Analysis on Research Hotspots of Project Risk Management Based on CiteSpace

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Abstract. The project risk management is one of the construction procedure that the project builders are most concerned about. How to find the best way to avoid the risk through the project case is also what the current managers need to explore. In order to investigate the research hotspots and development trend of project risk management from 2014 to 2024, CiteSpace retrieval software was used to perform cluster search analysis on 998 relevant literatures in the core journals of China National Knowledge Infrastructure (CNKI) and Web of Science (WOS) during this period. The research mainly sorted out the hot time series and keywords, and analyzed the research trends and hotspots: Within the selected time range, the number of research literatures on hot topics showed an overall rising trend, and the number of hot keywords cluster also increased with time. The keywords of CNKI and WOS core journals in the two categories of Risk management and Construction management are all searched by cluster, so it can be considered that the two journals have similar results in the research development trend and cluster analysis. The project risk management method still needs to adopt a conservative and secure method, and the project portfolio risk management method has more innovative advantages. The traditional project risk management method can be extended to more comprehensive industries in the future, such as new energy industry and high-tech industry.

Keywords: CiteSpace; CNKI; Web of Science; time series analysis; cluster analysis.

1. Introduction

Regardless of the size and design difficulty of the project, a complete and effective engineering project is a complex work system, including design, measurement, construction, acceptance and other stages, which has the possibility of high risk in the implementation of each stage. The safety risk management in the construction stage is of great significance for ensuring the safety of people's lives and property and promoting social stability [1]. In order to ensure the reasonable progress and timely completion of engineering projects, some project researchers believe that identifying the risk factors of engineering project implementation is an important prerequisite for effective risk management [2]. It can be considered that the risk avoidance methods of engineering projects are constantly improving with the changes of The Times. For example, the risk avoidance methods once used in large-scale civil engineering can also be applied to the construction and maintenance of hydropower facilities. And the avoidance measures used for small projects can also be combined and used to become a set of risk avoidance system.

Sun et al. [3] believed that the project management system can be summarized into three specific aspects, which are objectivity, complexity and overall. Mistakes in any one aspect will lead to the risk delay of the project, and then generate unnecessary losses. Therefore, Wang Tao and other scholars studied practical projects, starting from project timeliness and stage planning, emphasizing the need to combine stakeholders and management departments to make overall planning and arrangement, and established practical risk research methods by means of avoidance mechanism and risk transfer [4, 5]. This paper makes use of the research literature from 2014 to 2024 as a reference, and summarize the mechanism and method of risk management in engineering projects.

2. Research Methods

2.1. CiteSpace

The purpose of this study is to use the analysis retrieval system of CiteSpace software to synthesize and derive the basic information of literature for topic cluster analysis. With information extraction and clustering as its main function, CiteSpace can process data, display trends and development trends through visual charts, and search and analyze the contents of WOS core journals, CNKI and other international academic literature [6]. Firstly, subject information keywords in scientific literature are extracted. Then, according to the correlation degree and contact density of each type of literature information, different correlation network lines are formed. Nodes of different sizes in the network diagram represent the main keywords of literature information, and the size of nodes depends on word frequency and centrality [7]. The network connection represents the connection between nodes. The correlation degree and clustering can be analyzed by using the network connection and network graph information, and the development trend of research disciplines and the research direction of related researchers can be found.

2.2. Database

In this paper, CNKI and WOS databases are retrieved and extracted from the highly cited core journal literature of great significance in the field of engineering project risk research for analysis. In the CNKI database, literature related to the risk management of engineering projects by Chinese scholars during 2014-2024 is mainly retrieved and exported. After the subject and subject range relevance screening, CiteSpace retrieval software was used to retrieve a total of 750 valid literature from dozens of institutions as sample data. In the process of extracting the WOS database, the research screened the literatures of international scope according to the same method mentioned above. However, due to the limitation of the export format by CiteSpace software, the initial retrieval samples were only 378 papers from international core journals. In order to ensure the accuracy of the study and the reliability of the trend analysis, secondary screening was carried out, and teaching literature and extended literature were deleted. A total of 248 valid literature were obtained as sample data after software de-duplication. Therefore, the data and literature provided by CNKI and WOS databases will be analyzed separately in this study, and conclusions will be summarized. This paper divides the selected articles by keywords, and obtains CKNI and WOS retrieval time series graph, cluster graph and keyword network graph respectively according to the number of references and centrality. The index module value Q and the average contour value S of CiteSpace generated images can measure the drawing effect of the cluster map. Within the range [0,1), $Q > 0.3$ indicates that the structure of the generated cluster graph network is significant, and the larger the Q value is, the better the clustering effect is, S value reflects the fitting and homogeneity of the cluster graph network, $S > 0.5$ indicates that the generated cluster graph is reasonable, and $S > 0.7$ indicates that the cluster graph is highly credible [8]. According to the image results, Modularity Q=0.4618 in the CNKI image, Mean Silhouette =0.8192; In the WOS image, Modularity Q=0.3932, Mean Silhouette =0.7229. The clustering graph based on the CNKI and WOS databases in this study is reasonable and the network structure is significant.

3. Research Direction Data Analysis Based on CiteSpace

3.1. Timing Analysis

In this study, the time series analysis method of CiteSpace is used to draw the bar chart of the annual publication volume of engineering project risk management papers and the keyword co-occurrence time chart according to the time series. These two kinds of graphs are hierarchical classification analysis of researchers at different time stages by using time-point keyword clustering

method. At the same time, the macro-structure of the knowledge domain and its future development can be described through the time series diagram [9].

The relevant literature on project risk management in CNKI and WOS websites from 2014 to 2024 was selected and the valid data were analyzed in detail. Fig. 1 and Fig. 2 are time graphs of CNKI and WOS database publications, respectively. It can be seen from Fig. 1 and Fig. 2 that scholars' research on project risk management shows an overall increasing trend from 2014 to 2024, and the time series analysis trend of literatures in the two databases is roughly the same. In this stage of research, scholars not only extended the analysis method of project risk to other fields, but also gradually improved the concept of project risk. Fig. 3 is a keyword co-occurrence time graph derived by WOS, where #0 construction management, #1 project management, and #4 Chinese contractors are cluster topics with more nodes. Depending on the domain and the level of content, this kind of graph can provide a clear explanation: the # number section on the right side of the graph represents the large items that cluster keywords. For example, the WOS database studies the time nodes of two similar related keywords construction projects and project management, both from 2014, and has been extensively expanded in this area of research. In addition, the position of the image on the horizontal axis represents the point at which new research keywords are generated, while the size of the node represents centrality and correlation.

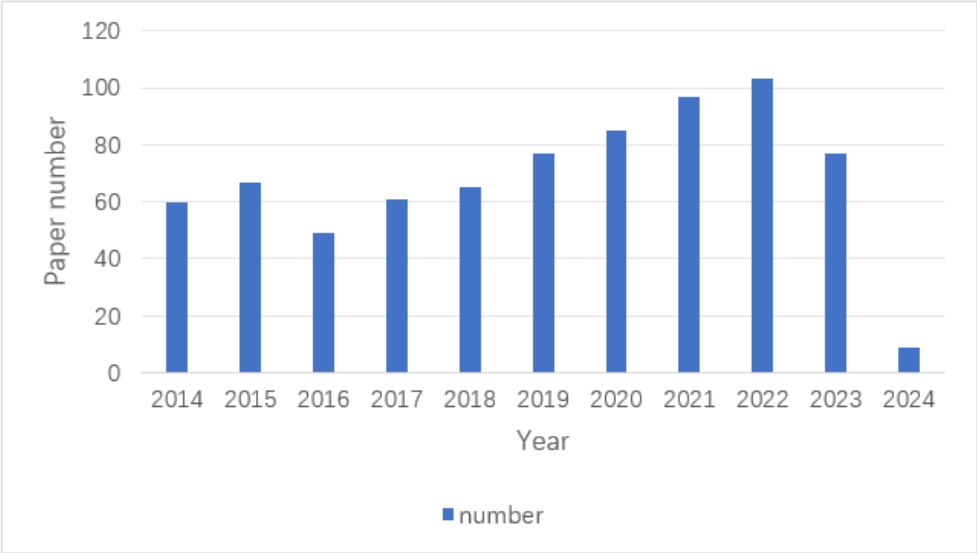

Fig 1. The number of new papers added annually by CNKI data.

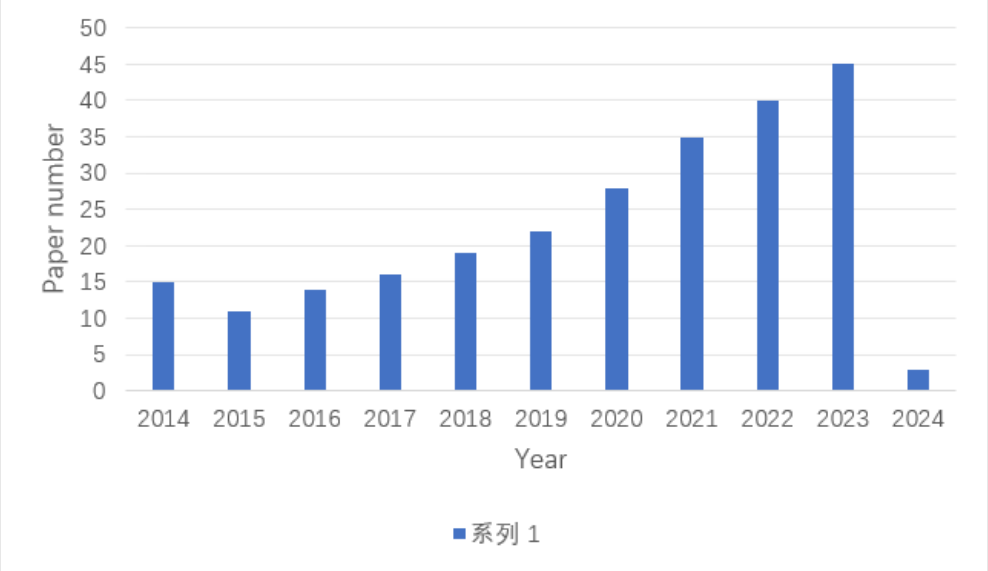

Fig 2. The number of new papers added annually by WOS data.

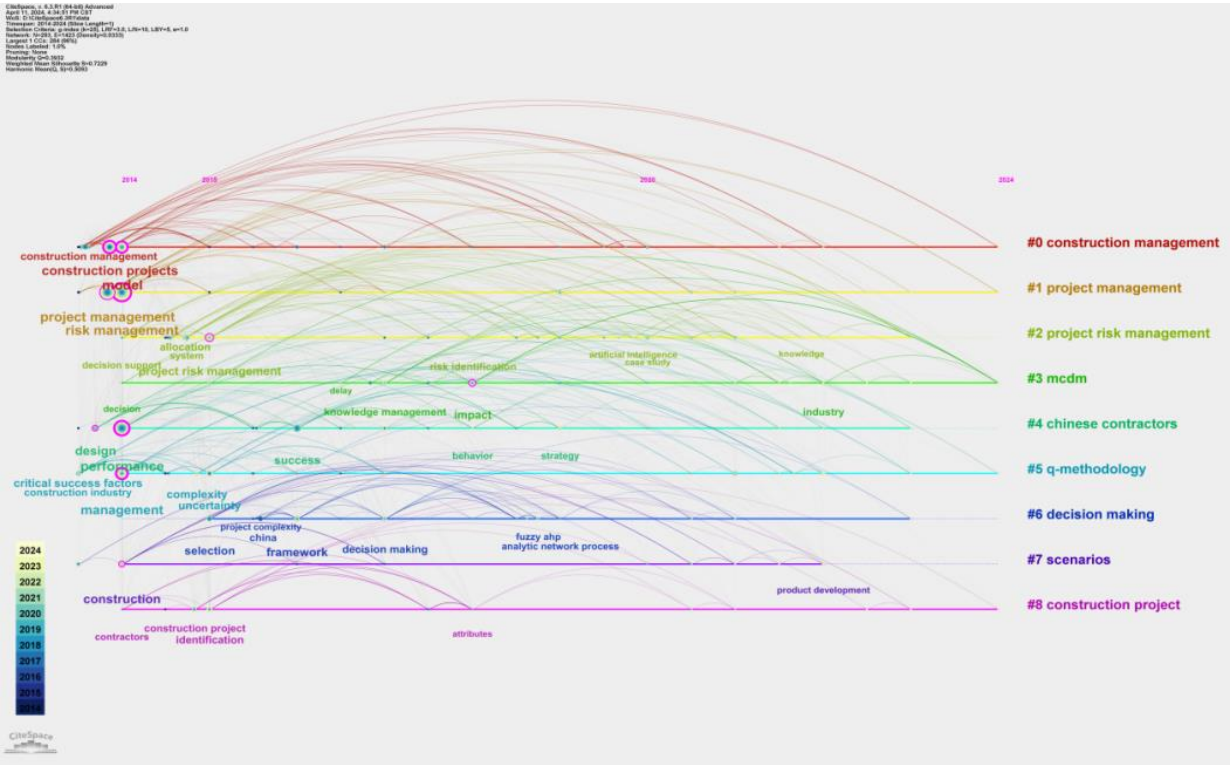

Fig 3. Keyword clustering time series diagram generated based on WOS.

3.2. Keyword Clustering

In order to analyze the key research areas of engineering project risk management, CiteSpace is used for cluster analysis of keywords. Firstly, the default algorithm of CiteSpace is used to classify keywords and test and extract labels. Different keyword clusters represent different knowledge fields. If the clusters are the same, the research fields are the same. This paper selects the number of clusters from 0 to 4, and selects the keywords of the top five categories with higher word frequency and centrality as research reference, as shown in Table 1 and Table 2.

Table 1. Keyword frequency and centrality information generated based on CNKI.

Sort	Frequency	Centrality	Year	Keywords
0	375	1.14	2014	Risk Management
1	233	0.25	2014	Construction Engineering
2	122	0.56	2014	Engineering Projects
3	107	0.2	2014	Project Management
4	74	0.12	2014	Risk

Table 2. Keyword frequency and centrality information generated based on WOS.

Sort	Frequency	Centrality	Year	Keywords
0	304	0.26	2014	Risk Management
1	170	0.18	2014	Project Management
2	152	0.21	2014	Management
3	99	0.24	2014	Performance
4	65	0.23	2014	Model

According to the excel tables derived from CiteSpace keyword frequency and centrality and the keyword network graph generated from the exported literature, it can be seen that the data derived from CKNI and WOS have similar keyword induction in risk management and project management. For example, Table 1 and Table 2 show that the literature from the two websites have word frequencies of 375 and 104 in the risk management section, and 107 and 70 in the project management

section. This can fully prove that in the content of risk management of engineering projects, research is mainly aimed at risk management avoidance of projects, actively looking for ways to minimize losses, and constantly expanding to actual engineering projects, even including the industrial planning of large-scale industrial industries, such as aerospace park and oil refinery park. Table 3, which is generated by using the keyword prominence chart of CNKI database, illustrates the proportion of two keywords Problem and Financial Management mentioned in research literature, and can speculate the impact of these two factors on project risk management. Table 3 corresponds to the keyword network diagram of WOS database. Fig. 4 can clearly show the situation of keyword hotspots and network links, and larger points such as Risk management and Project management can explain the proportion of these factors in literature data, and also show that these two factors have a high impact on the research topic.

Table 3. Keywords with the strongest citation bursts in CNKI.

Keywords	Year	Strength	Begin	End	2014 - 2024
Manage Risks	2015	1.27	2021	2024	
Analysis	2015	2.07	2015	2017	
Financial Management	2016	2.78	2020	2021	
Problem	2021	2.7	2021	2022	
Tendering and bidding	2015	1.93	2019	2020	
Risk analysis	2014	1.61	2014	2015	
Project	2016	1.28	2016	2017	
Exchange rate risk	2019	1.22	2019	2020	
Building construction	2019	1.22	2019	2020	
AHP method	2014	1.2	2014	2015	



Fig 4. Keyword information network diagram of WOS data.

In order to summarize and distinguish the aggregation of research parts more clearly and effectively, the experiment uses network graph clipping and network method clipping to obtain the keyword cluster analysis graph, and summarizes the research content with reasonable regional coincidence and relevance. The results are shown in Fig. 5 and Fig. 6.

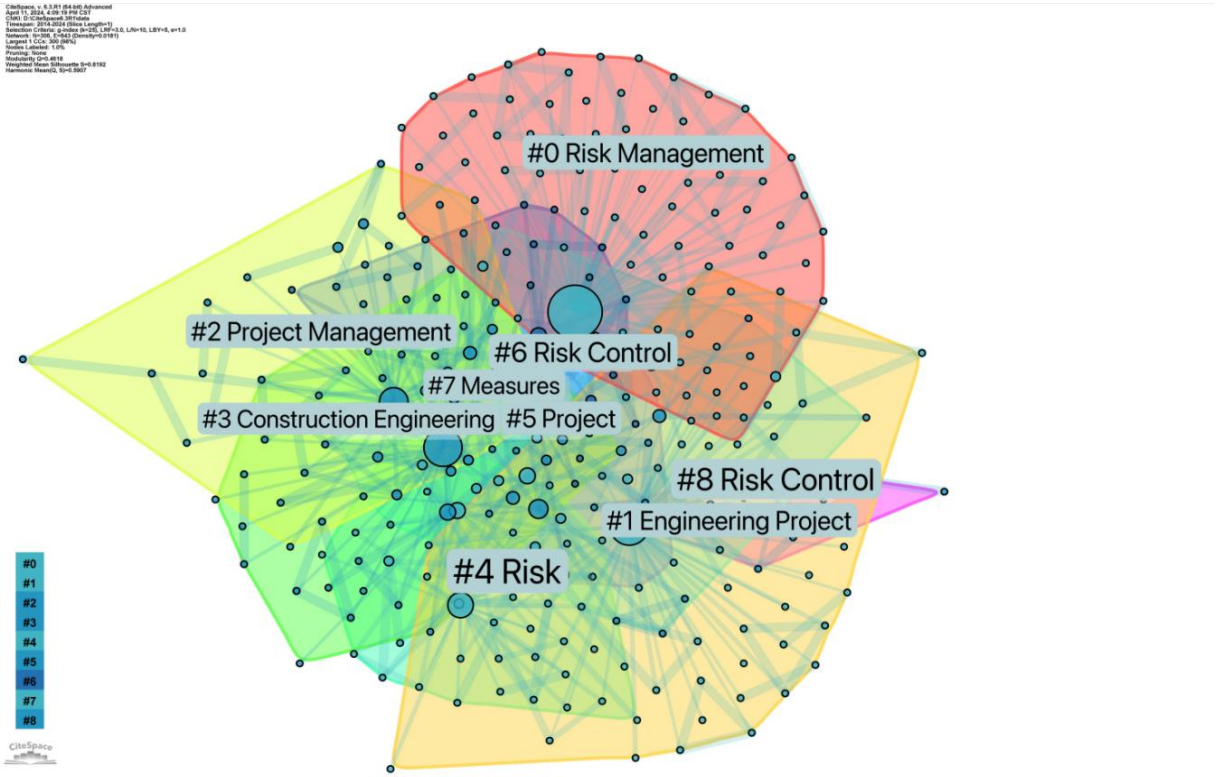

Fig 5. Keyword clustering analysis of CNKI data.

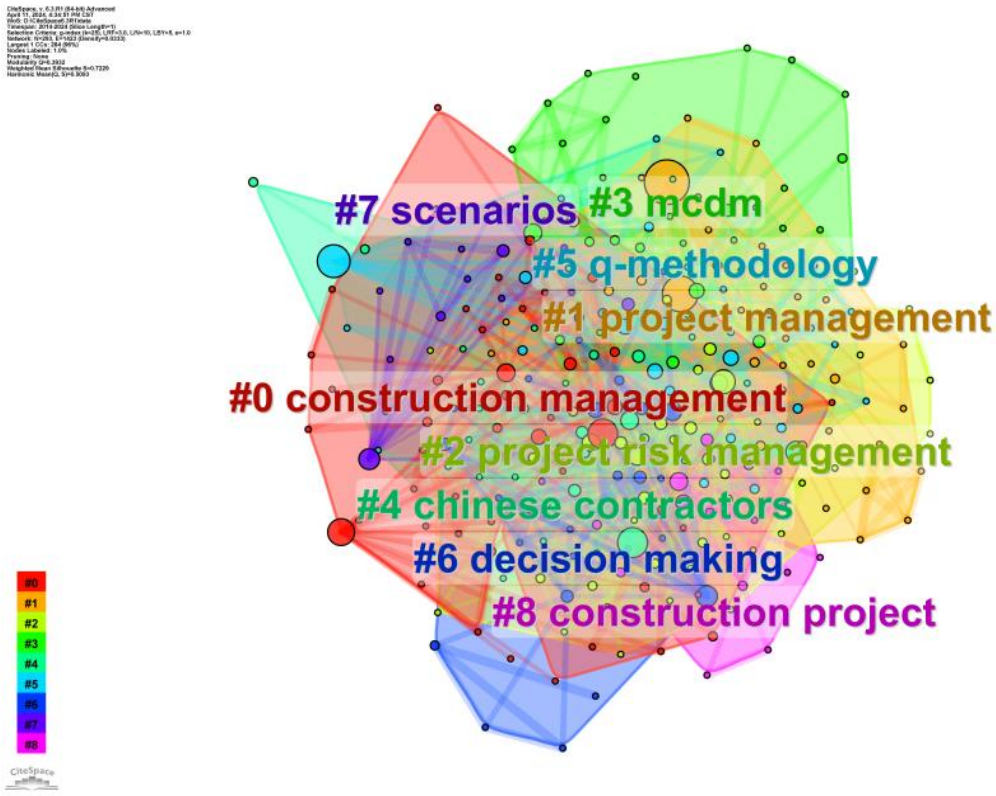

Fig 6. Keyword clustering analysis chart for WOS website.

According to Fig 5, in the data of CKNI, category #0 is named "Risk Management", which focuses on the research status and summary of risk assessment, prediction and avoidance in various engineering planning, and forecasts the risk avoidance measures in the future. Category #1 is named "Engineering project". The data of this part is mainly from international actual projects, and the risk situation of this kind of engineering projects is summarized. In category #2 "project management", the data summary is similar to category #1, but the literature content mainly puts forward project

management suggestions for specific examples, introduces the types of risks and countermeasures, and does not make too much summary, which belongs to the review literature. In category #3 "Construction Engineering", it mainly extends the discussion of categories #1 and #2, and carries out risk analysis for other large enterprise projects, such as the risk avoidance of new energy automobile industry and low emission industry, which belongs to the category extension of the former. While category #4 "Risk" mainly introduces the risks and types of risks faced by large-scale projects, which has little to do with specific engineering projects. It is a summary of the types of project risks.

In the WOS data keyword network diagram of Fig 6, category #0 is named "Construction Management", which mainly introduces the management measures of large-scale projects, gives a large number of examples and analyses in terms of project risks and countermeasures, and mainly explains the relevant content of risk avoidance. The name of category #1 is "project management", which is similar to CKNI data. This part mainly analyzes actual projects in the world and makes specific analysis according to specific situations, but the difference is that the literature here makes more detailed planning and outlook on the risks of different projects. In #2 "project risk management", it mainly studies and analyzes engineering projects in different fields, countries and time, and evaluates and summarizes the risks of engineering structures and construction materials in combination with the professional knowledge of engineering management. It is a summary of risk management mainly for large-scale construction projects, which is highly professional. In category #3 "mcdm", it mainly introduces the decision making of multi-criteria, which then affects the formulation of risk decisions and measures, which belongs to the category content extension of the former. While category #4 "Chinese contractors" is the main influence factor of introducing personnel, similar to category #4 of CKNI data, which has little relationship with specific engineering projects, but only summarizes a specific category of project risk.

3.3. Research Hotspots

The keyword sequence graph, network graph and cluster graph generated by CiteSpace clearly show the research trend and expansion direction of experts and scholars in the field of engineering project risk management, and the attention of major keywords can also represent the research situation in a certain field during this period. According to CiteSpace data screening, the following analysis can be made:

In terms of time development trend, the number of documents originating from CNKI and WOS websites showed an upward trend during the period of 2014-2024. Related research on risk management of engineering projects in this section mainly focuses on risk avoidance and program planning, assisted by other influential factors such as contract relationship, project management, risk model components and other fields, the risk management system is jointly formed, and the independence of the risk management system is guaranteed through professional supervision [10]. The research theme and content mainly focus on the avoidance of risk management of engineering projects, analysis of influencing factors, as well as expanding and exploring the interaction relationship in other project risk avoidance aspects. At the same time, the continuous updating of the time nodes of the time series chart and the density of the network chart can reasonably explain the expansion of the content of this field. The risk management methods applied to engineering projects can gradually be used to solve the problems in the field of new energy and high-tech industry. For example, Wang Zhi et al. used the large-scale engineering of offshore oil exploitation to explain that reliable risk avoidance still depends on technology integration and personnel training [11].

In terms of keyword clustering, the words with high intensity in CNKI data are Risk Management, Engineering project, project management, Construction Engineering and Risk; In WOS data, the words with high intensity are Construction Management, Project management, Project risk management, mcdm and Chinese contractors. It can be seen that the hot spots of engineering project risk management mainly focus on project management and risk avoidance, at the same time, there are also decision-making and human factors. The breakthrough time of the above keywords in their respective databases is also the longest, indicating that the content related to these keywords has

important themes or development directions in the field of engineering project risk management in recent years, and these development trends and development directions are consistent with the situation of the time series diagram, so the results can be considered effective and reliable.

In terms of keyword centrality and word frequency, according to the data in Table 1 and Table 2, it can be seen that the high-frequency keywords in the literature all originated from 2014, the beginning year of the screening section. Therefore, it can be found that the research in the field of engineering project risk management had formed a relatively complete analysis system and research methods before 2014. At the same time, the results of Part 3.2 can also be explained that the research on project risk in the relevant international scope is mainly based on the planning extension of project management, and risk management and control is always discussed as a necessary part of engineering projects. It is necessary to adopt a conservative and prudent approach for different projects and adopt a combination of avoidance methods to control project risks [12].

To sum up, by clarifying the relationship between keywords, it can be concluded that the application areas of risk management are mainly engineering project management and project planning, etc., and its research and development trends are as follows: large-scale science and technology projects, new energy technology industry planning, etc.

4. Conclusion

Using CiteSpace retrieval software, this paper summarizes and analyzes the research literature of the core journals of engineering project risk management, and draws the following conclusions:

(1) This paper uses CiteSpace to cluster and summarize literature database. In the process of literature screening, a total of 998 valid data articles were selected by using CiteSpace's de-duplication ability, including 750 CNKI core journals and 248 WOS core journals. The retrieval function divides the previous literature into several keyword categories according to keywords, and visualizes the literature trends to help researchers clearly analyze the development of hot topics.

(2) Based on the analysis of time series, keywords and hot spots, the research results are as follows: Most international analysis of engineering project risk management focuses on project management and risk avoidance, especially most scholars emphasize the need to establish a sound risk management organization and establish an independent risk supervision system. In the cluster analysis, the research finds that the development of risk avoidance in high-tech industry has been mentioned in the literature in the past five years. It can be believed that with the continuous development of science and technology, basic risk avoidance measures and research methods are constantly updated, but on the whole, they are still included in the traditional system. In all major engineering projects, in order to properly guarantee the timeliness of the project, most research cases still choose relatively traditional methods for risk avoidance. Therefore, the study believes that the risk research of large engineering projects still needs to rely on relatively conservative measures, while many small projects can make innovative attempts to enrich the risk management research system.

(3) Due to the influence of research time limit and research database, only 1178 core journals were extracted in this study, and only 998 were valid data. Therefore, limited by the number of studies, there are certain deviations in the development trend and keyword clustering summary of this study. In addition, due to the limitation of research projects, the analysis scope of this study is also limited. However, the data cited in this study is the core journal literature, which is relatively representative and authoritative, so the research results are persuasive. In a word, risk avoidance and management should be carefully considered in the process of project management of all types. Various types of emerging technology industries can also learn from the management methods of traditional industries, and use the project portfolio risk management method to reduce the risk probability. In the future project construction, only by constantly improving the project management system, reasonably avoiding risks, and coordinating personnel training, can the construction risk be reduced and the innovation project management system be continuously enriched.

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