


Review

Recent Evolution of Research on Industrial Heritage in Western Europe and China Based on Bibliometric Analysis

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Abstract: Using the CiteSpace software and bibliometric methods, with the core collection of the Web of Science (WoS) database as the data source, the development of industrial heritage research in China and Western countries since the 2006 Wuxi Proposal was analyzed. The study found that the latest quantitative changes in China and Western countries' industrial heritage research have similar fluctuations. However, researchers and institutions in the two places are independent of each other, lacking in-depth cooperative research. Notwithstanding, comprehensive and holistic research needs to be strengthened. The research content in China mainly focuses on the issues of urban renewal, industrial heritage tourism and creative industries, whereas Western countries are dominated by heritage and community building industrial heritage, the exploration of tourism and the protection of industrial sites, post-industrial heritage protection, and new technology use. Finally, by comparing and analyzing the research status of the two regions, future research on industrial heritage in China and Western countries are encouraged.

Keywords: bibliometric analysis; CiteSpace; industrial heritage; network graph analysis; visualization

1. Introduction

The concept of modern industry and its heritage find their "roots" in Western Europe. In the second half of the nineteenth century, Britain became the leader of the first industrial revolution. With the saturation of the market and the increase in the cost of manufacturing, the industry gradually shifted to neighboring Western European countries, such as France, the Netherlands, Belgium, and Germany. In the middle of the twentieth century, with the decline and transformation of traditional industry, Western European countries entered the post-industrial era and began actions toward the protection of their industrial heritage [1–3]. Western Europe is the leading region for industrial manufacturing and industrial heritage research [4]. Their research on industrial heritage have the characteristics of a wide-subject, diverse research methods, and abundant research perspectives and contents [5,6].

During the twenty-first century, the concept of industrial heritage was introduced to China from Western Europe [7]. In 2006, the State Administration of the cultural heritage of China held the Wuxi Forum on the protection of Chinese cultural heritage in Wuxi, which was adopted as it firstly advocated the protection of industrial heritage. Since then, Chinese academic interest in industrial heritage research has gradually increased and the scope of research has begun to expand and deepen, which has a significant role in promoting the research and protection of industrial heritage in China [8].

At the same time, the State Administration of cultural relics of China issued a notice on strengthening the protection of industrial heritage, marking the rise of China's industrial heritage protection at the national level [9]. Compared with Western countries, China's industrial heritage research started late. However, industrial heritage has the characteristics of a large quantity, wide distribution, and that the categories are various [10].

In view of this, the visual analysis method with CiteSpace software is studied. Based on the bibliometric analysis and from the perspective of macro development, this paper systematically aims to:

- Summarize the latest research outcomes of industrial heritage in China and Western countries;
- Describe the development process of the industrial heritage discipline scientifically and quantitatively;
- Compare the outcomes and dynamic evolution laws of industrial heritage protection research in China and Western countries under two different development states horizontally, providing a valuable reference base for subsequent heritage conservation research.

The paper is structured accordingly research methods and tools: firstly, sections three and four discuss the current research status in China and Western countries; secondly, sections five and six provide the main findings of the work the summary and discusses the perspectives for its continuity.

2. Methods and Tools

To ensure the integrity and accuracy of the data, the core collection of the Web of Science (WoS) database was taken as the basic data source, with "industrial heritage" as the subject word, the retrieval time was from the release of Wuxi Proposal, the interval is set from 2006 to 2019, and 312 articles were retrieved [11]. After screening, 72 papers were collected from China, and 127 papers from Western Europe and other Western countries. The operation time of literature retrieval was 10 March 2020.

A scientific knowledge map is a graph showing the relationship between the development process and the structure of scientific knowledge. The retrieval results were analyzed using the knowledge map analysis software CiteSpace.5.6.R3 (64 bit). The CiteSpace knowledge map software is a visualization tool for information analysis based on the Java platform. With the function of knowledge navigation, it can track and process statistics data and scientific and research texts in specific fields, detect key paths and knowledge inflection points, analyze research context, and explore the latest trends in disciplines [12].

In this paper, we set the time slice as 1 year, and other operations as default settings, to obtain the relationship map of different areas. Among them, the clustering view of keywords mainly reflects the structural characteristics of clusters, highlighting key nodes and important connections [13]. The size of the nodes reflects the lifecycle and the influence of keywords. The color level of the nodes represents different years. The connection between nodes represents the number of times that two different keywords appear together. The thicker the connection, the more times they appear together [14].

Based on WoS statistics of the number of core papers on "industrial heritage" research since the 2006 Wuxi Forum, the number of documents in 2006–2019 changes over time (Figure 1). The development trend of the literature quantity shows the changing trend of academic attention to research topics within a certain time range. In terms of the fluctuation of quantity, China and Western countries maintain the same change in research focus on industrial heritage.

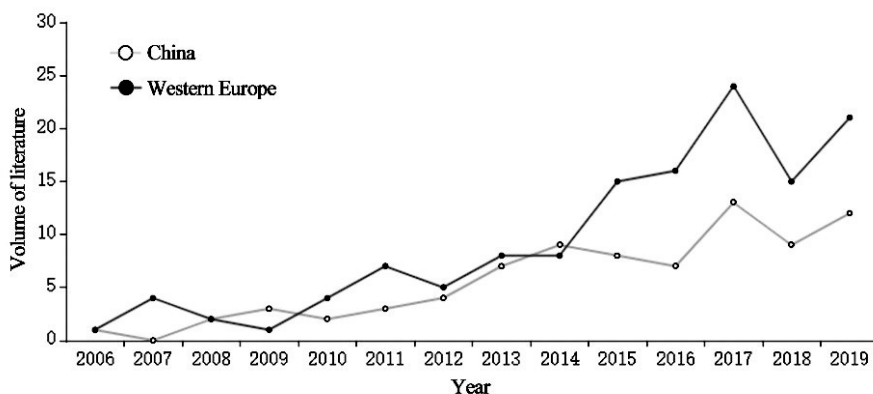


Figure 1. Number of papers published on industrial heritage in China and Western countries

3. Research and Development of Industrial Heritage in China

3.1. Characteristics of Author Cooperation Network Map

The authors’ cooperation knowledge map reveals the authors who lead a certain field in a certain period. There are 162 nodes and 136 connections in the map, indicating that there are more authors studying industrial sites and less overall cooperation between 2006 and 2019 (Figure 2). In the figure, there are mainly three close-cooperation scientific research teams, among which the largest number of papers are produced by the scientific research team with Yaolin Zhou as the core [15], followed by Changrui Zhang et al. [16]; the third core team is Honggang Xu et al. [17]. The composition of authors in the field of industrial heritage research in China is characterized by a small number of papers issued by a single author and a lack of cooperation among teams. There are 162 authors in 80 pieces of literature in China, among which four authors have more than two articles, and the core authors in this field are few.

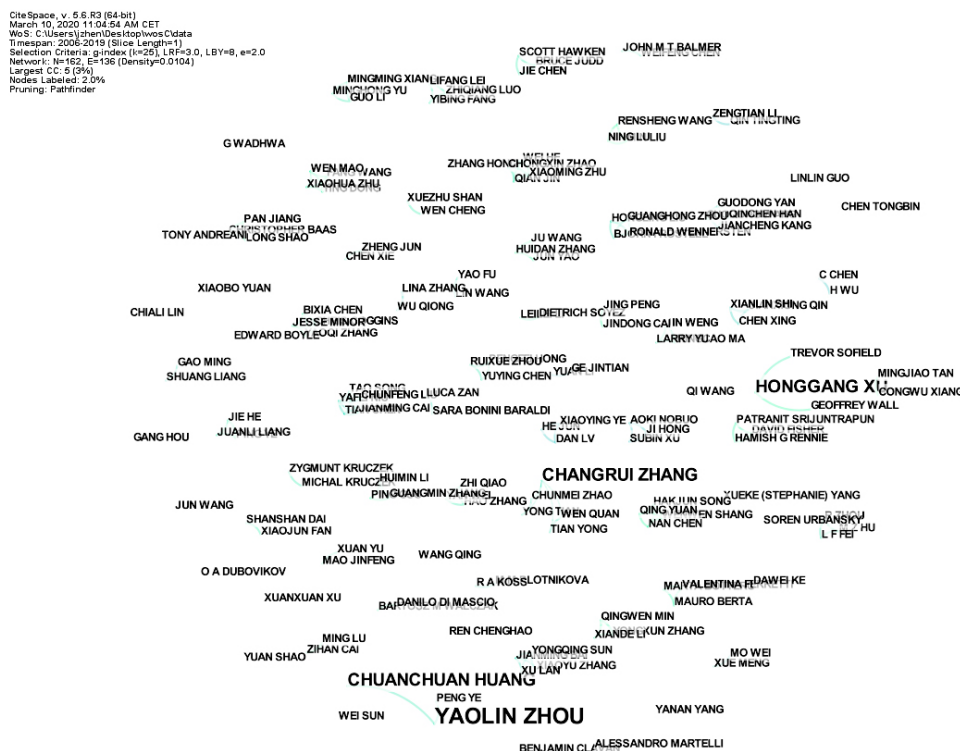


Figure 2. Knowledge map of co-authors of papers published on industrial heritage in China during 2006–2019.

3.2. Characteristics of the Institutional Cooperation Network Map

The number of papers issued by research institutions reflects the research capacity of the studied institutions to a certain extent. Through the statistical analysis, the development process and results of each research institution can be effectively distinguished [18]. There are 91 nodes and 42 connections in the map (Figure 3). The largest number of papers is at Wuhan University (5), followed by the Chinese Academy of Sciences (4) and Sun Yat-sen University (3). The research institutions shown in the map are research groups with more than two papers issued between 2006 and 2019—this distribution of institutions is similar to the distribution of researchers.

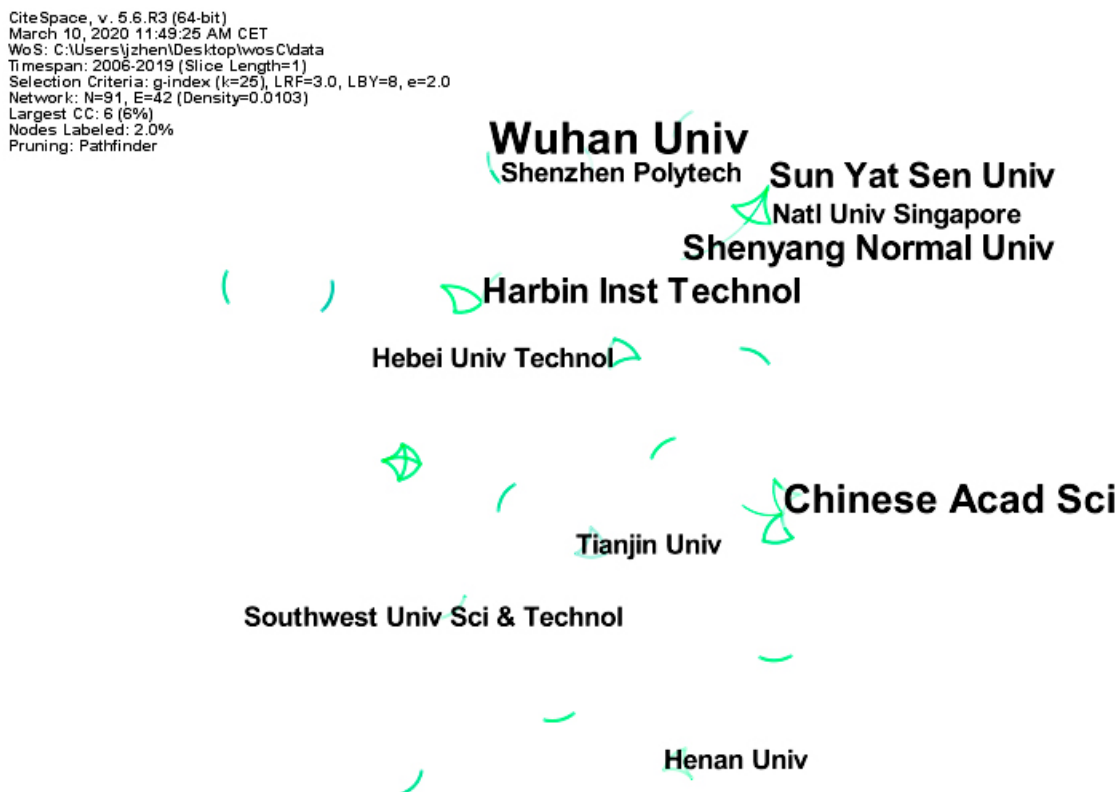


Figure 3. Knowledge map of cooperative institutions in the research on industrial heritage in China during 2006–2019.

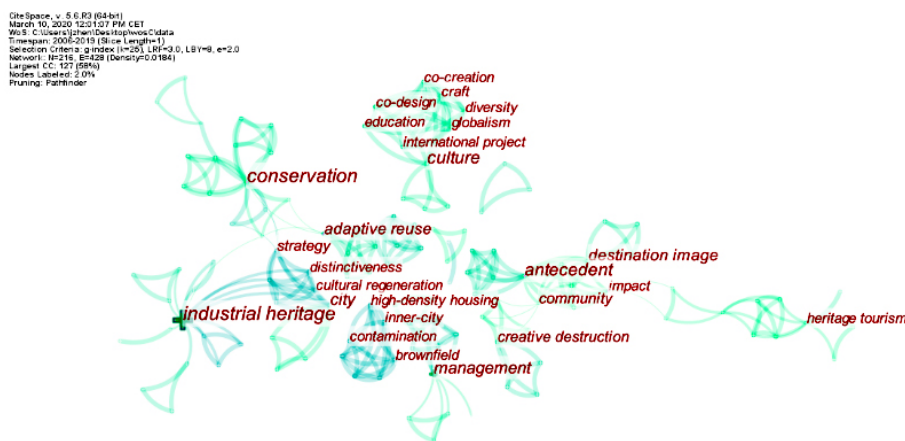
3.3. Research Hotspot Network Map Features

The knowledge map drawn by CiteSpace reflects the frequency of keywords in the literature and the correlation between keywords (Table 1). Based on the 78 latest pieces of research on China’s industrial heritage from 2006 to 2019, it is observed that protection and reuse have always been the focus of industrial heritage research. Over time, in addition to the keyword “industrial heritage”, the keywords “conservation” and “management” began to appear as new objects and methods for industrial heritage tourism and automobile industrial heritage. There are also other keywords, such as “cultural heritage”, “implementation strategy”, “model”, “innovation”, “constantly changing”, and “technology is innovating”.

Table 1. The top 20 high-frequency keywords of papers published on industrial heritage in China during 2006–2019.

No.	Count	Year	Keyword	No.	Count	Year	Keyword
1	18	2009	Industrial Heritage	11	2	2017	Culture
2	5	2013	Conservation	12	2	2016	Adaptive Reuse
3	4	2013	Management	13	2	2019	Conservation Planning
4	3	2015	Creative Industrial	14	2	2019	System
5	3	2017	Heritage Tourism	15	2	2015	Creative Destruction
6	3	2014	Automobile Industrial Heritage	16	2	2014	Strategy
7	3	2015	Impact	17	2	2019	Model
8	2	2015	Cultural Heritage	18	2	2015	Antecedent
9	2	2019	Community	19	2	2014	Protective Principle
10	2	2014	Implementation Strategy	20	2	2014	Renovation

From the clustering results (Figure 4), China’s industrial heritage research has formed a research framework with “industrial heritage” as the main research center, and industrial heritage and creative industries, industrial heritage tourism, industrial heritage protection and urban renewal as the most prominent topics, and the map is distributed in a triangular trend.

**Figure 4.** Clustering map of keywords of the papers on industrial heritage based on the Chinese literature during 2006–2019

3.3.1. Industrial Heritage Protection and Urban Renewal

After the founding of the People’s Republic of China in 1949, the government built extensive industrial infrastructure in the major cities [19], such as Shanghai, Harbin, Shengang, etc. With the transformation and development of society and the economy, many industrial facilities have completed their historical mission and have been gradually abandoned [20]. The protection of industrial heritage has gradually become an important part of urban construction. At present, the research on industrial heritage is closely combined with architecture and other disciplines [21]. Harbin is representative of a traditional industrial city of China, and has been facing the dilemma of population loss and community hollowing for a long time. Cai et al. [22], based on social survey data for the inhabitants of Harbin’s Central Street and Dao Wai historic block, established the measurement factors that affect inhabitants’ social integration to construct a measurement model. Comparing the status quo of the two blocks, they conclude that the promotion of inhabitant social integration requires enhancing dimensions, with lower measurement scores according to the specific conditions of the block. In this

manner, a fundamental theory for a socially inclusive revitalization of historic blocks was established to enhance social sustainability. Besides, Jun Yao [23], et al. take Chongqing as an example, and show the importance of integrating the protection elements and requirements into detailed urban control planning—special planning plays an important role in protecting industrial heritage.

3.3.2. Industrial Heritage Tourism

Industrial heritage tourism is a new form of tourism produced by the integration of industry and tourism [24]. Some of China's resource-based cities are suffering from mineral resource exhaustion and economic transition. Xu [25] analyzed the characteristics and development trend of the mineral-resource-exhausted cities in China and pointed out that the development of industrial heritage tourism is a way to renew and transfer the resource-exhausted cities. With the development of the economy, the research on industrial heritage tourism is increasing in China in many directions. First, it is a case study for a specific region, which provides some reference for other industrial heritage tourism. For example, Cai et al. [26] discuss the inevitability and importance of the Beijing Hangzhou Grand Canal as a world cultural site. With rich natural, engineering and cultural heritage values, it has been operated, improved and maintained for more than 2000 years—the canal represents the world's highest level of hydraulic advancement and water project management before the industrial revolution. Huang et al. [15] discuss the current situation and existing problems of heritage protection of the automobile industry in Shiyang, and put forward the implementation measures and strategies of protection principles. Like the salvage protection of the heritage of the automotive industry, promoting the process of standardizing the heritage of the automotive industry, achieves the productive preservation of the automotive industry's heritage. Secondly, researchers construct the problems and countermeasures of industrial heritage tourism development. For example, Yuan et al. [27] discuss the relationship between residents and industrial heritage tourism through a questionnaire, and emphasizes the importance of building a sense of participation. From the perspective of the heritage chain, Zan et al. [28] stressed the need to manage cultural heritage activities in all stages from an overall perspective. According to the value system, Jiang et al. [29] use the analytic hierarchy process (AHP) to evaluate the site value of six railway lines in the "national industrial heritage list". Based on their different value advantages, they put forward suggestions for the sustainable development of China's railway industrial heritage tourism.

3.3.3. Industrial Heritage and Creative Industries

The protection of urban industrial heritage is a great opportunity for the construction of creative cities [30]. Based on classic industrial heritage research, the research of the creative industry appears. Considering the creative factory sites 798 in Beijing and M50 in Shanghai as examples, the authors of [31] analyzed the advantages and disadvantages of the transformation of creative industries on the industrial heritage site identity and creative distribution regeneration, as well as the specific intervention measures. Yang [32] discusses three aspects for the "renaissance" of industrial heritage, namely functions, forms, and spatial productivity. From 2006 to 2019, research on industrial heritage has a trend of expanding and deepening in breadth and depth. It not only constructs the protection system of industrial heritage as a whole but also evaluates the value of industrial heritage from the perspective of economic measurement, thus forming a macro protection strategy closely related to economics [33,34]. This appears in several innovative types of research in this area.

4. Research and Development of Industrial Heritage in Western Countries

4.1. Network Characteristics of National Cooperation Map

In the WoS core database, the industrial-heritage-related literature in Western countries is far more extensive than that in China. There are 28 nodes and 33 connections in the map (Figure 5). In the figure, the largest number of publications is located in England (41 articles), with an intermediary centrality

of 0.41. England presents the highest level in all Western countries. More publications and a greater centrality indicate the depth of research in this field, the density of cooperation with other countries, and the international influence of England, followed by the USA (17 articles), France (14 articles), and Germany (13 articles), with more than ten publications in these countries. This fact shows that Western Europe and North America attach great importance to the study of industrial heritage and that there is a high degree of activity in foreign cooperation.

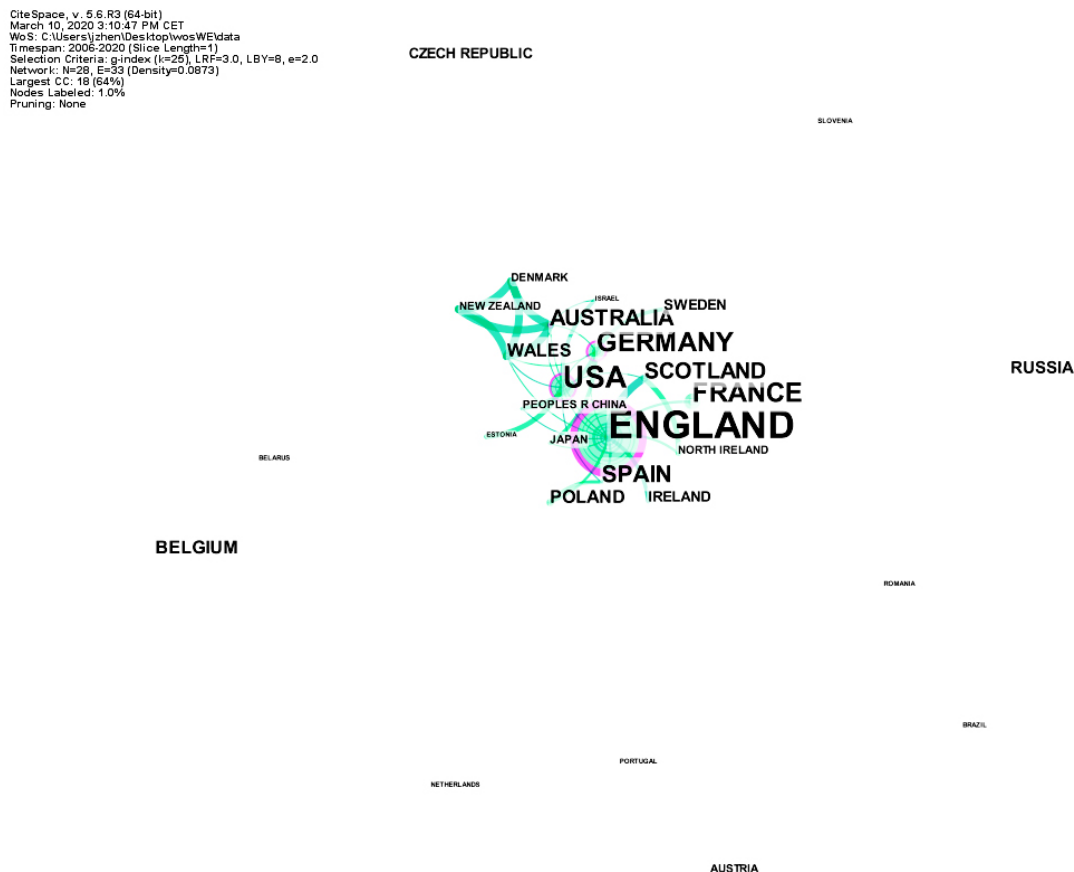


Figure 5. Knowledge map of cooperative countries in the research on industrial heritage based on Table 2006.

There are 161 nodes and 151 connections in the map (Figure 6), of which the largest number of publications come from Cardiff University (4); second is the University of Durham (3), the University of Sheffield (3), and the University of Manchester (3), indicating a strong scientific research influence. Combined with the above analysis of national cooperation networks, it is found that the number of national publications and the strength of their influence largely depend on the scientific research capacity of key national research institutions. In the scientific research teams shown in the atlas (with more than two papers), universities occupy the mainstream and the volume and influence of papers are all above the institutions.

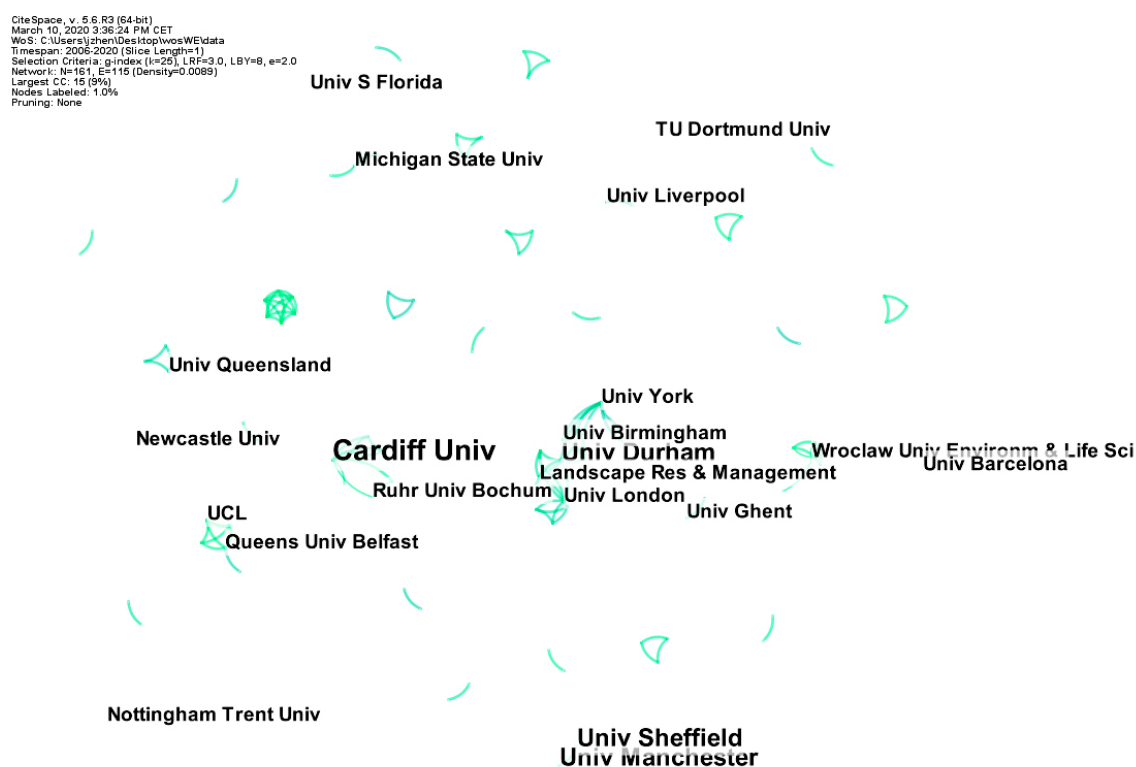


Figure 6. Knowledge map of cooperative institutions in the research on industrial heritage based on the Western literature during 2006–2019.

4.2. Research Hotspot Network Map

In the field of industrial heritage in Western countries, 172 documents have been retrieved in the past 16 years, and the overall development trend is larger than that in China. In the past 16 years, in addition of the central words “industrial heritage” and “heritage” have the highest frequency; the keywords with the next high frequency are “deindustrialization”, “landscape”, and “geotourism”, indicating that Western countries focus on the environmental and human ecological value of industrial heritage. More protection and renewal of industrial heritage has been performed than reconstruction and development. Over time, “remediation”, “climate change”, “community”, and “post-industrial landscape”, etc., have gradually become high-frequency words as well (Table 2). They belong to “site memory remodeling”, “community construction”, and “post-industrial heritage research”, respectively—this shows that industrial heritage research has been strengthened in terms of these fields, too.

Table 2. The top 20 high-frequency keywords of papers published on industrial heritage in Western countries during 2006–2019.

No.	Count	Year	Keyword	No.	Count	Year	Keyword
1	18	2011	Industrial Heritage	11	3	2010	Cultural Archaeology
2	12	2010	Heritage	12	3	2014	Industrial Archaeology
3	6	2011	Authenticity	13	3	2014	Architectural Heritage
4	4	2017	City	14	3	2015	Climate Change
5	4	2014	Catchment	15	3	2014	Change Detection
6	4	2010	Conservation	16	2	2019	Post-Industrial Landscape
7	4	2017	Deindustrialization	17	2	2017	Remediation
8	4	2012	Landscape	18	2	2017	Community
9	4	2011	Geotourism	19	2	2017	Management
10	3	2011	Industrial	20	2	2018	Archive

Combined with the keywords table and cluster map (Figure 7), the industrial heritage research in Western countries has formed a research framework with “heritage” and “industrial heritage” as the main research center, and with industrial heritage and creative industries, industrial heritage tourism, industrial heritage protection and urban renewal as the most prominent research topics—the map is distributed in a triangular trend. The research focus is divided into three parts.



Figure 7. Clustering map of keywords of the papers on industrial heritage based on the Western literature during 2006–2019.

4.2.1. Heritage and Community Building of Industrial Heritage

Specifically, large-scale urban construction in Western countries has developed into a stable status. Academic circles pay more attention to the protection of the existing city features and historical memory and centralize more their interests in the protection of historical and cultural heritage, social equity and justice, and other themes [35,36]. Industrial heritage has the function of historical genealogy and the cultural memory of community origin, and development and evolution, and plays an irreplaceable role in the human and cultural community. In the reconstruction and construction of industrial heritage, Cenci [37] argues that it is necessary to protect cultural heritage and characteristics represented by brownfield sites so that industrial heritage can evolve an identity and develop the character of a heritage site of benefit to the community. For the residents of the industrial site area, the most important thing is to establish a sense of belonging to the site through disidentification, territorialization, and the biology of people and sites [38]. Gourievidis [39] underlines the crucial function of social memory in heritage work, particularly in districts with high levels of socioeconomic deprivation twinned with a degraded self-image. Some mining heritage communities are facing challenges due to pollution. Despite the prevalence and significance of these deposits, they have been neglected by the cultural heritage community in favor of more easily interpretable remains such as mine buildings, technologies of ore procurement and processing, and the final products of manufacture [40]. Besides, there are many ways to preserve industrial heritage, such as building an industrial museum. Kift and Rita [41,42] stress the importance of the industrial museum. Taking the Ruhr Museum as an example, Ritter [43] believes that the old industrial area museum should focus on what was built in the region and how this changed in the context of deindustrialization. Vall [44] suggests that by examining in detail the historical context in which they were created we can better understand the nuanced and complex process of musealization and its relationship to the experience of economic change and deindustrialization. Raines [45] takes the ruins park of Ruhrgebiet as an example to prove that successful conservation has not simply memorized the past—by creating real social progress and promoting the planning process, it has meaningfully shaped the region’s future. McClelland [46] explores the history of the creation of the system for the conservation of architectural heritage in Northern Ireland. Madgin [47],

taking Castlefield, Manchester as an example, stresses the need for continuous assessment of industrial heritage to define its role in urban renewal.

4.2.2. Exploration on the Path of Tourism and Protection of Industrial Sites

The development of industrial heritage tourism projects in Western countries is relatively developed. The research on industrial heritage tourism has a wide range of subjects, and the academic circles are still discussing the definition of its name. The word “industrial heritage tourism” represents different meanings in different languages [48]. All the tasks facing geotourism based on former industrial and mining facilities should form a coherent whole, covering the economic (profitability), ecological (neutrality) and socio cultural (social justice) aspects, and thus fit the concept of sustainable development into tourism [49]. Miyagawa et al. [50] compared two case studies, the salt heritage at Northwich Woodlands and the landscaping former coalfields at Bold Forest Park, St. Helens, to examine partnership for environmental regeneration and management in post-industrial landscapes in the northwest of England. In both cases, the overriding issue is being able to develop resources and partnerships. Coupland et al. [51] established four frames—each frame defines a social dimension in which authenticity can be experienced. Together, the four frames provide a productive means of discursively managing the competing priorities that lie at the heart of heritage tourism. Lei et al. [52] argued that the industrial landscapes reflect both former and current transboundary industrialization processes representing two or more nations’ painful and dissonant, but common, heritage. This should be mirrored more appropriately and consistently in industrial heritage tourism approaches and interpretation strategies. After theorizing and situating nostalgia in the academic discourses surrounding deindustrialization, Berger [53] addresses the deindustrialization process and the accompanying heritagization of the Ruhr before investigating the different meanings and layers of nostalgia that are attached to industrial heritage discourse in the region. Michel [54] compared two different strategies proposed by the French and British governments in 1990 regarding the role that industrial heritage may play in repairing the effects of deindustrialization. Scholars also try to connect the protection of industrial heritage with the political background [55–57].

4.2.3. Post-Industrial Heritage Protection and New Technology Use

An effective tool of the spatial and functional transformation of degraded areas is revitalization. Miśkowiec [58] assesses the impact of the transformation of industrial and urban structure in city areas historically associated with the textile industry. The comparative analysis is related to the largest centers of the textile industry heritage in the UK, France, and Poland. Intangible culture, the spiritual carrier of industrial heritage, is not immutable, but constantly evolving and being reinterpreted as an important part of people’s lives [59]. With the development of science and technology, increasingly more disciplines are involved in industrial heritage research. Howard [60] established that future climate change is likely to pose significant challenges for heritage management, especially in landscape settings such as river valleys, as the magnitude, intensity, and nature of geomorphological processes alter in response to changing threshold conditions. Meanwhile, research equipment is also upgrading. Kincey et al. [61] present the results of research focusing on the interactions between industrial heritage sites and their semi-natural landscape context within the upland landscapes of Alston Moor, the North Pennines, UK. Change detection using multispectral Landsat data was combined with detailed mapping from airborne lidar, aerial photographs, and fieldwork to quantify the rate and nature of the changing condition of selected industrial archaeological sites. Eleanor [62] created immersive and 360° experiences of the historic city that allows the user or viewer to explore how the city might have been in the past from a “first-person” perspective based on a project in Wolverhampton. Opitz [63] introduced the application status and development suggestions of Airborne Laser Scanning (ALS) technology in the industrial heritage archeology community, noting that researchers need to adapt the basic methods used to new landscapes and types of archaeological remains and to integrate the practice of working with ALS with diverse fieldwork and research practices.

5. Results

Based on the statistical analysis of the literature on industrial heritage, this study finds that the volume of industrial heritage research in China and Western countries has been rising steadily in recent years, which has a certain relationship with the economic transformation stage of China and Western countries. The social value of cultural heritage and the development of cultural economy have promoted the development of industrial heritage in the two regions. China's research on industrial heritage started based on analyzing the concept and drawing lessons from the case study of Western Europe, and began to study the connotations, extension, type, characteristics, and value of all aspects of industrial heritage. The basic concepts of industrial heritage are consistent. However, at present, the depth and cutting-edge level of research lag behind Western countries. After decades of development in Western countries, the research and protection of industrial heritage have become more comprehensive, integrated, in-depth, and more interdisciplinary as more subjects involved. Compare with these two areas, they present the following research trends:

Western Europe:

- Diversity in a complex context. Western Europe's involvement in the protection of industrial heritage from the discipline of industrial archaeology is particularly evident in the study of mining heritage areas with outstanding technical features. Both sides combine the context of site preservation, urban transformation, and other disciplines from architecture, urban planning, and tourism.
- Active research. The awareness of the preservation of industrial heritage in Western Europe has its origins in technological innovation, and the treatment of large numbers of abandoned industrial areas has given rise to spontaneous thinking.

China:

- Passive research. The Chinese study was government-led and tied to planning for the future of the city from the beginning.
- The special and challenging coexist. China's research is based on Western Europe, but China has its own special cultural characteristics and historical trajectory. China must learn from the experience of Western European knowledge at the same time. Further, the local adaptation to protect China's local industrial heritage is a major challenge.

Both China and Western Europe attach great importance to the study of industrial heritage tourism and industrial heritage value evaluation, and interdisciplinary research is increasingly close. In the past 16 years, the research on industrial heritage has shown a stable growth trend, and in recent years, the number of international publications has increased significantly. Nonetheless, according to the bibliometric analysis, there are differences in the development of industrial heritage research between China and Western Europe. The research methods and means in China are greatly influenced by foreign countries and a lack of innovation.

6. Discussion

As the leading region, Western European research is guided by factual development. The research have several branches, such as applying new techniques, community restoration, and ecological environment restoration, etc. Notwithstanding, they have extended in many directions but there is no unified category.

As a developing region, China's industrial heritage research is guided by national policy priorities. Researchers do not put protection and reuse issues in the context of urban planning, and prospectively solve the problems faced by the transformation of resource-exhausted cities, especially in their brownfield ecological environment restoration. Most of the studies on the protection and reuse of industrial heritage are based on case studies exploring the ways and means of protection and reuse, and lack in-depth analysis from the perspective of economics and sociology, especially the research on

the construction of an overall system and policy system. In further research on industrial heritage, the following directions can be considered:

- First, the theoretical basis of industrial heritage research, the development of a complete discipline system of industrial heritage, and the promotion of standardized development of industrial archaeology and industrial heritage protection and reuse.
- Second, the cooperation between China and Western Europe shows that the industrial heritage of China and Western Europe are in different stages of development. Strengthening cooperation is conducive to the realization of complementary advantages.
- Third, research on the relationship between regional and urban development and industrial heritage. The revitalization of old industrial towns and the reuse of industrial heritage, not only including the town sbut also the regions.
- Fourth, ecological environment restoration can start from the direction of green infrastructure to restore or reuse industrial heritage brownfield sites.

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Nomenclature

Acronyms Original

WoS	Web of Science
AHP	Analytic Hierarchy Process
ALS	Airborne Laser Scanning

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