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Research Article

A Study of the Influence of Collaboration Networks and Knowledge Networks on the Citations of Papers in Sports Industry in China

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A scientific paper's citation represents its influence, which is the most intuitive indicator to access the quality of papers. This paper mainly adopts the social network analysis method, using the authors and the keywords of sports industry papers in China to constitute the networks of collaboration and knowledge, to explore effects of the degree centrality of authors and keywords and the structural hole of authors and keywords on the citation of papers in the collaboration and knowledge networks and draw the following conclusions: (1) as for collaboration networks, the degree centrality at the paper level is positively correlated with citations; (2) in the collaboration network, the positive correlation between the structural hole at the paper level and citations does not exist; (3) within knowledge networks, an inverted-U shape was found between degree centrality and paper's citation; and (4) within knowledge networks, a positive correlation is in existence between the structural hole of papers and their citation. This study synthesizes the already widely used collaboration network with the knowledge network constructed through keywords, distinguishes from the previous network features focusing at the author level, and explores research projects of Chinese Sports Industry from the paper level, providing a new perspective for the research of sports industry in China, complementing the methods and ideas of sports industry research, as well as providing a reference for the research in other disciplinary fields.

1. Introduction

An article's citation manifests the times of the article will be used in subsequent research [1, 2], also the simplest and direct way to evaluate the paper, which represents the position of the paper in the context of academic research and the role it plays in scientific activities from the perspective of historical retrospection [3], and it plays an important role in talent evaluation, scientific research project establishment, and scientific research award. In addition, a series of indexes are derived from the citation amount of the paper. Therefore, the citations of a paper are often used to appraise the papers' impact [4, 5]. As the final manifestation of research achievements, the influence of papers can reflect the usefulness in some fields [6–8]; the higher the citations of a paper, the more recognized the paper's conclusion and the

greater the reference and significance for other scholars to conduct follow-up research. Previous studies have found that papers' citations vary greatly, with some papers receiving many citations, some reaching hundreds or even thousands of citations, while the majority of papers receive fewer citations, or even nearly 20% of papers are not cited at all [9, 10]. This may cause the consideration of academia: what exactly are the principal factors affecting the papers' citation?

Scholars studied several factors affecting the citations of a paper from different perspectives. For example, Bornmann et al. (2008) found that the emergence of citation relationships in academic papers may be due to academic aspects, or it may be due to some nonacademic considerations [11]. Tahamtan et al. (2016) outline the factors affecting the citations of a paper, most notably, followed by reasons such

as the abstract and other paper-related factors, the impact factor and other journal-related factors, number of authors, and other author-related factors [12].

With the development of social network research, Abbasi and Jaafari (2013) suggest that it is feasible to explore the number of citations of papers by constructing social networks [13]. Scientific collaboration networks are also a typical type of social network that is coming into the limelight [14, 15]. Authors have relatively different access to resources depending on their position in the scientific collaboration network, which can significantly affect the number of citations they receive [16, 17]. For instance, Li et al. (2013) found that the degree centrality of authors in a collaboration network was positively correlated with their citations [18]. Abbasi et al. (2011) investigated the relationship between authors' network characteristics in scientific collaboration networks and their citation performance and found that authors' degree centrality was positively associated with author citation performance, as was structural hole [19]. Based on this, since the knowledge network and collaboration network are also typical social networks, and they will affect the citation at the same time, this research attempts to further explore how the knowledge network affects the citation of papers, that is, quantity.

Compared with the collaboration network, another typical social network, that is the knowledge network, has not been attached importance in the research of paper citations. Knowledge networks are networks formed by the combination of scientific knowledge elements that can represent categories of knowledge domains. For example, patents are often divided into categories to distinguish them from technical features, and different patent categories represent different knowledge elements [20]. Similarly, after embodying knowledge elements that are keywords in scientific research papers, a collection of papers can also construct a complex knowledge network from a macro perspective. The current research also proves that the keywords of papers can be considered as knowledge elements. For instance, Su and Lee (2010), Assefa and Rorissa (2013), and Yang et al. (2016) built a knowledge structure map of a subject through keywords [21–23], Xie et al. (2008) used keywords to analyze trends in the evolution of research hotspots [24], and Chen (2006) used keywords to detect knowledge hotspots [25]. However, there are few research projects on the issue how knowledge networks affect the influence of papers. On the theoretical level, the collaboration network is decoupled from the knowledge network reciprocally, and the author's position does not commensurate with his knowledge elements' position. On the one hand, papers usually have different network structure characteristics in the embedded two networks. On the other hand, the formation mechanism of the two types of network structure characteristics is different. The formation of the collaboration networks structure characteristics mainly depends on the author of the paper. The formation of the structural characteristics of knowledge network depends on a large number of other past studies, so the two types of network should be treated differently. On the practical level, since the optimization of collaboration networks mainly involves collaborators selection, the optimization of knowledge networks further involves the adjustment of the research theme and the way of expression during the whole research process, and the content and timing of the optimization of them are different. Therefore, a separate discussion between the two can also further enrich the solution to the problem of increasing paper citation and influence.

Based on this, this study uses keywords to represent the knowledge elements of the papers, and because knowledge elements are affiliated by the co-occurrence of keywords in predecessor's research, we construct a knowledge network through keyword co-occurrence. The size of the knowledge network will grow larger over time, while the categories of knowledge elements will become richer and new combinations of knowledge elements will be added [26]. The richer the variety of knowledge elements and the new combinations that are constantly being added ultimately also promote the evolution of knowledge networks. In this research, we argue that a knowledge element's position affects the opportunities of combining knowledge elements with others. For instance, a centrical knowledge element is more searchable because it has more element-coupled content and experience. Therefore, we believe that the location attribute of the knowledge element affects the citation of the paper. By introducing knowledge networks, we hope to enrich the research on the influencing factors of paper citations.

The data used in this study are publications on China's sports industry from 2000 to 2021. The 2018 Government Work Report made it clear that the sports industry entered the overall layout of the national economy for the first time, and the sports industry was also clearly defined by the National Development and Reform Commission as a "new wind outlet" for economic development. In 2019, the Outline for Building a Leading Sports Nation was issued by the General Office of the State Council, which proposed that by 2035, the sports industry will be developed into one of the pillar industries of the national economy. It can be predicted that the sports industry will usher in a golden period of development. The scientific research on the sports industry also provides a scientific guarantee for the sports industry to become the pillar industry of the national economy. Of course, the in-depth and promotion of the research cannot be separated from the reference and significance brought by the related citations. Previous publications on citations focus on the author level, institutional level, or journal level. However, considering that citations vary in different publications for the same author, and the average citation is not enough to reflect the influence level of each paper, this paper made a specific analysis of the citation amount from the paper level. Considering the average level of authors or keywords in each paper, this paper studies the influence of the average degree centrality and average structure hole of authors or keywords on the citation from the collaboration and knowledge networks, respectively. It concerned how authors' and keywords' location attributes in the network affect the citations of a paper, which gives a new dimension to study the influencing factors of citations in the sports industry and provides a reference for the improvement of the quality of papers in sports industry and even the field of

sports science. At the same time, this study can not only provide theoretical reference for subsequent scholars on how to improve scientific research quality and the amount of citation but also provide the theory basis for performance evaluation of the scientific research of scholars and the scientific guarantee for the sports industry to become a pillar industry of the national economy. This study has the following contributions: (1) we have constructed a knowledge network by using keywords from the paper, which fills a gap in previous research and will inspire further relevant research; (2) particularly, the mechanism about how degree centrality and structural holes in collaboration and knowledge networks impinge on citations is probed respectively. Specifically, the location attributes of nodes in those two networks are taken as the influencing factors on citations; and (3) this study places emphasis on article-level citations.

2. Theoretical Background and Research Hypothesis

Collaboration and knowledge networks are important contents of social network analysis and common methods in scientific research. The network characteristics of each node in the network vary, and the opportunity to acquire new information in the network is also different [27]. The feature analysis for nodes in collaboration and knowledge networks is the key to the application of social network analysis methods and high-quality achievement. In our study, degree centrality and structural hole are picked as two network attribute indexes to carry out related research. Degree centrality shows the amount of nodes who are in direct contact with node i in an N-nodes network. The higher the degree centrality of a node, the more nodes it contacts, and the more superior the node is in the network. Structural hole refers to that in the network, if a node has a direct connection with two nodes that are not in direct connection with each other, then this node occupies a position of the structural hole. Structural hole is a key attribute of nodes in a network. By occupying the position of the structural hole, nodes can obtain nonredundant information efficiently. Two network characteristic indexes, degree centrality and structural hole, were selected for the following two reasons: first, with the deepening of the scientific research, more scholars prefer to study local indicators of network attributes, and the degree of centrality and structure hole is not only a commonly used indicator in network analysis but also the network attribute local index [27]; second, if other independent variables, such as betweenness centrality and closeness centrality, are added, the inhibiting effect may be generated when the model is established and the combined effect of independent variables on dependent variables is analyzed, thus leading to the reverse β coefficient [19].

2.1. The Collaboration Network.
The collaboration network in this research, in other words, is the researcher coauthorship network, where nodes and ties represent researchers' cooperative relationship in prior papers. The collaboration network refers to scientific collaboration network, in which each node means an author, and the existing edges between nodes indicate that two authors have worked together previously.

2.1.1. The Influence of Degree Centrality on Citations in Collaboration Network. If a central location is occupied by an author in a collaboration network, it means that the author is likely to have numerous connections and access to the required information and resources [16]. The external information and fresh ideas provided by the resource can promote the research process. At the same time, by exchanging ideas with more different authors, their theoretical horizons can be broadened to a certain extent, which is of great benefits to improving the research quality. All these make them more likely to produce highly influential scientific research results [28]. Meanwhile, the higher the degree centrality of authors, the more frequently they cooperate with others in the collaboration network, which is bound to enhance their popularity, gain structural social capital, and get more attention and citation for their achievements. Some scholars have found that in the collaboration network at the author level, the degree centrality of authors is positively correlated with their citation performance. Abbasi et al. (2011) found that the degree centrality of authors was positively correlated with the g-index constructed based on the citation of articles [19]. Hao et al. (2020) studied 14,913 publications in SCIENCE journal from 2000 to 2018 and found that, in the scientific collaboration network at the author level, authors' degree centrality has a positive correlation with citation of their papers [29]. Thus,

H1a: for a paper, its authors' average degree centrality in the collaboration network is positively correlated to its citation count.

2.1.2. The Influence of Structural Holes on Citations in Collaboration Network. If an author is connected with those who are not connected to each other, then he crosses the structural hole. For instance, there are authors A, B, and C, author A is a structural loophole connecting author B and author C. When author A is in direct contact with two partners (author B and author C), there is no connection between the two partners. In other words, author A occupies the structural holes location. The structural hole illustrates the degree of interrelation among authors who have cooperated with an author in the cooperation network. The more structural holes the author occupies, the easier it is to gain control advantage [30], that is, authors occupying structural holes are more likely to have potential opportunities to control the flow of information between unconnected authors [31]. Moreover, structural holes are the hub of heterogeneous information flow in the network. The ties established by structural holes are nonredundant, and authors occupying the positions of structural holes can obtain a large amount of nonredundant information. With such nonredundant information, authors are more likely to improve their research quality and obtain more citations.

H1b: for a paper, its authors' structural holes in the collaboration network are positively correlated to its citation count.

2.2. The Knowledge Network.

The knowledge network here is composed of the keywords in papers as knowledge elements, in which every node signifies a keyword, and the interconnection between nodes means the co-occurrence of keywords in previous studies. The knowledge network refers to the network composed of the keywords of the paper as knowledge elements, in which each node means a keyword, and the existing edges between nodes indicate the co-occurrence of keywords in previous studies.

2.2.1. The Influence of Degree Centrality on Citations in Knowledge Network.

Knowledge elements' degree centrality in the knowledge network indicates the degree of combination with other elements. Knowledge elements consist of parts that depend on each other to form a larger scale of knowledge system [32]. The combinatorial opportunities tend to rise with the increasing of knowledge element's centrality, and two main reasons have been issued here. Firstly, an element with higher degree centrality must have been integrated to more of them, that is to say, it is a knowledge element with a wider scope and better applicability, which will also prompt the authors to carry out a more in-depth discussion on this knowledge element in the subsequent research [33]. Secondly, higher degree centrality of knowledge elements can provide authors with more examples of this combination of knowledge elements and inspire them to carry out innovative research from different ideas and perspectives. Therefore, the citation count of papers related to this knowledge element will also be enhanced with the continuous development of related research at this knowledge element. However, when the degree centrality of knowledge elements reaches a certain degree, the combination opportunities of knowledge elements may decrease. That is to say, when knowledge elements are excessively combined, their combined value will reduce. Combining with this knowledge element may lead to insufficient innovation in the final scientific research results, and the citation count of papers related to this knowledge element in subsequent studies will also be reduced. Therefore,

H2a: for a paper, its keywords' average degree centrality in the knowledge network has an inverted-*U* shape on its citation count.

2.2.2. The Influence of Structural Holes on Citations in Knowledge Network.

If a knowledge element is directly related to two nondirectly connected elements in the knowledge network, then the knowledge element occupies the position of structural holes. The search for knowledge is mostly internal search or related search [34]. Therefore, knowledge elements located in structural holes can provide more opportunities for combination of two knowledge elements that have no direct connection [35]. If a knowledge element occupies more structural holes, then the author can find more nonredundant relevant knowledge elements through this knowledge element and can find more combinations of knowledge elements that have never appeared, and the paper containing this knowledge element will also receive more references. Thus,

H2b: for a paper, its keywords' average structural holes in the knowledge network are positively related to its citation count.

3. Research Methods

3.1. Data Collection.

All data acquired are from the Chinese Social Science Citation Index (CSSCI) database and the General Contents of Chinese Core Journals (core of Peking University) database. We search "sports industry" in the retrieval field, which is limited to "subject,", and the publication time is limited to 2000–2021. The final excerpt preserves the name, author, key words, citation count and other information of all publications, and 7,465 pieces of original data obtained.

3.2. Variables Selection and Measurement

3.2.1. Dependent Variables.

The dependent variable is citations that have been normalized of each paper in our sample publications. Referring to the method proposed by Cannella and McFadyen in 2016 [36], the citation count of an article is first subtracted from the average citations of all sports industry articles published during the same year and then divided by the standard deviation of the citations for all sports industry articles published in the same year. Finally, the normalized citations of this paper are obtained. This method can eliminate the citation bias of articles published in different years. Its normalized citations calculation is as follows:

$$\text{normalized citations}_i = \frac{\text{citations}_i - \text{citationsmean}_{\text{all}}}{\text{citations standard deviation}_{\text{all}}}. \quad (1)$$

3.2.2. Independent Variables.

The disquisitive independent variables involve in degree centrality and structural holes in collaboration and knowledge networks constructed based on all the papers in the sample. The specific methods are as follows:

(1) Construction of the Collaboration and Knowledge Networks. The collaboration and knowledge networks here are typical social networks constructed based on the papers of sports industry journals in China from 2000 to 2021. Both in this study are constructed by Python.

(2) Measurements of Degree Centrality and Structural Holes. Two groups of independent variable, the degree centrality and structural holes, in both collaboration and knowledge networks, are discussed in this study at the level of papers. The specific node degree and structural hole are calculated by Python.

(a) Calculation of degree centrality

   (i) Firstly, to acquire the degree centrality, we reckon the number nodes that are directly relevant to the node. Then, we make standardized treatment. To obtain the standardized degree centrality, the value is divided by the amount of remaining nodes. The formula is as follows:

$$\text{normalized degree centrality}_i = \frac{\text{degree centrality}_i}{g-1}. \tag{2}$$

   (ii) In the formula, g represents the amount of nodes in the network.

(b) Calculation of structural holes

   (i) Burt's constraint method was first adopted [37, 38] to reckon the network constraint C_i, which indicates the strength i is constrained by its adjacent nodes. We use 2 minus the constraint metric C_i 2 to obtain the control advantage that i generates by crossing structural holes.

$$\text{Structural holes}_i = 2 - C_i = 2 - \sum_j \left(p_{ij} + \sum_{k,k_j^1,k_j^1} p_{ik}p_{kj} \right)^2, \tag{3}$$

where i indicates the target node and p_{ij} represents the ratio node j to the contact point of node i. For example, i is connected to five nodes including j, then p_{ij} equals 1/5. Node k has a connection with node i and j simultaneously. The more ties between i and other elements exist, the smaller value of p_{ij} and p_{ik} and less constraint node i have. Meanwhile, the more ties k has with other elements, the lower p_{kj} k has, thereby lower the constraint on i.

(3) Degree centrality and structural holes at paper level. The basic unit focuses on paper-level degree centrality and structural hole. Because of the nonuniqueness of authors and elements in a paper, both indicators need to be averaged to paper level. This research draws on the method of calculating paper-level degree centrality and structural holes proposed by Guan et al. (2017) [27]. For instance, there are three authors in a paper whose degrees are 1.2, 1.3, and 1.4, respectively, then the average degree centrality value of the paper's authors in the collaboration network is $(1.2 + 1.3+1.4)/3 = 1.3$. Structure holes in collaboration networks and degree centrality in knowledge networks both are equal to structure holes.

4. Regression Results and Analysis

4.1. Descriptive Statistics. In the collaboration network, if the author's degree centrality is 0, it indicates that the author has no cooperative relationship with other authors. Therefore, authors with degree centrality of 0 can be excluded from the collaboration network. After processing, the number of nodes in the collaboration network is finally 4,851. The mean, median, standard deviation, minimum, and maximum values of variables in the collaboration network are depicted in Table 1. In the knowledge network, although there is no knowledge element with degree centrality of 0, some keywords need to be combined manually. For example, "2008 Olympic Games" and "2008 Beijing Olympic Games" both refer to the 2008 Olympic Games held in Beijing, so they can be combined into one. Through manual screening and merging of all the keywords, the final number of knowledge network nodes is 7379. And the mean value, median, standard deviation, minimum value, and maximum value of variables in the knowledge network are listed in Table 2.

In Tables 1 and 2, as for the collaboration network, degree centrality is significantly different from that in the knowledge network. The mean value of degree centrality in the collaboration network equals to 0.001, the standard deviation is 0.001, and the maximum value is 0.014. However, in the knowledge network, the mean value of degree centrality equals to 0.008, the standard deviation and the maximum value are 0.009 and 0.074, respectively. The difference between structural holes in the collaboration network and knowledge network is small. The mean value of the structural holes in the collaboration network equals to 1.335, the standard deviation is 0.295, the minimum and maximum values are 0.009 and 1.959, respectively. However, in the knowledge network, the mean value of structural holes is 1.783, the standard deviation is 0.21, the minimum value is 0.875, and the maximum value is 1.997. Because of the normalization, the average of the citations in both collaboration and knowledge networks is 0.

4.2. Regression Analysis

4.2.1. The Collaboration Network

(1) Degree Centrality as the Independent Variable. In order to verify whether there is a nonlinear relation between degree centrality of collaboration network and the citation count of the paper, a quadratic term was added into the regression, and the regression analysis was conducted by using Stata. The results are shown in Table 3.

Table 3 signifies that the quadratic regression is significant ($p \leq 0.05$), and the quadratic coefficient is $-6441.203 < 0$, preliminarily determined to be an inverted-U relationship. The UTEST test was conducted to further verify the relationship. The results are shown in Table 4.

As can be seen from Table 4, the extreme value is out of [0.000, 0.014], so the null hypothesis cannot be rejected. Therefore, there is no U or inverted U relationship. In order to verify whether there is a linear relationship, unary linear regression is conducted. The results are shown in Table 5.

Table 5 signifies the significance ($p \leq 0.01$) of unary linear regression, and the coefficient is $135.674 > 0$, that indicates the degree is marked positive correlated with citation count, which verifies the hypothesis H1a, that is, the average degree centrality of a paper's author in the collaboration network is positively correlated to its citation count.

TABLE 1: Descriptive statistics of collaboration network variables.

	N	Mean	Std. Dev.	Min.	Max.
Citation	4851	0	0.998	−0.984	12.351
Degree	4851	0.001	0.001	0	0.014
Structure hole	4851	1.335	0.295	0.875	1.959

TABLE 2: Descriptive statistics of knowledge network variables.

	N	Mean	Std. Dev.	Min.	Max.
Citation	7379	0	0.999	−0.888	13.376
Degree	7379	0.008	0.009	0	0.074
Structure hole	7379	1.783	0.21	0.875	1.997

TABLE 3: Collaboration network degree centrality quadratic regression.

Citation	Coef.	St. Err.	t-value	p-value	[95% Conf. Interval]		Sig.
Degree	182.095	21.43	8.50	≤0.001	140.082	224.108	***
Degree2	−6441.203	2627.278	−2.45	0.014	−11591.858	−1290.547	**
Constant	−0.178	0.022	−8.22	≤0.001	−0.221	−0.136	***

*** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

TABLE 4: Collaboration network degree centrality UTEST.

	Lower bound	Upper bound
Interval	0.000	0.014
Slope	179.471	3.683
Extreme point: 0.0141352		
Test: H1: inverse U shape vs. H0: monotone or U shape		
Extremum outside interval: trivial failure to reject H0		

TABLE 5: Collaboration network degree centrality unary linear regression.

Citation	Coef.	St. err.	t value	p value	95% conf. interval		Sig.
Degree	135.674	10.042	13.51	≤0.001	115.986	155.361	***
Constant	−0.148	0.018	−8.30	≤0.001	−0.183	−0.113	***

*** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

(2) Structural Holes as the Independent Variable. In order to verify whether there is a nonlinear relationship between structural holes in collaboration network and citation count of a paper, a quadratic term was added into the regression, and the regression analysis was conducted by using Stata. The results are shown in Table 6.

Table 6 shows that the result of quadratic regression is significant ($p \le 0.01$), and the quadratic coefficient is 0.981 > 0, preliminarily determined to be a U-shaped relationship. The UTEST test was conducted to further verify the relationship. The results are shown in Table 7.

As can be seen from Table 7, the extreme point is in range of the data [0.875, 1.959], and the UTEST results are significant ($p \le 0.05$), so the null hypothesis is rejected at the statistical level of 5%. Meanwhile, the slope interval in the result ranges from −0.361 to 1.767, which is consistent with the preliminary U relationship determined by quadratic regression. Therefore, we can consider that there is a U

relationship. The regression results are inconsistent with the research hypothesis H1b.

4.2.2. The Knowledge Network

(1) Degree Centrality as the Independent Variable. In order to verify whether there is a nonlinear relationship between the moderate centrality of knowledge network and the citation amount of the paper, a quadratic term was added into the regression, and the regression analysis was conducted by using Stata. The results are shown in Table 8.

We can see from Table 8 that the quadratic regression is significant ($p \le 0.05$), and the quadratic coefficient is −204.433 < 0, preliminarily determined to be an inverted-U relationship. The UTEST test was conducted to further verify the relationship. The results have been shown in Table 9.

As can be seen from Table 9, the extreme value is within [0, 0.074], and the UTEST results are significant ($p \le 0.05$),

TABLE 6: Quadratic regression of collaboration network structure holes.

Citation	Coef.	St. err.	t value	p value	95% conf. interval		Sig.
Structure hole	−2.078	0.477	−4.36	≤0.001	−3.013	−1.143	***
Structure holé2	0.981	0.175	5.62	≤0.001	0.639	1.323	***
Constant	0.939	0.314	2.99	0.003	0.324	1.555	***

***$p < 0.01$, **$p < 0.05$ and *$p < 0.1$.

TABLE 7: Collaboration network structure UTEST.

	Lower bound	Upper bound
Interval	0.875	1.959
Slope	−0.361	1.767
t value	−2.052	8.231
$P > |t|$	0.020	0.000

Extreme point: 1.058766
Test: $H1$: UU shape vs. $H0$: monotone or inverse UU shape
Overall test of presence of a U shape: t value = 2.05
$P > |t| = 0.020$

TABLE 8: Knowledge network degree central quadratic regression.

Citation	Coef.	St. err.	t value	p value	95% conf. interval		Sig.
Degree	10.171	3.068	3.32	0.001	4.157	16.184	***
Degreé2	−204.433	84.489	−2.42	0.016	−370.054	−38.811	**
Constant	−0.055	0.019	−2.84	0.004	−0.093	−0.017	***

***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$.

TABLE 9: Knowledge network degree centrality UTEST.

	Lower bound	Upper bound
Interval	0.000	0.074
Slope	10.138	−20.003
t-value	3.318	−2.039
$P > |t|$	0.000	0.021

Extreme point: 0.0248758
Test: $H1$: UU shape vs. $H0$: monotone or inverse UU shape
Overall test of presence of an inverse UU shape: t value = 2.04
$P > |t| = 0.0208$

so the null hypothesis is rejected at the statistical level of 5%. Meanwhile, the slope interval in the result ranges from 10.138 to −20.003, which is consistent with the preliminary result of quadratic regression that it is an inverted-U relationship. Therefore, it can be considered that there is an inverted-U relationship, which also verifies the hypothesis H2a.

(2) Structural Holes as the Independent Variable. In order to verify whether there is a nonlinear relationship between structural holes in the knowledge network and citation count of a paper, a quadratic term is added into the regression, and the regression analysis is conducted by using Stata. The results are shown in Table 10.

Table 10 signifies the significance ($p \leq 0.01$) of quadratic regression, and the quadratic coefficient is $0.444 > 0$, preliminarily determined to be a U relationship. The UTEST test was conducted to further verify the relationship. The results are shown in Table 11.

TABLE 10: Quadratic regression of knowledge network structural holes.

Citation	Coef.	St. err.	t value	p value	(95% conf. interval)		Sig.
Structure hole	−1.122	0.544	−2.06	0.039	−2.188	−0.057	**
Structure holé2	0.444	0.169	2.63	0.009	0.113	0.776	***
Constant	0.569	0.431	1.32	0.186	−0.275	1.414	

***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$.

Table 11 shows that the extreme value is in range of [0.875, 1.997], but the UTEST results are not significant ($p > 0.05$). Therefore, there is no U or inverted-U shape relation. In order to verify whether there is a linear relationship, unary linear regression is conducted. The results are shown in Table 12.

In Table 12, the unary linear regression result was significant ($p \leq 0.01$), and the coefficient was $0.298 > 0$,

TABLE 11: Knowledge network structural holes UTEST.

<!—Col Count:3F0E0	Lower bound	Upper bound
Interval	0.875	1.997
Slope	−0.345	0.652
t-value	−1.374	4.480
$P > |t|$	0.085	0.000

Extreme point: 1.263264
Test: $H1$: UU shape vs. $H0$: monotone or inverse UU shape
Overall test of presence of a inverse UU shape: t value = 1.37
$P > |t| = 0.0847$

TABLE 12: Knowledge network structural holes unitary linear regression.

Citation	Coef.	St. err.	t value	p value	(95% conf. interval)		Sig.
Structure hole	0.298	0.055	5.40	≤0.001	0.19	0.407	***
Constant	−0.532	0.099	−5.36	≤0.001	−0.726	−0.337	***

*** $p < 0.1$, ** $p < 0.05$, and * $p < 0.1$

indicating that the structural holes are significant positively correlated with its citation, which also verifies the hypothesis H2b, that is, for a paper, its keywords' average structural holes in the knowledge network are positively related to its citation count.

5. Conclusion

This paper, by using the 2000–2021 Chinese Social Science Citation Index (CSSCI) database and Chinese Core Journals Particular Overview (core) of Peking University database in sports industry data in China, constructs the keywords knowledge and authors collaboration network and explores the relationship between network structure attributes and citation count from two perspectives. Our above results can be concluded as the following findings.

First of all, as for the collaboration network, the average degree centrality of a paper's author is positively correlated with its citation count, that is, with the increase of the average degree centrality of the paper's author, the citation count also increases. Authors with higher degree centrality tend to cooperate with others with high degree centrality, which makes it easier to find more innovative ideas and acquires more opportunities to share resources, thus improving the quality of paper research. At the same time, authors with the higher degree centrality usually acquire relatively higher academic status in the field, and cooperating with them is more likely to gain the attention and support of peers, thus increasing the citation count of their papers.

Secondly, in the collaboration network, the average structural holes of a paper's author are not positively correlated with citation.

Thirdly, we confirmed that the average degree centrality of keywords in the knowledge network had an inverted-U shape impact on citation count, that is, with the increase of the average degree centrality of all keywords, the citation of a paper increases at first and then decreases when it reaches a certain altitude. The knowledge element tends to combine with other knowledge elements in pace of the increase of the degree centrality of the knowledge element. It will improve the utilization rate of existing knowledge elements and provide more elements combination model, and the knowledge elements of related papers citation count will rise with knowledge elements' growth. When the degree centrality of knowledge element reaches a certain degree, the research on this knowledge element has been relatively sufficient, and the value of combining and studying this knowledge element is relatively low. Therefore, the citation amount of papers related to this knowledge element will also decrease due to the lack of innovation.

Finally, we found that the average structural holes of keywords in the knowledge network for a paper are positively correlated with citation count. The increase of the structure holes of all the keywords in a paper can lead to an increase in citation count for a paper. When the knowledge element occupies more of the structural holes, the knowledge element connects more with more nonredundant knowledge elements and may find more fresh knowledge element combination. Therefore, as the paper's richness of the average structural holes, perhaps it contains more novel knowledge element combinations, thus increasing the citation count.

6. Research Implications and Limitations

By analyzing the characteristics of the social networks at the paper level, this paper enriches the research on collaboration and knowledge networks of sports industry and paper citations and reveals the influence of the two networks on citation count in the sports industry. Through this study, we can find that the citation count of sports industry papers will be affected by the attributes of its own network structure. Therefore, it is necessary to seek cooperation with more scholars while writing papers and select collaborators with a high degree centrality as far as possible, which is conducive to increasing the citation count of papers and improving the influence of scientific research. At the same time, the study will make the knowledge elements of the paper highly cited and innovative, which is conducive to improving the citation

count of a paper. Moreover, the more structural holes knowledge elements occupy, the more conducive to improving the citation count of a paper.

At the same time, some contributions at theoretical level have been made. Firstly, this study not only involves the collaboration network, which has been widely used, but also constructs the knowledge network through keywords and applies the collaboration and knowledge network to the research of the sports industry, which provides new approaches and thoughts for the research of sports industry in China. Secondly, compared with previous studies that mostly focus on the network attributes at the author level, the basic research unit of this study focuses on the paper level, which furnishes a new perspective for following research projects of the sports industry and other disciplines. Finally, the study can not only provide theoretical reference for scholars in the sports industry on how to improve the quality of scientific research and increase the citation count but also provide a theoretical basis for predicting the citations count of papers and evaluating scholars' research performance through a more scientific comprehensive way.

Our study also has some limitations. Firstly, authors of collaboration and keywords of knowledge networks have not been given a certain weight, and the contribution degree for the author and the importance of keywords in each paper have not been distinguished, which have reached a common understanding in academia, and we need to further promote in the subsequent research projects. Secondly, the relationship between structural holes and citations in the collaboration network and the reasons for their generation need to be discussed and explained in the following research projects.

Data Availability

The original data used in this study are from the Chinese Social Sciences Citation Index (CSSCI) database and General Contents of Chinese Core Journals (core of Peking University) database. The original data used to support the findings of this study are available from https://cssci.nju.edu.cn/.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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