needs of the market. These publications show a high variety and degree of customization in the individual activities carried out, indicating a trend in the industry towards more customized and innovative solutions. The trend towards customization is driven by the need for more targeted, economical, and customer-specific solutions.

While off-site modular construction has seen significant growth, on-site customization, which accounts for a substantial portion of industry, has clearly been under-explored. On-site customization has the potential to address specific site conditions and client needs more directly, offering a level of flexibility that off-site method might lack. The flexibility is essential for projects where site circumstances are unpredictable or where clients demand last minute changes that cannot be accommodated in a factory setting (Zhou et al. 2021). Emerging technology such as 3D printing exemplify this potential by, enabling the rapid construction of complex structures with materials efficiency and design freedom (Richardson 2017).

As an example of building modularization, ConXtech developed a highly modular structural steel system that emphasized speed, safety, and flexibility (Viana et al. 2017). The technology enables fast and effective assembly without the need for on-site welding by utilising standardised components and BIM for design integration. By employing accurate jigs for foundation alignment and visual aids for bolting, errors and rework are greatly reduced, making the system more practical for on-site implementation. This case study combines modularity with advanced digital tools to demonstrate effective on-site customization techniques (Viana et al. 2017).

An example of IoT-enabled on-site customization is presented by Zhou et al. (2021) in a comprehensive case study focusing on the implementation of IoT-enabled technologies for on-site customization in building projects. The study demonstrated how incorporating IoT into current construction methods could improve flexibility and responsiveness to specific site conditions and client needs. The case study described the use of sensors and real-time data analytics to track and modify construction activities on the site, ensuring that any changes to the original schedule could be promptly addressed. This approach allowed for real-time customization and adjustments, significantly improving the efficiency and effectiveness of on-site construction processes.

However, this does not mean that off-site customization has been fully researched; it simply indicates that, up to now, off-site customization has received more attention from researchers.

In summary, the variety and type of innovations indicate an evolving terrain focused on digital-based customization practices to address current challenges and opportunities, highlighting the need for further research into on-site customization to fully realize its potential. This suggests a crucial area for further research to fully leverage on-site customization, enhancing the practical applicability and responsiveness of construction practices to diverse client demands. The need for further research into on-site customization is evident to fully realize its potential and complement the advancement made in off-site construction methods.

3.4. Geographical distribution of research

1) Publications by country of author

The geographical analysis of research publications by the country of the author (see Figure 3) highlights the global diversity and reach of academic contributions.

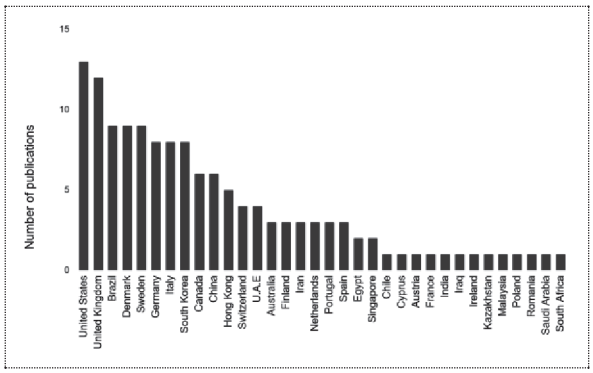

Figure 3. Geographical distribution of publication by country of author

The United States and the United Kingdom lead with 13 and 12 publications, respectively, implying a strong research infrastructure and focus on academic activities in the AEC domain. Other significant contributors include Brazil, Denmark, Sweden, South Korea, and Germany, showcasing the international collaboration and relevance of these technologies. The

representation from countries like Canada and China further underscores the universal applicability of these findings.

2) Publications by country of investigation

Distribution of research publications by country of investigation (see Figure 4). With 68 publications worldwide, this highlights very high levels of international collaboration and research that extends across many countries.

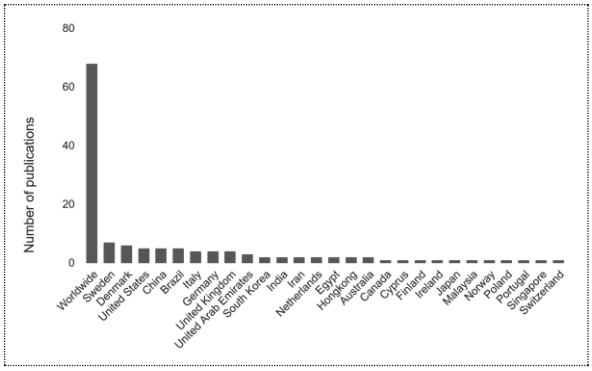

Figure 4. Geographical distribution of publication by country of investigation

Significant research activity was also undertaken in Sweden (7 publications), Denmark (6 publications), Brazil (5 publications), China (5 publications) and the USA (5 publications). This diversity reflects the international attention given to these issues and the research conducted on them, demonstrating the global significance of these areas of inquiry.

3.5. Source journals and conferences

An analysis of source journals reveals the following:

1) Journals and conferences with more than 2 publications (8)

"Automation in construction" stands out with a substantial contribution of 22 publications, highlighting its significant role in disseminating research on digital technologies and automation in the construction industry. "Buildings" also has a notable presence with 11 publications, emphasizing its focus on building technologies and management. Other prominent journals and conferences include "Construction management and economics" (5), "Construction innovation" (4), "Journal of building engineering" (4), "Open construction and building technology" (3), "ZEMCH international conference" (4) and "IOP conference series: earth and environmental science" (3). This concentration in specific journals and conferences indicates the key platforms where research on these innovative topics is being published.

2) Journals and conferences with 2 publications (10)

Several journals have made moderate contributions, each with 2 publications. These include "Applied sciences (Switzerland)", "Energies", "Engineering, construction and architectural management", "Frontiers of architectural research", "International journal of construction management", "Journal of architectural engineering", "Journal of computing in civil engineering", "Open house international", "Acta polytechnica CTU proceedings", and "Lecture notes in mechanical engineering". These journals reflect a diverse range of topics within the AEC industry, from architectural research to civil engineering and energy management.

3) Journals and conferences with 1 publication (60)

There are numerous journals and conferences that have contributed a single publication each, demonstrating a wide range of interests and research efforts across the industry. These include: "3D printing and additive manufacturing", "Advanced engineering informatics", "Architectural engineering and design management", "Architecture and engineering", "Assembly automation", "Building and environment", "Building research and information", "Bulletin of the polish academy of sciences: technical sciences", "Canadian journal of civil engineering", "Computer communications", "Computers in industry", "Designs", "Energy and built environment", "Frontiers in built environment", "Housing studies", "International journal of architectonic, spatial, and environmental design", "International journal of construction supply chain management", "International journal of low-carbon technologies", "International journal of modern manufacturing technologies", "International journal of precision engineering and manufacturing", "International journal of production economics", "International journal of sustainable building technology and urban development", "Journal of building pathology and rehabilitation", "Journal of engineering research", "Journal of facade design and engineering", "Journal of information technology in construction", "Journal of intelligent information systems", "Mathematics", "Neural computing and applications", "Organization, technology and management in construction", "Plan journal", "Proceedings of institution of civil engineers: management, procurement and law", "Structural engineer", "Technology architecture and design", "Theory and practice of logic programming", "Wood material science and engineering", "10th international conference on design and decision support systems, DDSS 2010", "2009 26th international symposium on automation and robotics in construction, ISARC 2009", "2021 3rd international sustainability and resilience conference: climate change", "ASME 2019 14th international manufacturing science and engineering conference, MSEC 2019", "CAADRIA 2006 - the association for computer-aided architectural design research in Asia: rhythm and harmony in digital space, "CAADRIA 2016, 21st international conference on computer-aided architectural design research in Asia - living systems and micro-utopias: towards continuous designing", "CEUR workshop proceedings", "Computing in civil and building engineering - proceedings of the 2014 international conference on computing in civil and building

engineering", "Handbook of research in mass customization and personalization", "ICCREM 2016: BIM application and offsite construction - proceedings of the 2016 international conference on construction and real estate management", "IEEE international conference on industrial engineering and engineering management", "IFIP advances in information and communication technology", "ISARC 2013 - 30th international symposium on automation and robotics in construction and mining, held in conjunction with the 23rd world mining congress", "Lecture notes in civil engineering", "Lecture notes in networks and systems", "Materials today: proceedings", "Procedia engineering", "Proceedings of 2022 international additive manufacturing conference, IAM 2022", "Proceedings of the 37th international symposium on automation and robotics in construction, ISARC 2020: from demonstration to practical use - to new stage of construction robot", "Proceedings of the European conference on computing in construction", "Proceedings of the international conference on education and research in computer aided architectural design in Europe", "RILEM bookseries", "Understanding and managing the construction process: theory and practice - 14th annual conference of the international group for lean construction, IGLC-14".

3.6. Journal quality and citation analysis

The journal quality analysis gauges the impact and reputation of the journals in which the selected studies are published (see Figure 5). Most of the research publications are in Q1 journals, indicating high-quality and widely recognized research.

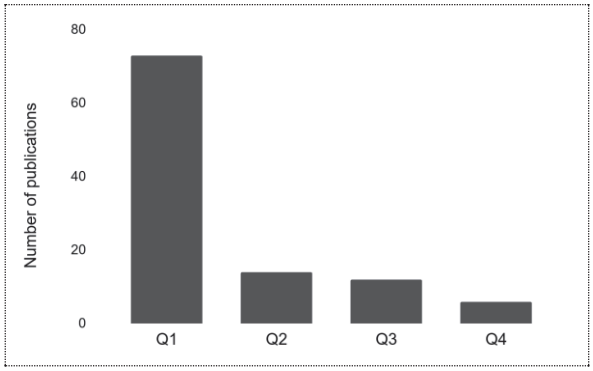

Figure 5. Journal quality analysis

Q2 journals also have a substantial presence, while fewer publications are found in Q3 and Q4 journals. The citation analysis further reveals the influence of these studies, with many publications receiving multiple citations, reflecting their impact on the scientific community. However, recent publications have fewer citations due to the limited time since their release.

3.7. Analysis of research methodologies

The analysis of research methodologies (see Figure 6) shows a strong preference for case studies, which dominate the field with 94 publications. Theoretical research and experimental studies are also prevalent highlighting the importance of theory application and controlled investigations. Literature reviews, surveys, design science research, and empirical studies add to the diversity of methods employed, providing a comprehensive examination of the research questions. This variety strengthens the generalizability and practicality of the results.

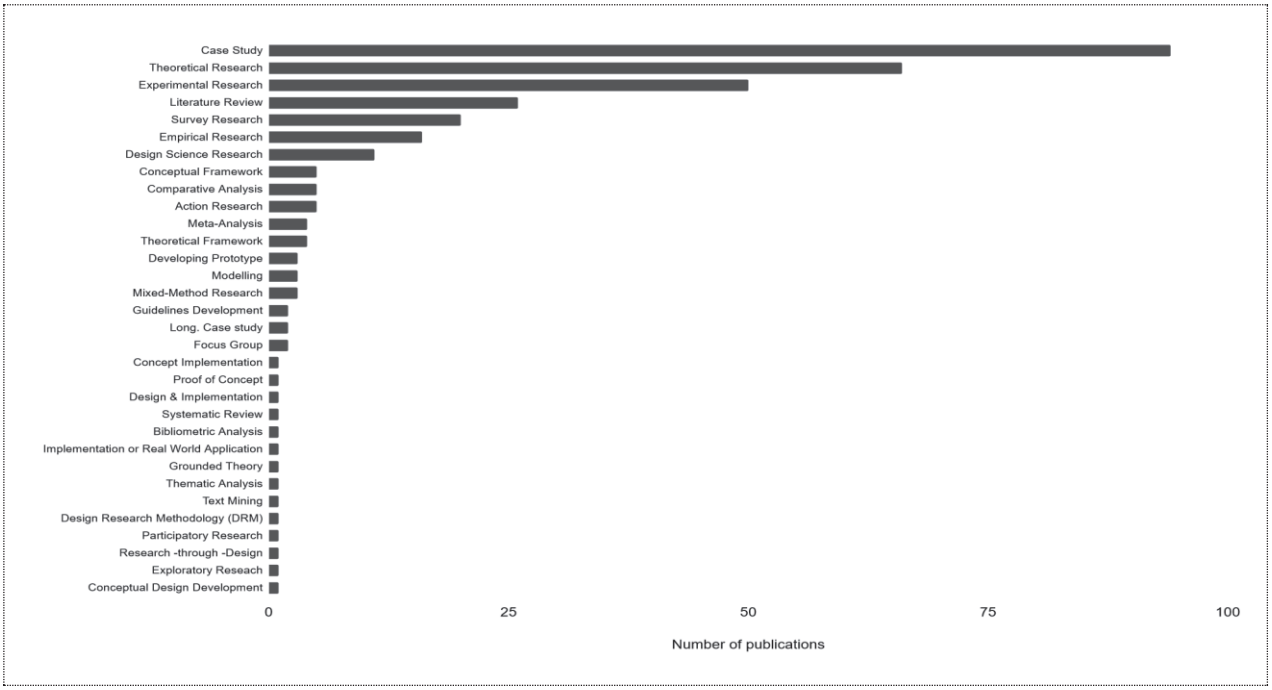

Figure 6. Analysis of research methodology

3.8. Analysis of barriers and challenges

The frequency analysis of risk and challenge categories across the retained papers (see Figure 7) indicates that technical challenges are the most frequent, followed by organizational and financial issues. These challenges highlight the complexities involved in integrating new technologies into the construction industry and underscore the need for continued research and development to address these barriers.

4. DISCUSSION AND CONCLUSION

The findings from our literature review provide a comprehensive understanding of the state of the art and prospects of customization in AEC industry, considering the mass customization approach and a number of innovations such as product configurators that could enhance customization performance. One of the most significant insights is the pivotal role of digital technologies, particularly product configurator,

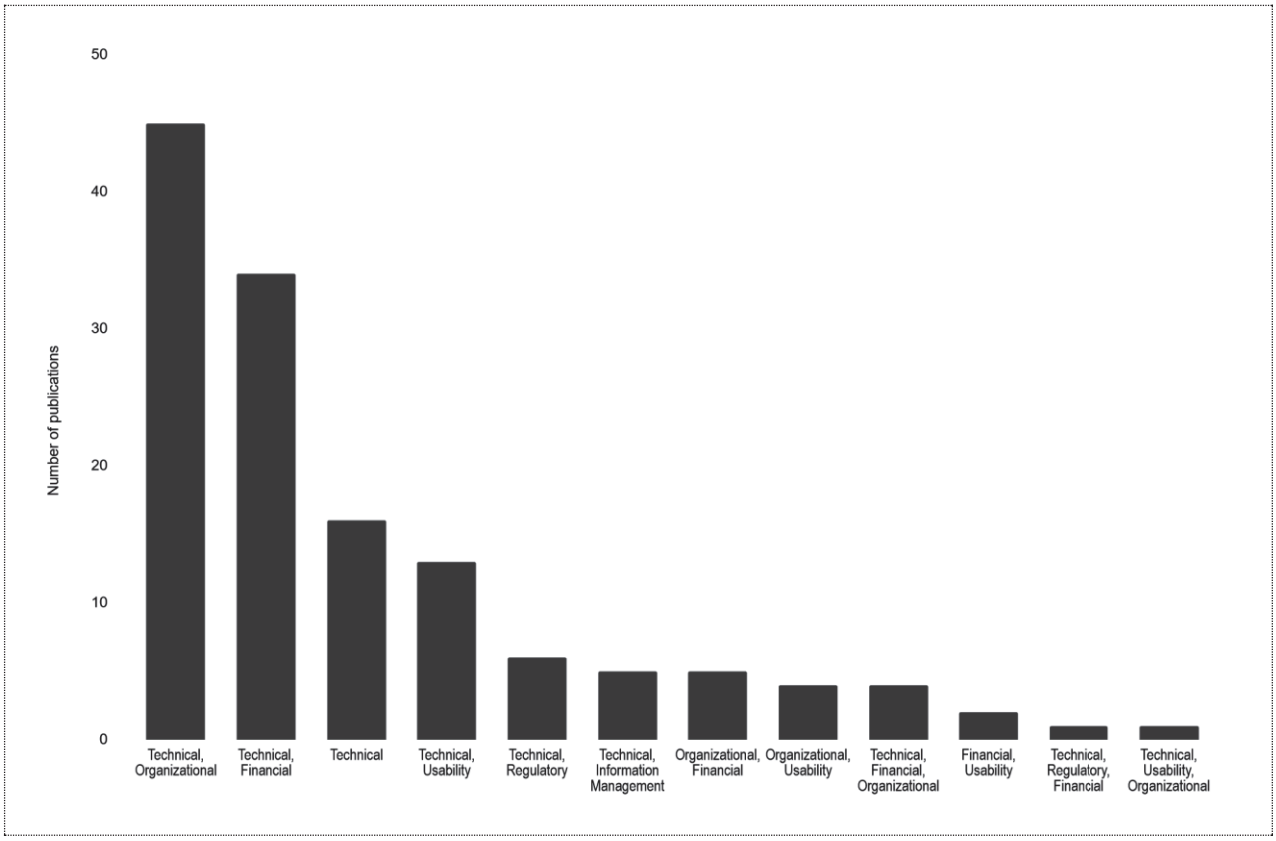

Figure 7. Frequency analysis of risk and challenges

BIM and 3D printing, in advancing customization and efficiency in construction practices. By providing a rich 3D model with geometry, location, and spatial relationships, BIM facilitates high precision level and effective collaboration among stakeholders and thus reduces errors and rework (Abbasnejad et al. 2020, Farr et al. 2014). The prominence of 3D printing further underscores its revolutionizing potential, allowing for rapid construction of complex structures, reducing material waste, and enabling greater design freedom (Egan 2023, Quah et al. 2023).

Despite the obvious advancements in off-site modular construction, there remains a significant gap in the adoption of similar technologies for on-site practices (Zhou et al. 2021). The integration of product configurators and digital twin technologies has shown promise in bridging this gap by enabling real-time customization and efficient project management. Digital twin technology provides virtual representation of physical buildings, enabling customization and management through real-time monitoring and simulation (Rafsanjani and Nabizadeh 2023).

The geographical analysis of the study implies a strong global interest, with substantial contributions from the United States, United Kingdom, and several European countries. This indicates the global application of these technologies and its relevance in addressing the demands for flexibility, efficiency, and sustainability in the building industry. The significant number of high-quality publications in top-tier journals underscores the significance of this research domain within the academic community.

In conclusion, the increasing integration of digital technologies such as BIM, 3D printing, and digital twins is transforming the building industry by enhancing customization and efficiency. Product configurator as one of the enablers of mass customization, blends the gains of mass production with the ability to meet specific client needs. However, there is a significant gap in the application of these technologies for on-site construction,

highlighting an opportunity and a challenge at the same time.

The results suggest that practitioners in the building industry should focus on integrating these digital technologies into their workflows to achieve greater customization and efficiency. For example, BIM can be used to improve project coordination and reduce errors, while 3D printing can facilitate the rapid construction of complex designs with minimal waste. Product configurators allow the efficient customization of building elements without compromising standard and meeting client-specific requirements. Digital twin solutions help in monitoring the system real-time and simulation that can improve the efficiency of project management and operations. Practitioners can use these technologies for an improved flexibility, accuracy, and overall sustainability of building projects.

Future research should be directed to developing frameworks and empirical studies to support the broader implementation of these technologies in building construction, with special attention to on-site practices, ultimately aiming to move the industry towards a more innovative and sustainable future.

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