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# Driving Sustainable Cultural Heritage Tourism in China through Heritage Building Information Modeling

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**Abstract:** In recent years, applying building information modeling (BIM) digital technologies to cultural heritage management, monitoring, restoration, with the objective of advancing the sustainable development of both cultural heritage protection and tourism in China, has become a prominent research focus. However, there are a few studies that comprehensively investigate the relationship between BIM, Chinese cultural heritage, and sustainable tourism development. In order to explore the application of BIM in the protection and inheritance of Chinese cultural heritage, as well as its potential in promoting the sustainable development of cultural heritage tourism, this paper adopts the quantitative research method of bibliometrics to explore the research hotspots, development background, and evolution trends of BIM-driven sustainable development in Chinese cultural heritage tourism. By using data obtained from the China Knowledge Network database, multi-level bibliometrics analysis has been conducted through visualized knowledge graphs. The results suggest that the popular research keywords for driving sustainable cultural heritage tourism in China through BIM since year 2000 (23 years) include heritage tourism, heritage protection, building heritage, digital technology, and tourism development. Three research hotspots have been identified, which are cultural heritage protection, cultural heritage tourism development, and cultural heritage tourism management. In terms of tourism development and management, building virtual interactive scenes of cultural heritage facilitated by BIM to enhance tourism experience of tourists, using BIM to assist in efficient management, intelligent decision-making, and personalized services of cultural heritage tourism, assist in better promoting the sustainable development of cultural heritage tourism. In terms of coordinating and managing stakeholders in cultural heritage tourism, BIM technology provides technical support to the government, industry managers, and community residents in information communication, and industry management by constructing a digital model of cultural heritage to better balance the rights and interests of stakeholders.

**Keywords:** cultural; heritage building information modeling (HBIM); tourism; China; sustainable development



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## 1. Introduction

Cultural heritage represents the spiritual wealth and cultural treasures left by humanity over the long course of history, encompassing commemorative movable and immovable artifacts as well as that reflects cultural diversity [1]. The types of cultural heritage have evolved with changes in human perspectives on cultural heritage, extending from early artifacts and ruins to historic towns, cultural landscapes, linear heritage, and living heritage [2]. Architectural heritage as an important type of cultural heritage and regional marker has been served as a witness to historical culture of the city and intricately intertwined with the local natural surroundings and customs [3].

The safeguarding of cultural heritage has been accorded a pivotal position within the discourse and considerations of the heritage community. The preservation of building

heritage, however, confronts daunting challenges, primarily attributed to factors including human-inflicted damage [4] and natural disaster erosion [5]. In 1972, the United Nations Educational, Scientific and Cultural Organization issued the Convention Concerning the Protection of the World Cultural and Natural Heritage, which assists to raise awareness of heritage conservation. Since then, as a new form of tourism, heritage tourism has been gradually emerged and made significant progress worldwide [6]. Currently, over 40% of travelers worldwide consider heritage as a core element of tourism [7], from which heritage is receiving increasing attention as a new tourist attraction. Practically, the cultural heritage community viewed cultural heritage tourism as a threat, believing that tourism development would bring excessive foot traffic and development disputes [8], which could potentially damage the historical sites and buildings. Meanwhile, excessive commercialization could have negative impact on the cultural essence of heritage buildings [9]. However, by appropriate planning and management, cultural heritage tourism significantly contributes to the safeguarding and preservation of cultural heritage [10]. Moderate tourism development assist to increase social attention to cultural heritage and promote the dissemination and exchange of cultural values [11]. Through tourism activities, more people will have first-hand opportunities to experience the unique charm of cultural heritage, thereby enhancing awareness of protection of cultural heritage. At the same time, tourism development ensures the activation of the economic potential of cultural heritage [12,13], from which tourism revenue provides financial support for the restoration and maintenance of cultural heritage, ensuring that the historical sites and cultures can be preserved and passed down in the long term [14]. However, architectural and structural modifications, development disputes, and human-caused damage brought about by the tourism development of cultural heritage could contradict the original intention of the concept of protection. As such, achieving a harmonious equilibrium amidst the tensions of development and protection is imperative.

Since adhering to the Convention on the Safeguarding of the World's Cultural and Natural Heritage in 1985, China has witnessed a steady augmentation in the quantity of inscribed world cultural heritage sites and become the number one in the world [15]. From the beginning of the 21st century, the focus of protection of cultural heritage has shifted from implementing "rescuing projects" and "key protections" to promoting "productive protection" and "activated utilization" [16]. In 2022, the State Council of China released the "14th Five-Year Plan" for the development of the tourism industry, proposing a concept of "building a number of rich world-class tourist attractions of cultural heritage" and emphasizing "efforts to achieve a higher quality, efficient, equitable, sustainable, and safer development of the tourism industry" [17]. However, how to achieve this goal and balance cultural heritage protection and tourism development has become a focus for government policy makers, cultural heritage managers, and tourism managers. Actually, the application of digital technology is one of the important means in the protection of cultural heritage [18]. Based on digital technology, the digitization of cultural heritage transforms a physical cultural heritage into a virtual entity, which not only effectively solves the problems of precise measurement and data storage but also promotes the online dissemination of cultural heritage [19]. This provides solutions for balancing "tourism development" and "protection" of cultural heritage, contributing to the modernization and sustainable development of cultural heritage tourism to a certain extent. Among these digital technologies, Building Information Modeling (BIM) technology has demonstrated a significant value in the field of cultural heritage, especially in the protection of architectural heritage, becoming the core and link of cultural heritage digitization [20]. Meanwhile, BIM is a process that has been widely spread in the fields of architecture, engineering, and construction. The process controls the building from the planning stage to the management, maintenance, and operation stage [21]. In addition, BIM is a methodology that emphasizes the consolidation and dissemination of project-related data among a diverse array of experts. By implementing BIM platforms, professionals are empowered to enhance their coordination efforts, foster collaboration, and facilitate seamless integration throughout

the coordination of various disciplines and tasks inherent in a comprehensive construction project [22]. Thus, BIM is not only technology but also a process and a methodology.

BIM refers to something that integrates, manages, analyzes, and shares building information through digitalization during the full life cycle of building design, construction, and operation [23]. The concept of HBIM (Historic Building Information Modeling) was initially introduced by Murphy in 2009 [24], utilizing HBIM technology to analyze heritage building information via techniques, including laser scanning and photogrammetric methodologies, from which complex building components can be measured and calculated to generate digital 3D models. HBIM sometimes serves as a framework that extends beyond the modeling of solely historical buildings, encompassing the information modeling of various heritage structures [25]. BIM and Geographic Information System (GIS) technologies form a technology cluster for large-scale cultural heritage. When integrated with Virtual Reality (VR), Augmented Reality (AR), and game engines, HBIM has been efficiently facilitated in the exhibition and dissemination of cultural heritage through various means [26]. HBIM has also spawned other information models, such as the Landscape Information Model (LIM), which is an industry application of BIM technology to landscape objects and practical needs in landscape architecture [27,28]. Additionally, the City Information Model (CIM) is a three-dimensional urban spatial model based on urban information data and an organic combination of urban information. It is mainly used for urban planning and management, helping urban managers to better understand and plan urban space [29]. Further, integrated with LIM, CIM, GIS, and VR/AR, BIM has always been the fundamental core technology and system in the process of digitizing cultural heritage. Thus, applying BIM to cultural heritage management, monitoring, restoration, with the objective of advancing the sustainable development of both cultural heritage protection and tourism, has become a prominent research focus in recent years [30].

Nonetheless, the systematic exploration of the intersectional contributions emanating from the field of BIM, Chinese cultural heritage and sustainable tourism remain a sparsely traversed terrain within academic research. Therefore, this study endeavors to bridge this gap by delving into the unexplored territory of how digital technologies, particularly BIM, enhance the safeguarding of cultural heritage while concurrently promoting the harmonious growth of sustainable tourism within these cherished sites. The present study aims to offer a pioneering perspective that addresses the pressing challenges of balancing development and conservation in the context of cultural heritage tourism and to promote the high-quality and sustainable development of Chinese cultural heritage tourism. Furthermore, it contributes to the expanding knowledge by shedding light on the current research landscape and emerging hotspots within the domain of BIM-facilitated cultural heritage preservation, thereby advancing the discourse on sustainable cultural heritage tourism in China, for which the subsequent inquiries need to be comprehensively addressed:

1. What is the current research status in China regarding BIM, Chinese cultural heritage, and sustainable tourism development?
2. What are the main research themes on BIM, Chinese cultural heritage, and sustainable tourism development?
3. What are the future research trends in the relationship between BIM, Chinese cultural heritage, and sustainable tourism development?

As such, this paper aims to explore the potential of BIM in driving sustainable cultural heritage tourism in China. Thus, the subsequent sections of this paper are structured as below: Section 2 delineates the research methodology undertaken, comprehensively elucidating the methodologies and techniques implemented for data acquisition and analysis. Section 3 primarily focuses on the application of mapping and visualization to present the findings in a comprehensive and insightful manner. In Section 4, we delve into the current state of the art, identifying research hotspots and emerging trends that have been delved into, which may shape the future of the field of research. Section 5 summarizes the

main contributions of this study, highlights implications for both theoretical and practical advancements and offers suggestions for the further research.

## 2. Materials and Methods

This paper focuses on BIM, Chinese cultural heritage, and sustainable tourism development, which are characterized by interdisciplinary integration, of which the current research direction and development trend are not yet clear. Hence, this paper adopts a quantitative research method to deeply explore the research hotspots, development context, and evolution trends in the field of BIM-driven sustainable development of Chinese cultural heritage tourism.

This study adopts a bibliometric approach, a quantitative methodology that centers on diverse external attributes of scientific and technological publications, employing mathematical and statistical techniques to characterize and appraise the prevailing state of affairs in science and technology, and predicts development trends [31]. This research method assists in conducting an in-depth analysis of the current research status in specific fields, exploring various aspects, such as research topics, subject distribution, research levels, time distribution, research institutions, authors, geographical distribution, and keywords, providing support of comprehensive data. Naturally, bibliometrics analysis may have certain limitations, such as overemphasizing quantitative analysis while ignoring qualitative analysis, making it difficult to fully reveal the core and narrative structure of the research field. Based on the results of analysis via bibliometrics, this paper further explores the research hotspots in the field by integrating graphs and contents, conducting an in-depth exploration of BIM-driven sustainable tourism development for Chinese cultural heritage, aiming to comprehensively reveal the development trends in this research field.

In addition, this paper utilizes the CiteSpace v.6.2.R6 software tool for bibliometrics analysis. The CiteSpace v.6.2.R6, a JAVA 17-based platform for visualizing and analyzing the literature, enables diversified, dynamic, and time-based visual analysis of the literature, which helps to discover the historical pathways and future development trends from a vast corpus of sample data [32].

Further, as shown in Figure 1, the research flow is divided into five phases, of which the first three phases involve data collection, while the fourth and fifth phases are for data analysis. The first phase is to select a database for data collection. As the world's largest Chinese database, China National Knowledge Internet (CNKI) serves as the data source for this paper. The second phase is sample selection. In the CNKI database, advanced precise searches were conducted using the following search criteria: "Subject = 'Building Information Modeling' or 'BIM' or 'HBIM' or 'CIM'" and "Subject = 'Cultural Heritage' or 'Historical Heritage' or 'Architectural Heritage' or 'Heritage Protection'" or "Subject = 'Heritage Tourism' and Subject = 'Sustainable'". The search spanned "All Years" and the literature type was selected as "Journal". A total of 264 articles have been retrieved. The third phase is sample screening. To ensure data validity, duplicated search results were removed and organized, and irrelevant articles such as conference information and commentary reports were excluded. As such, 258 valid articles have been obtained. The fourth phase involves quantitative analysis, primarily focusing on three aspects: (1) analysis of publication time and disciplines and (2) analysis of keyword co-occurrence, clustering, and emergent maps. The fifth phase is discussion, providing an in-depth investigation of research hotspots and future trends in the field.

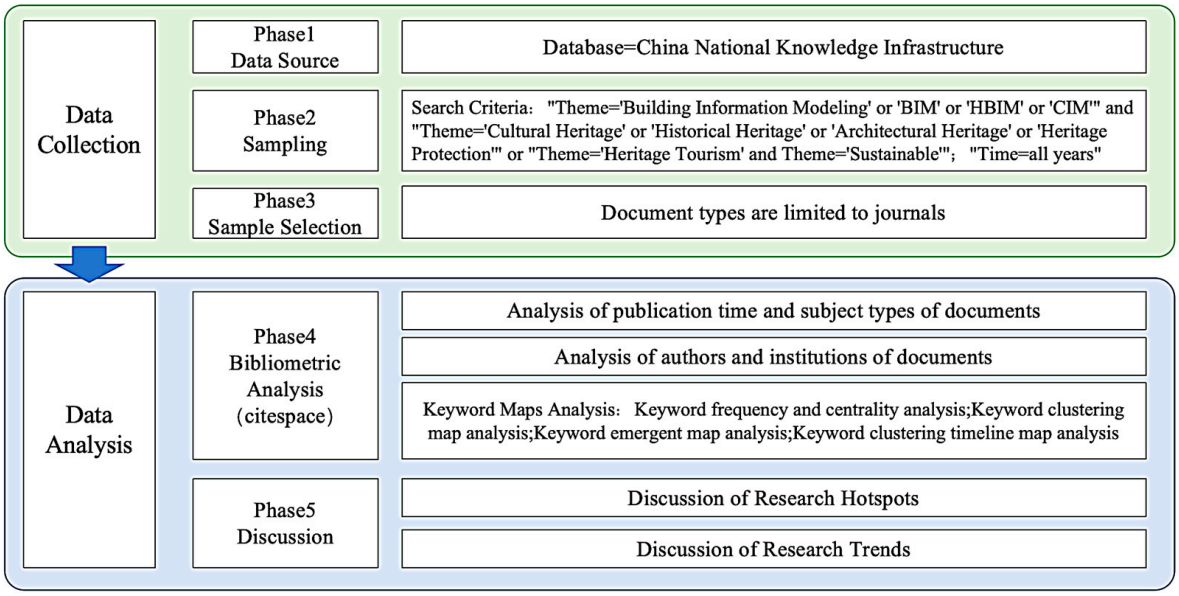


**Figure 1.** The flow of the research method (generated by authors).

## 3. Results

### *3.1. Publication Trend*

The number of publications and their timing of publication serve as important criteria for evaluating the research activity level and development trends within the field.

As shown in Figure 2, from the perspective of the publication timeline, research on BIM-driven sustainable cultural heritage tourism in China, the obtained 258 articles, have been categorized into two stages. First is the initial phase (year 2000 to 2010), with the earliest literature in the field dating back to 2000. In the 1990s, the sustainable development of cultural heritage tourism gained international attention. In 1995, United Nations Educational, Scientific and Cultural Organization and the World Tourism Organization convened for the "World Conference on Sustainable Tourism Development" and passed the "Charter for Sustainable Tourism Development" and the "Action Plan for Sustainable Tourism Development" [33], proposing "establishing a database including cultural heritage themes" and "seeking suitable technical methods for cultural heritage tourism". The proliferation of digital technologies, including BIM, within the realm of cultural heritage tourism has progressively garnered attention and been advocated for their application. In 2000, the China National Tourism Administration launched 27 World Heritage sites as its flagship products to tourists, sparking a wave of cultural heritage tourism in China. As such, there is a gradual progression towards conducting research that explores the utilization of digital technologies, such as BIM, in the context of sustainable cultural heritage tourism. However, during this stage, the number of publications remains modest, which suggests a consistent yet gradual growth trajectory, averaging approximately 5.1 publications annually.

The second stage is the development phase (from year 2011 to present). The number of publications during this stage has increased, with an average of 16.3 articles published per year. From 2021 to 2023, the average annual publication exceeded 20 articles. During the second decade of the 21st century, China has been an active participant in international forums and conventions pertaining to culture and tourism, fostering safeguarding, advocacy, and environment-friendly development to enrich cultural heritage. The application of digital technologies such as BIM, GIS, and VR to drive the sustainable development of cultural heritage tourism is becoming more widespread. Overall, the number of publications has maintained an upward trend, indicating that this field will remain a hot topic for future research.

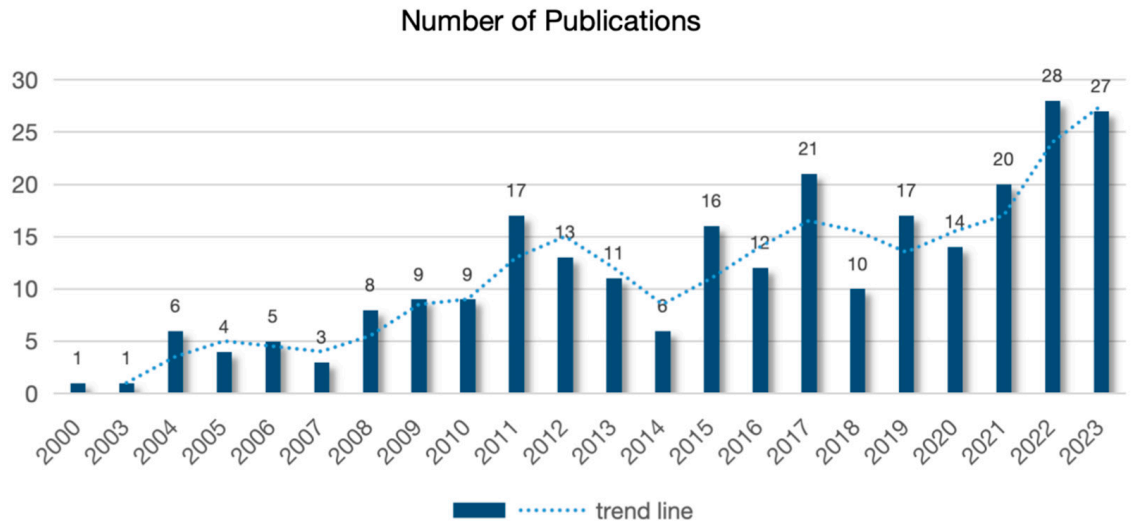


**Figure 2.** The number of published articles in the China National Knowledge Internet (CNKI) from year 2000 to 2023 on building information modeling (BIM), Chinese cultural heritage, and sustainable tourism (generated by authors).

### *3.2. Distribution of Subjects*

By analyzing the dispersal of fields from the obtained data, the research distribution of the subject across various disciplines can be discovered. By utilizing the visualization function of CNKI to analyze the 264 retrieved articles, we found that the research disciplines related to the theme of "BIM-driven sustainable development of cultural heritage tourism in China" were relatively concentrated. The distribution of the main disciplines is shown in Figure 3. The distribution of subject areas of tourism leads in publication, comprising 39.37% of all the published articles, followed by culture (18.84%), architectural science and engineering (17.63%), and computer software and computer applications (8.45%). These four disciplines account for 84.29% of all the obtained articles.

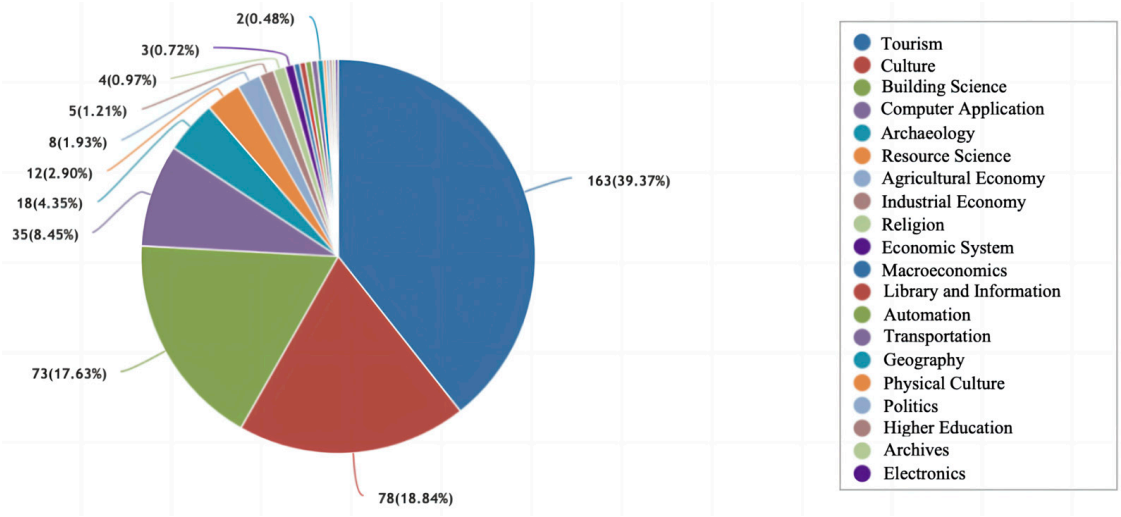


**Figure 3.** Distribution of subject areas involved in the research literature (264 articles) on BIM, Chinese cultural heritage, and sustainable tourism (generated by authors).

### *3.3. Keyword Map*

Keywords serve as a condensed representation of themes of the studies, of which their frequency, association, and emergence assist in revealing research hotspots, intrinsic relationships, and the significance within a particular field. Through keyword analysis,

the knowledge framework of the research can be visually presented, allowing for the exploration of hot topics, core research themes, and evolutionary trends [34].

#### 3.3.1. Keyword Frequency and Centrality

Keyword frequency analysis reveals hotspots in the research field. By conducting a keyword co-occurrence analysis of the literature, a keyword co-occurrence map was obtained, with 269 nodes, 392 links, and a network density of 0.0109, as shown in Figure 4. The size of the nodes represents the frequency of keyword occurrences in the literature. Larger nodes indicate higher frequency of keyword occurrences, and the links between nodes represent the interconnections between keywords, where the larger the font size of the network node is, the higher the frequency of keyword co-occurrence is. Keywords such as "heritage tourism", "heritage protection", "building heritage", "tourism development", "digital technique", "sustainable", "cultural heritage", "BIM", and "tourist resources" appear more frequently as research hotspots in BIM-driven sustainable development of Chinese cultural heritage tourism. In addition, most keywords are presented in a network state, where there are not many isolated nodes, indicating a strong correlation between the keywords.

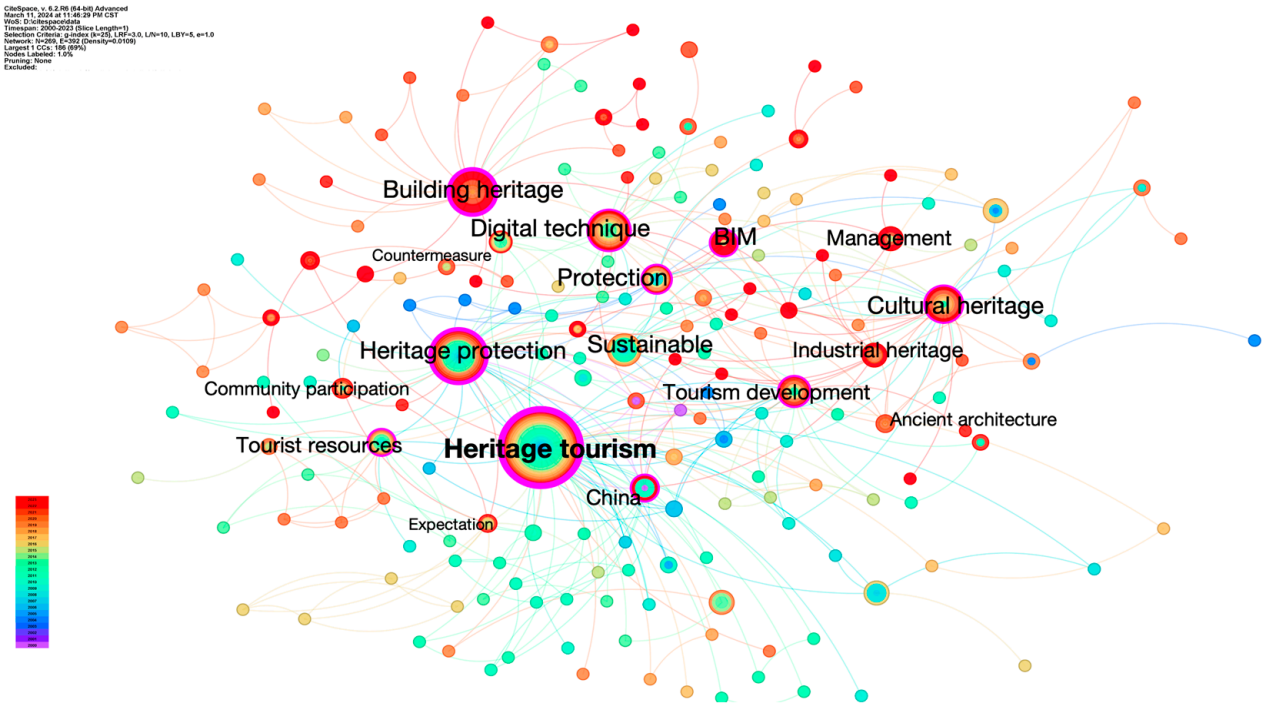


**Figure 4.** Keyword co-occurrence map on BIM, Chinese cultural heritage, and sustainable tourism (generated by authors).

In addition, as shown in Table 1, there are eight high-frequency keywords with a centrality higher than 0.1, namely: "heritage tourism" (0.4), "heritage protection" (0.29), "building heritage" (0.21), "digital technology" (0.19), "cultural heritage" (0.18), "tourism development" (0.15), "BIM" (0.12), and "sustainable" (0.1); keywords that exhibit a centrality value surpassing 0.1 are considered to be of significance. In terms of frequency, among the above keywords, except "sustainable", the frequencies of the other seven keywords are all higher than 10.

**Table 1.** High-frequency keywords, word frequency and centrality statistics on BIM, Chinese cultural heritage, and sustainable tourism (generated by authors).

| Serial Number | Keywords | Frequency | Centrality |
|---|---|---|---|
| 1 | Heritage tourism | 34 | 0.4 |
| 2 | Heritage protection | 24 | 0.29 |
| 3 | Tourism development | 18 | 0.15 |
| 4 | Cultural heritage | 17 | 0.18 |
| 5 | Building heritage | 15 | 0.21 |
| 6 | Digital technique | 11 | 0.19 |
| 7 | BIM | 10 | 0.12 |
| 8 | Protection | 8 | 0.05 |
| 9 | Industrial heritage | 6 | 0.08 |
| 10 | Sustainable | 6 | 0.1 |

As such, the research hotspots of BIM-driven sustainable development of Chinese cultural heritage tourism are mainly concentrated on the following aspects: heritage tourism, heritage protection, tourism development, cultural heritage, building heritage, digital technique, and BIM.

### 3.3.2. Keyword Clustering

The research area within the field has been explored through keyword clustering analysis, which was executed utilizing the CiteSpace v.6.2.R6, from which there are two values in the keyword clustering map that can assess the effectiveness of the clustering. One is the Silhouette clustering and average silhouette value, where S-value > 0.5 indicates a significant clustering structure, while an S-value > 0.7 is convincing. Another is the Modularity clustering and module value, where a Q-value > 0.3 suggests meaningful clustering. As shown in the top-left corner of Figure 5, the S-value is 0.9074, and the Q-value is 0.7355. Hence, the clustering of keywords on BIM, Chinese cultural heritage, and sustainable tourism have high credibility. These clusters reflect the main research directions of BIM-driven sustainable development of Chinese cultural heritage tourism from 2000 to 2023, focusing on heritage tourism, heritage protection, building heritage, tourism development, cultural heritage, industrial heritage, and digital technology, as shown in Figure 5.

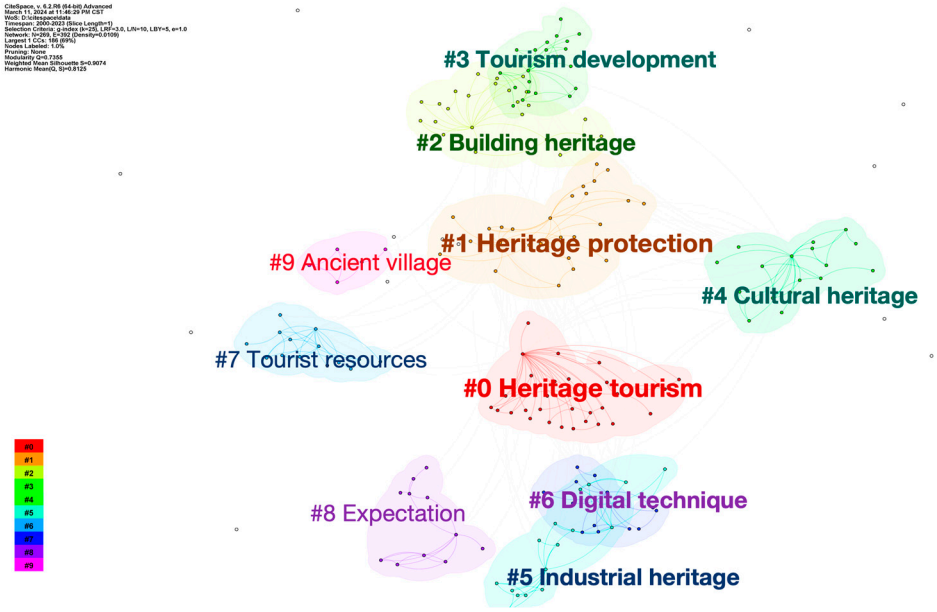


**Figure 5.** Keyword clustering map on BIM, Chinese cultural heritage, and sustainable tourism (generated by authors).

Moreover, utilizing the outcomes derived from the clustering map, an additional keyword clustering table has been set up. As shown in Table 2, the clustering size, clustering silhouette, and clustering keywords of each cluster block are listed. The clustering silhouette value serves as an evaluative metric for assessing the quality and effectiveness of clustering. A silhouette value approaching 1 signifies superior clustering performance. The clustering blocks are sorted according to their silhouette values. As shown in Table 2, the silhouette values of the 10 clusters in the Figure 5 are all above 0.8, indicating good clustering results. In terms of the cluster size, the cluster sizes of heritage tourism, heritage protection, building heritage, and tourism development are above 20, indicating that there are a great number of studies on these clusters, which are the hot issues in BIM, Chinese cultural heritage, and sustainable tourism.

**Table 2.** Keywords clustering table on BIM, Chinese cultural heritage, and sustainable tourism (generated by authors).

| Serial Number | Cluster Labels | Cluster Silhouette | Cluster Size | Cluster Keywords |
|---|---|---|---|---|
| 1 | #9 Ancient village | 0.982 | 5 | Traditional villages; BIM; Village heritage; Information records; Protection; |
| 2 | #1 Heritage protection | 0.966 | 26 | World heritage; Sustainable development; BIM; Information technology; World heritage tourism; Historical park; |
| 3 | #8 Expectation | 0.955 | 11 | Theories; Theoretical model; Tourism development; World Heritage; Sustainable; Sustainable development; |
| 4 | #5 Industrial heritage | 0.954 | 17 | Industrial heritage; Tourism mode; World Natural Heritage; Strategic management; Protection measures; |
| 5 | #2 Building heritage | 0.947 | 25 | Architectural heritage; Building information; Heritage management; BIM; Full life cycle management; Professional development; |
| 6 | #7 Tourist resources | 0.931 | 14 | Tourism resources; Sustainable development; Natural resources; Resource utilization; Resource planning; Digital application; |
| 7 | #4 Cultural heritage | 0.915 | 18 | Cultural heritage; Digital display; 3D reconstruction; Digital protection; Sustainable development; Cultural inheritance; |
| 8 | #0 Heritage tourism | 0.84 | 32 | Heritage tourism; Sustainable development; Tourism experience; Community participation; Digital technology; Immersive experience; Tourism satisfaction; Tourism management; Tourism services; |
| 9 | #6 Digital technique | 0.835 | 13 | BIM; Information recording; Geographic Information Systems; 3D laser scanning; Digital mapping; Virtual reality; Information silos; |
| 10 | #3 Tourism development | 0.817 | 21 | Tourism development; World Heritage; Intangible cultural heritage; Heritage destruction; Contradictions and conflicts; Problem analysis; |

Furthermore, in order to obtain the specific details of clustering, the keywords in the clustering tags are further analyzed, as shown in Table 2. Cluster 0 "heritage tourism" focuses on the sustainable development of heritage tourism, of which the keywords include "heritage tourism", "sustainable development", "tourism experience", "community participation", and "digital technology". Cluster 1 "heritage protection" is set to explore the relationship between BIM, information technology, heritage protection, and sustainable development. Cluster 2 "building heritage" concerns the protection of building heritage, for which the keywords include "building information", "BIM", "full life cycle management",

and "heritage management". Cluster 3 "tourism development" is regarding contradictions and conflicts brought about by heritage tourism development, with keywords such as "heritage destruction", "conventions and conflicts", and "problem analysis", which need to be alleviated by using digital technologies such as BIM. Cluster 4 "cultural heritage" has the digital protection and presentation of heritage, of which the keywords are "digital display", "3D reconstruction", and "digital protection". Cluster 5 "industrial heritage" is related to the tourism development strategy of industrial heritage. Cluster 6 "digital technology" is associated with keywords "BIM", "information recording", "geographic information systems", "3D laser scanning", "digital mapping", and "virtual reality".

As shown in Figure 5, the cluster tags not only are independent of each other but also have certain connections, suggesting that the research field of BIM-driven sustainable development of Chinese cultural heritage tourism shows its characteristics of integrating exploration and radiating their research topics. As such, the 10 key clustering results obtained by keyword clustering are further integrated into three main research directions: (1) the application of BIM and other digital technologies for the protection of cultural heritage, such as GIS and 3D reconstruction technology; (2) BIM and development of cultural heritage tourism; (3) BIM and management of cultural heritage tourism.

#### 3.3.3. Emergent Keywords

Emergent keywords represent key terms whose frequency of usage abruptly rises or exhibits a significant increase during a specified timeline [35]. Through the analysis of keyword emergence maps, the phased cutting-edge research areas of BIM-driven sustainable development of Chinese cultural heritage tourism can be demonstrated. A keyword emergent analysis is conducted with the minimum duration set to 1 year and $\gamma$ (yield) set to 0.5, resulting in a total of 13 emergent keywords with the strongest citation bursts, such as "world heritage protection", "cultural heritage", "heritage tourism", "authenticity", "ancient village", "tourism", "countermeasure", "tourism development", "community participation", "industrial heritage", "building heritage", "ancient building", and "integration of culture and tourism", as shown in Table 3.

**Table 3.** Top 13 keywords with the strongest citation bursts on BIM, Chinese cultural heritage, and sustainable tourism (generated by authors).

| Keywords | Year | Strength | Begin | End | Year 2000 to 2023 |
|---|---|---|---|---|---|
| World Heritage protection | 2000 | 2.88 | 2000 | 2011 | |
| Cultural heritage | 2004 | 2.47 | 2004 | 2009 | |
| Heritage tourism | 2000 | 2.24 | 2005 | 2009 | |
| Authenticity | 2006 | 1.34 | 2006 | 2006 | |
| Ancient village | 2007 | 1.91 | 2007 | 2008 | |
| Tourism | 2004 | 1.43 | 2010 | 2012 | |
| Countermeasure | 2012 | 1.56 | 2012 | 2016 | |
| Tourism development | 2009 | 1.84 | 2013 | 2013 | |
| Community participation | 2013 | 1.81 | 2013 | 2014 | |
| Industrial heritage | 2017 | 1.42 | 2017 | 2023 | |
| Building heritage | 2013 | 3.86 | 2018 | 2023 | |
| Ancient building | 2019 | 1.48 | 2019 | 2021 | |
| Integration of culture and tourism | 2021 | 1.41 | 2021 | 2023 | |

In addition, as shown in Table 3, the four keywords with the strongest citation bursts are: "building heritage" with 3.86 strength of citation in year 2018, followed by "world heritage protection" (2.88) in 2000, "cultural heritage" (2.47) in 2004, and "heritage tourism" (2.24) in 2005.

Further, based on the concentration of emergent keywords with the strongest citation bursts, it can be roughly divided into three major time periods. The first period is from year 2000 to 2010. During this time, "world heritage protection" appeared the earliest and

lasted the longest. In 1998, studies first combined intangible cultural heritage with tourism, introducing a novel framework for advanced preservation of intangible cultural heritage. In addition, research during this period focused more on Chinese heritage included in the scope of world heritage. In 2004, China joined the UNESCO Convention for the Protection of the Intangible Cultural Heritage, in which research attention on heritage protection began to increase. Subsequently, research attention on "heritage tourism" began to increase in 2005, which indicates that during this period, how to organically integrate heritage protection with tourism became a research hotspot. Further, the emergent strength of citation of the keyword "world heritage protection" is 2.88, ranking second among all the emergent keywords with the longest duration (11 years) from 2000 to 2011, which indicates that for a long period in the early stages, it is the most cited keywords associated with the integration of BIM, Chinese cultural heritage, and sustainable tourism.

The second period is from year 2010 to 2016. China issued policies such as the "Interim Measures for the Protection and Management of National Intangible Cultural Heritage". This ignited a surge of investigations into the realm of heritage tourism, and the research perspective in the field shifted from "heritage protection" to "heritage tourism development". The emergent strength of citation burst of "tourism countermeasures" and "tourism development" are relatively high, and perspectives such as the heritage tourism value, tourism products, industrialization of heritage tourism, and driving forces for heritage tourism development became new research hotspots on the integration of BIM, Chinese cultural heritage, and sustainable tourism. Overall, the emergent strength of citation burst of keywords in this stage is relatively low, indicating that there is no particularly prominent research focus in this stage.

The third period is from year 2017 to 2023, in which heritage tourism research has entered a stage of in-depth study and integrated development has become a research hotspot. Emergent keywords such as "industrial heritage", "building heritage", "ancient architecture", and "cultural and tourism integration" have a high emergent strength of citation burst during this period. Heritage tourism has gradually shifted from developing tourism products for the world heritage to a broader range of "building", "technology", and "cultural tourism", exploring the diversity of sustainable development of heritage tourism from an integrated perspective. In addition, the emergent strength of citation burst of the keyword "building heritage" is 3.86, which is not only the highest value among all the emergent keywords in this stage but also among all the obtained keywords of all the periods, which indicates that the theoretical need and urgency of applied research on "building heritage" are most prominent at this stage. Furthermore, "Industrial heritage" and "architectural heritage" have appeared since 2017 and 2018 to the present, indicating that the current frontier topics of research on BIM-driven sustainable development of Chinese cultural heritage tourism are focused on these two types of cultural heritage.

#### 3.3.4. Clustering Timeline of Keywords

The timeline view of keywords generated by CiteSpace arranges the keywords of the same cluster in chronological order on the same horizontal line, focusing on the internal connections and influences within the cluster [32], reflecting the hotspots and trends of research topics. As shown in Figure 6, research hotspots first appeared in the cluster#0 "heritage tourism" and the cluster#1 "heritage protection", which are closely related to subsequent research. The integration of BIM, Chinese cultural heritage, and sustainable tourism concerns the relationship between BIM and heritage utilization, protection, and tourism. In the cluster#2 "building heritage", the core research domains primarily focus on the integration of technology in heritage building design and safeguarding, intricately intertwined with the deployment of digital technologies rooted in BIM methodologies and IoT sensing technologies for the purpose of information governance. The hotspots in the cluster#3 "tourism development" appeared later, focusing more on tourism management. The cluster#4 "cultural heritage" has more connections with other clusters, whose research hotspots are related to ancient architecture and ancient culture. The cluster#5 "industrial

heritage" has industrial heritage resources, tourism models, and tourism marketing factors. The cluster#6 "digital technique" is used for application and change of technology, from BIM to virtual reality and light and shadow technologies. The cluster#7 "tourism resources" address the exploit, protection, socio-economic, and innovative development of tourism resources in heritage sites. The cluster#8 "expectation" considers theoretical development of the integration of BIM, Chinese cultural heritage, and sustainable tourism. The appearance of the cluster#9 "ancient village" shows that the protection and tourism development of cultural heritage of ancient villages have attracted attention in recent years.

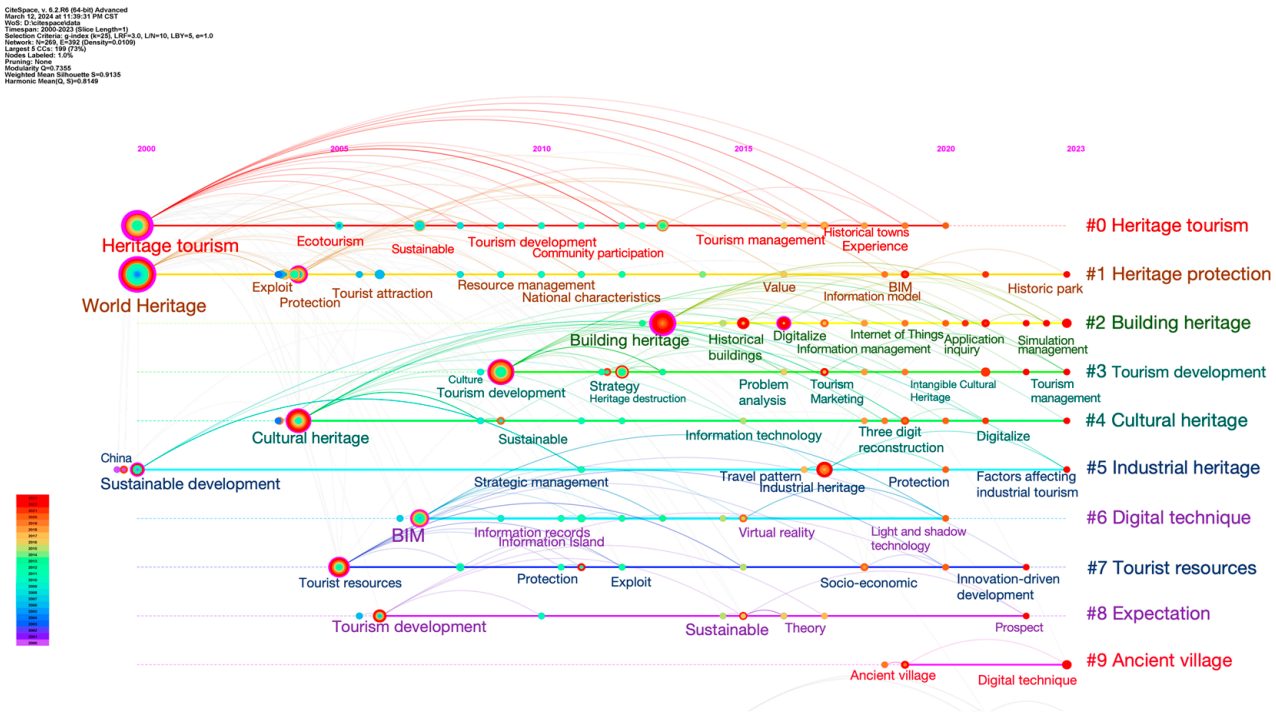


**Figure 6.** Keyword clustering timeline map on BIM, Chinese cultural heritage, and sustainable tourism (generated by authors).

## 4. Discussion

### *4.1. Research Hotspots*

The results of Figure 4 on keyword co-occurrence, Figure 5 on keyword clustering, Table 1 on keyword frequency and centrality statistics, and Table 2 on keyword clustering, suggest that the research hotspots in BIM-driven sustainable development of Chinese cultural heritage tourism mainly focus on cultural heritage tourism development, cultural heritage tourism management, and cultural heritage tourism protection. The research hotspots in the field from year 2000 to 2023 are summarized into the following four aspects, namely, BIM for heritage and protection, BIM for cultural heritage tourism development, management of cultural heritage tourism, and coordination and management of stakeholders.

#### 4.1.1. Building Information Modelling (BIM) for Heritage and Protection

The results of Sections 3.3.1 and 3.3.2 indicate that the premise of heritage tourism is heritage protection and inheritance and that heritage protection is a key focus of BIM-driven sustainable development of Chinese cultural heritage tourism. Additionally, the results of Figures 4 and 5 suggest that industrial heritage and building heritage in China are the primary types of cultural heritage in the field of heritage protection research. Further, the results of Table 3 demonstrate a high level of attention to industrial and architectural heritage in recent years in China. Due to their special historical significance, these heritages possess high protection value [36]. However, in the context of rapid urbanization in China,

many building and industrial heritages face severe damage and idleness due to outdated protection methods, lack of scientific management, and weak protection awareness [37]. Currently, the sustainable development of heritage tourism also faces challenges in China such as the damage to the appearance and structure of cultural heritage increases the difficulty of cultural tourism development [38] and affects the viewing experience of tourists, leading to a decrease in the attractiveness of cultural heritage to tourists.

In addition, heritage protection includes preventive protection and restorative protection in China. The result of Table 2 suggest that BIM is an essential technological foundation for life cycle management in architectural heritage protection in China [39]. In terms of preventive protection, BIM technology not only accurately reproduces the external form and internal structure of building heritage by constructing high-precision 3D digital models but also lays a solid foundation for comprehensive assessment and monitoring of heritage [23,40]. As such, BIM technology assists in simulating the response of buildings in different natural disaster scenarios, assessing their vulnerability, and developing targeted risk mitigation strategies, which effectively improves the pertinence and effectiveness of preventive protection [41]. Additionally, BIM technology has promoted the intelligence of preventive protection work. By integrating sensor data and real-time monitoring systems through the Internet of Things, BIM platforms facilitate the monitoring of the health status of building heritage in real time and detect and warn potential problems promptly [42].

With respect to restorative protection, the implementation of digital protection for building cultural heritage with BIM via the core, intensive 3D point cloud technology [43,44] and Light Detection and Ranging technology [45,46] can quickly assist in acquiring 3D data of buildings [47] and is often used for 3D reconstruction [48] and structural drawing of building cultural heritage. The parametric, visual, and consistent characteristics and advantages of BIM technology [49] make the digital management of the entire process more efficient, including design, construction, and operation [43]. By sorting out the BIM application strategy modes [50] for various teams, such as construction, design, planning, and management, in various stages, a reasonable repair and protection plan can be formulated [51], and an operation and maintenance management framework [52,53] with the objective of maintaining sustainable protection and progress in heritage architecture throughout their life cycle can be further established in China. As such, sustainable protection and development of heritage buildings throughout their life cycle can be achieved [52].

Further, industrial heritage, being a pivotal hallmark of China's urban evolution, has garnered substantial attention recently regarding preservation, transforming into a salient research focal point and a prevailing trend within the discipline. BIM technology emerges as a pivotal tool in mitigating the complexities associated with the rejuvenation of industrial heritage [54], establishing a digital information database for industrial heritage [55], and activating new vitality for industrial heritage [56].

Although BIM technology has shown great potential in the protection of architectural and industrial heritage in China, it still faces challenges and limitations. For some historical and severely damaged building and industrial heritage, accurate data collection and information modeling are facing technical challenges. Additionally, with the continuous development of technology, how to keep BIM technology updated and upgraded to adapt to changing protection needs in China is also an urgent issue to be addressed. This is also a direction that cultural heritage conservation workers and research teams should focus on in the future.

#### 4.1.2. BIM for Cultural Heritage Tourism Development

The results of Sections 3.3.1 and 3.3.2 indicate that a key focus of BIM-driven sustainable development of Chinese cultural heritage tourism is heritage tourism and tourism development. Development of cultural heritage tourism, as an effective means, can not only promote the cultural dissemination and inheritance of heritage [57] but also generate income, provide financial support for heritage protection, and add vitality to the local

economy [58], achieving sustainable development of heritage protection, heritage tourism, and the local economy.

However, cultural heritage tourism development also has negative impacts in China. The results of Table 2 on the "tourism development" cluster suggest that conflicts between heritage destruction and the development of cultural heritage tourism in China need to be addressed. They include the excessive development of commercial tourism leading to periodic overload of tourist reception, which makes the integrity of the original cultural heritage appearance vulnerable to damage [59,60]; and due to insufficient tourism development, tourists are unable to deeply understand the historical significance of cultural heritage [61], thereby reducing their travel experience, which is not conducive to the cultural inheritance of heritage and restricts the sustainable development of cultural heritage tourism [62,63].

The adoption of digital techniques, such as BIM, could effectively alleviate the above challenges. The results of Table 2 reveal that digital show-off and expression provide a better tourism experience to tourists in China. BIM is used to simulate and analyze the movement and interaction of people inside and outside the building, evaluate the building's maximum occupancy, and avoid overloading tourists and heritage damage [44,63]. In addition, BIM integrated with other digital technologies, such as 3D laser scanning, VR, and virtual simulation [43,64], digitally express and visualize cultural heritage entities. For instance, by implementing BIM technology with VR/AR technology and using various techniques, such as lighting and scene arrangement, it is possible to accurately restore the original form and details of cultural heritage, create immersive and emotionally resonant digital display scenes [65], and help tourists gain a deeper understanding of cultural heritage, bringing them an immersive experience [66]. Further, digital show-off is employed to surpass the boundaries of time and space and achieve barrier free dissemination of cultural heritage [67]. Through various digital media technologies such as live streaming and online exhibitions, the value of cultural heritage can be conveyed to a wider audience [68], promoting the inheritance of heritage culture in China.

#### 4.1.3. Management of Cultural Heritage Tourism

The results of Sections 3.3.1 and 3.3.2 indicate that the employment of BIM technology has the potential to not only merely enhance the preservation and showcase cultural heritage but also exerts a favorable influence on the administration of cultural heritage tourism, thereby fostering the sustainability of such endeavors within China. Additionally, the results of Table 2 suggest that using BIM and video surveillance to monitor the movement trajectory of tourists inside buildings can better manage tourist traffic [69]. Integrating BIM and GIS technology can be applied to tourism planning [70], spatial agglomeration trends of tourism areas [71], spatial structure correlation analysis, tourism resource databases and path analysis [72], and drawing of tourism resource maps [73]. Thus, heritage tourism managers can more accurately grasp the distribution of tourism resources, optimize tourism routes, plan, adjust tourism routes and attraction opening hours reasonably [74], and enhance the integrity of building cultural heritage protection and tourist experience in China.

In addition, the information surveying and recording system with BIM as the core technology can better collect and preserve data related to cultural heritage [75], assisting tourists in attaining a profounder comprehension of the historical background, evolution, and current condition of cultural heritage. In the information collection process, BIM technology provides a data visualization application framework for building heritage in the research of building heritage data sampling [76]. This enables workers to use advanced visualization tools to accurately collect, analyze, and present every detail of building heritage. BIM technology also provides different information about building heritage at different times and coordinates different information at the same time node, meeting the demand for multi-temporal and diversified building information in cultural heritage information recording [64,77]. By comparing information from different periods, the evolution pro-

cess of cultural heritage can be presented. This enables tourists to comprehensively and meticulously understand the historical changes of cultural heritage, which is of great help for tourists to perceive the historical value and cultural connotation of cultural heritage. Whilst BIM technology can solve the problems of information loss and damage [78] and "information silos" [79] in current building heritage information management and provide more scientific archive recording, operation, maintenance, management, and display of cultural heritage, constructing a practical and feasible heritage information management system [80,81], which are assisted to achieve data sharing and joint management to improve the efficiency and level of cultural heritage management in China.

However, the application of technology in cultural heritage tourism management in China also faces some challenges and controversies. On one hand, the introduction of technology may impact traditional cultural values, requiring a balance between tradition and modernity. On the other hand, the use of technology may raise issues such as data security and privacy protection, necessitating the formulation of corresponding policies and measures for regulation in China.

#### 4.1.4. Coordination and Management of Stakeholders

The results of Sections 3.3.2 and 3.3.3 show that the stakeholders of cultural heritage tourism management in China include community residents, the government, industry management entities, tourists, and special interest groups, who have both cooperative and conflicting relationships [82]. Among them, the government and cultural heritage protection groups pay more attention to the transmission and protection of cultural heritage. The industrial manager considers economic benefits more, while residents are concerned about the income and impact of living brought about by tourism [83]. Therefore, coordinating the relationships among the stakeholders to achieve maximum satisfaction and balance of their respective rights is an important guarantee for BIM-driven sustainable development of Chinese cultural heritage tourism [84].

The results of Tables 2 and 3 indicate that, as direct stakeholders of cultural heritage tourism, the depth of participation in management of heritage communities is directly related to the sustainable development potential of heritage tourism [85,86]. BIM technology, by providing detailed digital models of cultural heritage, not only enhances community residents' awareness and protection of the social and cultural characteristics of heritage sites [87] but also promotes their deep integration into tourism planning and management processes, enriching the authenticity and depth of tourism experiences [88]. Thus, it plays a significant part in maintaining the authenticity of heritage, safeguarding the rights and interests of community residents, and enhancing the scientific nature of tourism planning [89].

The key role of BIM digital technologies in coordinating stakeholders is to facilitate information communication and interaction among stakeholders in China. The integration of BIM and digital image recognition technology, along with the increasingly popular mobile internet technology, cloud computing, and big data systems [90], enables the government, professionals, and the public to access the backend database of heritage building information for information dissemination and communication. This data platform has become a bridge to promote information communication and resource sharing in China [87].

Furthermore, the government often plays a leading role in the protection and management of cultural heritage [91]. The application of BIM technology facilitates the construction of heritage data informatization and information management systems, helping the government achieve refined zoning, grading management, and a full process supervision system. From early warning and process monitoring to later evaluation and adjustment, it comprehensively improves the effectiveness of management, reduces the risk of market mechanism distortion that may be caused by government leadership, and thus reduces the risk of conflicts between stakeholders [92]. For industry management personnel, they not only possess market insights and innovation capabilities but also need to continuously improve in heritage protection, tourism management, community coordination, and external

relationship management [93]. BIM technology provides powerful data support and visualization tools for these industry management professionals, making decision-making more scientific and management more efficient [94], injecting new vitality into the coordinated management of cultural heritage tourism in China.

Hence, BIM technology has played an important role in coordinating and managing stakeholders of cultural heritage tourism under the government-led framework, further promoting the sustainable development of Chinese cultural heritage tourism.

### *4.2. A Whole Life Cycle Management*

The results of Section 3.3.2 and Table 2 suggest that the life cycle is an important issue for building heritage. Life cycle management refers to a series of information collection, construction, maintenance, and sharing activities implemented for the heritage, ancillary facilities, and surrounding environment of a building from the moment that enters the protection category to its disintegration and disappearance due to various factors [79]. Thus, the BIM-based whole life cycle management strategy incorporates a full process of protecting, controlling, researching, displaying, utilizing, constructing, and operating maintenance of architectural heritage into the service scope. By flexibly and deeply integrating BIM technology into each stage of the life cycle, a seamless flow, sharing, and integrated governance of information throughout the life cycle of a heritage could be achieved, which has a profound and positive impact on the sustainability and healthy evolution of a heritage building [95].

Cultural heritage tourism relies on building heritage and is closely related to the life cycle of building heritage. With the discovery, protection, planning, and development of building heritage, heritage tourism exhibits a regular life cycle. According to Butler's Tourism Area Life Cycle theory, the evolution of tourist destinations is divided into six stages, including exploration, participation, development, stabilization, stagnation, and decline or revival stages [96]. Based on this theory, a full life cycle management of BIM has a high degree of integration with the life cycle of cultural heritage tourism. The results of Sections 3.3 and 4.1 indicate the utilization of BIM throughout the entire life cycle of cultural heritage tourism as outlined hereinafter.

During the exploration stage, BIM technology could be used for preliminary data collection and modeling. Additionally, through high-precision scanning and photogrammetry, BIM facilitate the construction of three-dimensional digital models of cultural heritage, supplying precise foundational data and serving as a cornerstone for subsequent endeavors in tourism planning and conservation strategies. Further, the application of BIM is mainly reflected in the digital recording of heritage, current status assessment, and preliminary analysis of tourism potential.

In the participation stage, BIM technology is used to assist in designing tourist experience paths, optimizing tour routes, enhancing tourist experiences, and reducing the impact of tourist activities on heritage. While BIM models serve as educational tools, allowing visitors to have a preliminary understanding of cultural heritage before visiting, through VR and AR technologies, thereby improving the quality of the tourism experience.

In the development stage, tourism activities have significantly increased, and higher requirements have been put forward for the preservation and management of cultural heritage. The adoption of BIM technology is extensive, including repair plans and disaster prevention. Through the collaborative work platform of BIM, real-time sharing of information from multiple parties, such as design, construction, and supervision, could be achieved to improve construction efficiency, from which changes on the status of cultural heritage is continuously monitored, and potential issues will be promptly identified and addressed, which could maintain the enduring protection of the heritage over time.

In the stable stage, the integration of tourism market tends to stabilize, and BIM technology could further expand applications, such as using BIM models for digital showoff, providing tourists with intensive, vivid, and immersive visiting experiences through

technologies such as VR and holographic projection, which simultaneously coordinate the relationships between stakeholders of cultural heritage tourism.

When tourist destinations have been developed into a stagnant stage and the growth of tourist numbers slows down, BIM technology assists in the innovative development of tourism products, exploring new value points of cultural heritage through digital means, attracting new tourist groups, and promoting the recovery of the tourism market. In addition, if the development of tourist destinations has failed to effectively respond to the challenges of stagnation, it may enter a decline stage. On the contrary, revitalization could be achieved through innovative strategies and effective management. Thus, BIM technology could be used during the decline stage to facilitate the assessment of the current status of heritage, developing targeted revitalization plans and promoting the sustained expansion of cultural heritage tourism while preserving its authenticity.

### *4.3. Research Trends*

The results of Section 3.1 indicate that a number of publications in BIM-driven sustainable development of Chinese cultural heritage tourism have formed a growing trend in recent years and will sustain its high-level performance of popularity in the future. In addition, the key research focus of the past mainly include BIM in promoting cultural heritage protection, tourism development, tourism management, and stakeholder coordination and management. The future BIM technology-driven sustainable development of cultural heritage tourism has a high research and application value. Further, the results of Section 4.1, Table 3, and Figure 6, suggest that the possible trends in the field of BIM-driven sustainable development of Chinese cultural heritage tourism are precise restoration and protection of cultural heritage via BIM, construction of virtual scenes for cultural heritage to enhance tourism experience through BIM environment, and smart management of cultural heritage tourism using BIM in China.

#### 4.3.1. Precise Restoration and Protection of Cultural Heritage via BIM

The results of Sections 3.3.1 and 3.3.2 indicate that heritage protection is an important issue for BIM-driven sustainable development of Chinese cultural heritage tourism. As suggested in above Section 4.1.1, BIM technology has played a key role in the protection of cultural heritage, and there is still a huge demand for precise restoration and protection of cultural heritage in the future. Integrating BIM with other digital technologies for the protection of cultural heritage will also have high research heat in the future, such as integrating BIM technology with high-precision scanning, photogrammetry, and 3D laser scanning; consequently, the accuracy and efficiency of cultural heritage digitization will be improved, achieving comprehensive and accurate collection and reconstruction of its form, color, and texture. This process not only provides digital backup to the permanent protection of cultural heritage but also provides precise guidance for subsequent restoration work. The integration of BIM technology with Internet of Things, sensors, and other technologies collects real-time environmental data of cultural heritage in the tourism development process, uses BIM models for data analysis and prediction, establishes an early warning platform, and achieves refined management, thereby reducing the risks and problems brought by cultural heritage tourism development and preventing cultural heritage from being damaged due to tourism development.

#### 4.3.2. Construction of Virtual Scenes for Cultural Heritage to Enhance Tourism Experience through BIM Environment

As revealed in above Sections 4.1.2 and 4.1.3, the role and advantages of digital technologies, such as BIM in tourism development and management in China, have gradually shifted from auxiliary to leading development and from the "technology-assisted digital show-off of cultural heritage" to the "technology-led cultural heritage tourism product and scene design". Upon the progression and enhancement of digital interactive technology and the increasing demand for interactive tourism experience among tourists, the pivotal

research emphasis in the forthcoming era could evolve exploring avenues for leveraging BIM and assorted digital technologies to augment and enrich the tourism experiences of visitors. By integrating BIM with extended reality (XR) technology, VR and AR can be used to promote the sharing of building heritage information and create highly interactive virtual environments, which can be used for the construction of virtual museums and tourism scenes [97]. Based on virtual scenes, tourists can remotely interact with the scene through online platforms and use VR or AR glasses to create an immersive virtual experience. In the future, the integration of BIM and virtual intelligence presentation technology will continue to optimize the construction and upgrading of virtual scenes for cultural heritage tourism, enhance tourism experience of tourists on the cultural heritage within heritage tourism theme extraction, scene design, route planning, and other aspects, which facilitate to foster the sustainable progress and conservation of cultural heritage tourism in China.

#### 4.3.3. Smart Management of Cultural Heritage Tourism Using BIM

As highlighted in above Section 4.1.3, BIM has played a certain role in cultural heritage tourism management in China, but mainly focuses on data management, and flow monitoring, with less research on the overall planning of smart management of cultural heritage tourism. The intelligent management system for cultural heritage tourism based on BIM helps to achieve efficient management, intelligent decision-making, personalized services, and foster sustainable development of cultural heritage tourism in China. In addition, by utilizing BIM and real-time monitoring information, machine learning algorithms can be used to analyze tourist behavior patterns, predict tourist traffic, and distribute points of interest. By comprehensively evaluating the tourist carrying capacity of heritage sites and the degree of congestion in scenic areas, measures, such as dynamically adjusting tourist routes, controlling tourist density, and optimizing the service facility layout, can be taken to improve the management efficiency of tourist attractions. Integrating BIM technology with big data analysis could assist in dynamically monitoring and evaluating the status of cultural heritage, simulating the effects of different tourism development and heritage protection plans, and making decisions for managers. Further, based on personalized needs such as tourist preferences and time constraints, utilizing the spatial information provided by BIM, travel routes for tourists could be designed and customized to provide immersive and interactive cultural heritage tourism experiences in China.

### *4.4. Research Challenges and Limitations*

#### 4.4.1. Research Challenges

The paramount importance of safeguarding and transmitting cultural heritage has consistently been underscored within the realm of cultural preservation. Cultural heritage tourism, as a pivotal force, contributes positively to the dissemination of cultural values [11], fostering heightened public consciousness towards heritage protection and augmenting financial resources dedicated to preserving cultural heritage [14]. The application of BIM and other digital technologies plays a certain balancing role between cultural heritage protection and tourism development, promoting the sustainable development of cultural heritage tourism in China. Past studies on the BIM-driven sustainable development of Chinese cultural heritage tourism mainly focus on using qualitative analysis to conduct strategic and theoretical research. There is a lack of research that is looking into conceptual models and quantitative data analysis. Additionally, there are a few studies using bibliometrics to investigate, although the past studies have explored BIM and architectural cultural heritage protection from a technical perspective [26] or have dug into BIM and cultural heritage tourism from the perspective of global sustainable development goals [19,98]. Hence, this paper explores the relationship between BIM and sustainable development and cultural heritage tourism in China from the perspective of technological application scenarios, using bibliometric methods, which proposes research hotspots and development trends, addressing the gap in the relationship between BIM, Chinese cultural heritage, and

sustainable tourism. As such, this paper provides rich data support for researchers in this field and has an important reference value for future research directions.

#### 4.4.2. Research Limitations

This paper employs a bibliometric method to explore the research on BIM-driven sustainable development of Chinese cultural heritage tourism, but there are still certain limitations that may affect the comprehensiveness and universality of the results. The data source of this paper is collected from CNKI, which is the largest literature database platform in China, and the focus of this paper is on Chinese domestic research data. In addition, bibliometric methods may be influenced and limited by various factors such as the set of search keywords and search time. The same concept may have multiple synonyms, and if these synonyms are omitted during the data search process, it may lead to the omission of the relevant literature and deviation of search results. Additionally, bibliometric methods rely on the published literature, and the application research of BIM in the area of Chinese cultural heritage tourism may not have been included in the literature, such as industry cases, policy documents, and unpublished research results, which may cause the results with less paying timely attention to some of the latest developments or niche applications.

## 5. Conclusions

This paper set to explore the research focus and hotspots, emerging fields, development trends, and future directions of BIM-driven sustainable development of Chinese cultural heritage tourism. This paper employs the bibliometric method to quantitatively analyze published studies related to BIM, Chinese cultural heritage, and sustainable tourism from the China CNKI database, for which a multi-level analysis via visual knowledge graph has been conducted. The main contributions of this paper are as follows:

In terms of methodology, this paper used quantitative research methods, using a bibliometric method to systematically collect and quantitatively analyze the data of BIM, Chinese cultural heritage, and sustainable tourism, from the China CNKI database. A multi-level analysis framework, application of visual knowledge graphs, and interdisciplinary integration research perspectives are constructed, which provides abundant data support and methodological references for subsequent researchers.

In terms of research technology, this paper uses the CiteSpace v.6.2.R6 software tool to conduct bibliometric statistics and analysis for obtaining a number of knowledge maps of keywords, such as keyword co-occurrence, clustering, and emergence. Through keyword clustering analysis, the vast literature data are divided into several interrelated research topics, revealing the inherent connections and development logic between each topic. Additionally, the development progress of research hotspots in the progress periods has been explored through analysis of time series, whilst the impact of policy promotion, technological innovation, and major events on research directions at key timelines have been screened. Further, the future research trends of BIM-driven sustainable development of Chinese cultural heritage tourism have been revealed.

In terms of research findings, the popular research keywords for driving sustainable cultural heritage tourism in China through BIM since year 2000 (23 years) include heritage tourism, heritage protection, building heritage, digital technology, and tourism development. Three research hotspots have been identified such as cultural heritage protection, cultural heritage tourism development, and cultural heritage tourism management. In addition, in terms of tourism development and management, building virtual interactive scenes of cultural heritage facilitated by BIM to enhance tourism experience of tourists and using BIM to assist in efficient management, intelligent decision-making, and personalized services of cultural heritage tourism, assist in better promoting the sustainable development of cultural heritage tourism. Further, in terms of coordinating and managing stakeholders in cultural heritage tourism, BIM technology provides technical support to the government, industry managers, and community residents in information communication and industry management, by constructing a digital model of cultural heritage, for better

balancing the rights and interests of stakeholders. Thus, the government and cultural heritage managers should implement the concept of protective development of cultural heritage, and tourism managers should develop and manage cultural heritage tourism projects, achieving sustainable development of cultural heritage tourism. Importantly, this paper has explored the integration of BIM life cycle and cultural heritage tourism life cycle from the perspective of the full life cycle and analyzed the application of BIM in the full life cycle of cultural heritage tourism.

The main limitation of this paper is that only the China CNKI database was used to obtain the data. Future research could further expand the data sources such as Web of Science, SCOPUS, and ScienceDirect and increase the types of data, such as conference papers, to explore the research field more deeply and comprehensively.

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