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Research on the evolutionary characteristics of interdisciplinary degree and intersections of library and information science: Based on the keywords coupling analysis of the National Social Science Fund Projects

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ABSTRACT

From the perspective of the National Social Science Fund projects, this paper explored a new way to research on the interdisciplinarity, so as to improve the understanding of interdisciplinarity and its evolutionary characteristics in the domain of Library and Information Science (LIS). Based on the keywords extracted from the titles of the National Social Science Fund projects approved in the past ten years, this paper calculated the interdisciplinary degree and detected the intersections between LIS and other 22 disciplines by means of keywords coupling analysis, to reveal the evolutionary characteristics in the past ten years and investigate the evolution forms and mechanism. LIS has a strong interdisciplinary degree which is showing an increasing trend. The interdisciplinary and openness of LIS are the fundamental driving force of interdisciplinarity. Its interdisciplinarity is mainly manifested in the adherence to the discipline core and the expansion of the discipline edge. In the process of interdisciplinarity, LIS also has the problem of insufficient influence and penetration.

KEYWORDS

Interdisciplinarity; Keywords coupling analysis; Evolutionary characteristics; Knowledge structure

1 Introduction

Interdisciplinarity is a major trend in today's scientific development, and it is also a key way for human beings to deal with complex environments and major problems (Huang, 2021). As a new paradigm of scientific exploration, the intersection of disciplines is profoundly affecting and changing the mode and pattern of scientific development. The history of modern scientific development shows that interdisciplinary research is the source of major scientific achievements. Taking the 1901-2000 Centennial Nobel Prize in Natural Science as an example, 41.02% of the awards came from interdisciplinary research (Zhang et al., 2001). Disciplines are widely intertwined, traditional disciplinary barriers have been broken, and a large number of interdisciplinary disciplines have emerged. So far, more than 2,000 interdisci-

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plinary disciplines have been formed (Cao et al., 2019). The issue of interdisciplinary has been highly valued by the Chinese government and academic circles. In October 2020, the National Natural Science Foundation of China established the 9th department - Interdisciplinary Science Department; In January 2021, the Academic Degrees Committee of the State Council and the Ministry of Education jointly issued a notice to set up the category of "interdisciplinary", which has become the 14th discipline category in China. Academic attention to interdisciplinary issues is also increasing. Interdisciplinary research is of great significance, which embodies great value for the development of the discipline itself and mutual reference with other disciplines. It can not only seek a comprehensive understanding of the underlying significance and internal principles of interdisciplinary, but also provide important theoretical and data support for exploring the growth point of discipline development (Chen et al., 2021; C. Li et al., 2021; X. Li et al., 2022).

Library and Information Science (referred to as LIS) has been a practical and applied discipline since its birth. It is closely related to some disciplines, such as Computer Science, Data Science, Mathematics, Linguistics, Consulting, Science, Decision-making, etc., and has an interdisciplinary nature, which has the characteristics of "interdisciplinary" category (Zeng, 2021; C. Li et al., 2022). The empirical research on interdisciplinary issues often takes LIS as an example, taking papers published in this discipline as the research objects, and extracting information such as citations, keywords, authors, and source journals for measurement and analysis of interdisciplinary research. Chang and Huang (2012) used direct citation method, citation coupling method and author co-citation analysis to study the interdisciplinary situation of LIS. Sugimoto et al. (2011) used the academic pedigree network data extracted from Ph.D. dissertations to examine the interdisciplinary characteristics of LIS, and suggested that the academic pedigree of scholars should be used as one of the indicators to measure the interdisciplinary degree. Zhang et al. (2013) conducted a quantitative analysis on the interdisciplinary nature of LIS from the perspective of the number, distribution and difference of disciplinary classification of references. Yang and Jiang (2018) studied the interdisciplinarity, knowledge structure and knowledge evolution between LIS and other disciplines from the citation perspective of disciplines and journals. Ke and Zhu (2017) used JCR to analyze the interdisciplinary citations of LIS from the direct citation rate, the Brillouin indicators and the year-to-year elasticity coefficient, confirming that the interdisciplinary degree was increasing. Min and Sun (2014) established the intersection of keywords in the core journals of LIS and Journalism and Communication, obtained the high-frequency cross keywords of the two disciplines, and constructed a co-word matrix to analyze the hot spots of interdisciplinary research. Ma et al. (2019) constructed a comprehensive model of direct measurement of interdisciplinary intersection from three aspects: document direct citation, document coupling and common keywords, and calculated and analyzed the interdisciplinary degree between LIS and other six disciplines.

To sum up, scholars have carried out extensive researches around the topic of interdisciplinary, and fully confirmed the interdisciplinary characteristics of LIS. However, some aspects still need to be improved. Firstly, the existing research always took academic papers as the data source to conduct interdisciplinary quantitative analysis. Few research pays attention to other forms of scientific output than papers. Secondly, previous studies focused on the static perspective, with few dynamic studies on the evolution of interdisciplinary, and there was a lack of attention to the change law of interdisciplinary and the evolution characteristics of knowledge structure. Therefore, this study took the National Social Science Fund (NSSF) pro-

jects as samples, and calculated the interdisciplinary degree of LIS and other 22 disciplines in the field of Humanities and Social Sciences (referred to as H&SS) by means of keyword coupling method. This study also identified the discipline intersections. Focusing on the evolution characteristics of discipline interdisciplinary degree and intersections in recent ten years, this study aimed to further understand and grasp the development and evolution trend of discipline structure and discipline intersections of LIS from a new perspective. Relevant conclusions and findings are helpful for researchers to grasp the discipline development context and predict the discipline development trend as a whole. They also help discipline decision-makers to improve the discipline layout, improve science and technology policies, and better promote the interdisciplinary integration of relevant disciplines.

2 Data and Methods

This study took the NSSF projects as the research samples. Papers generally participate in bibliometric research as the output of scientific research, while the funding projects can be regarded as the starting point of scientific research. Projects are obviously problem-oriented, representing frontier and key issues in a certain field, so project data is more timely, forward-looking and strategic than paper data (Nichols, 2014). The NSSF is the highest-level scientific research project in the field of H&SS in China. This study selected the NSSF projects as data source instead of papers, in order to investigate the interdisciplinary nature of LIS from a new perspective.

This study used keywords as measurement units. Interdisciplinary research can be measured by different objects, including keywords, authors, and citations. Interdisciplinary research is essentially the mutual absorption and integration of knowledge in different disciplines. The measurement of knowledge content can better characterize the mutual penetration of knowledge than author cooperation and citation correlation (Rafols & Meyer, 2007). Therefore, compared with citation analysis and author analysis, keyword analysis not only directly represents the research theme and knowledge content, but also more suitable for fine-grained reflection of interdisciplinary. The keywords used in this study were directly extracted from the titles of the NSSF projects.

In this paper, the empirical research was conducted by means of keyword coupling analysis, with the specific steps as follows.

Step 1: Collecting NSSF projects data. From the website of the National Philosophy and Social Science Planning Office, we download the list of annual projects and youth projects approved by the National Social Science Fund in the last ten years (2012-2021), including the project name, category, discipline, approval time and other information. Because Education, Art, and Military are approved as separate disciplines, these three disciplines could not be included in this study. A total of 41,327 NSSF projects have been obtained in the past ten years, covering 23 disciplines, of which 1,407 were projects of LIS.

Step 2: Extracting keywords from NSSF projects. NLPIR Chinese word segmentation system was used to perform word segmentation processing on the titles of 41,327 NSSF projects in 23 disciplines, and then the machine word segmentation results were manually standardized to eliminate stop words and invalid words, as well as words lacking substantive meaning such as "Research", "Analysis" and "Pattern". Synonyms and English abbreviations, such as "My country" and "China", "Management Information System" and "MIS", "Evaluation" and "Assessment", etc., were merged. 6,537 valid keywords were obtained, with a total of 216,308 word frequencies. The subsequent keyword coupling analysis was cal-

culated based on these 6,537 valid keywords and their word frequencies.

Step 3: Calculating the interdisciplinary degree. The NSSF covers 23 disciplines (excluding separate disciplines). The total number of keywords owned by each discipline and the keyword coupling frequency between LIS and other 22 disciplines were counted respectively. Considering the large differences in discipline scale and the number of projects owned, there were also large differences in the number of keywords cut out. Therefore, the cosine similarity function was used to standardize the keyword coupling frequency between disciplines, and generate the standardized coupling strength coefficient to characterize the interdisciplinary degree.

It is assumed that the number of keywords owned by the two disciplines i and j is k_i and k_j respectively, the frequency of keyword coupling between the two disciplines is k_{ij}, then the standardized coupling strength coefficient is $k_{ij}=\frac{k_{ij}}{\sqrt{k_i * k_j}}$. k_{ij} is between 0 and 1. k_{ij} = 0 indicates that there is no intersection between the two disciplines. The higher the value of k_{ij}, the greater the degree of interdisciplinary.

Step 4: Identifying the intersections between disciplines. According to the frequency of keyword coupling between LIS and other 22 disciplines, the high-frequency coupling keywords between each two disciplines were regarded as the intersections of the two disciplines.

3 Research results

3.1 Overall comparison of interdisciplinary degree of LIS

Based on all the sample data in ten years, the interdisciplinary degree between LIS and 22 other disciplines was calculated, and Gephi was used for visualization. As shown in Figure 1, each node represented a discipline, and the size of the node indicated the number of projects in the discipline in ten years; the line represented the interdisciplinary degree between LIS and various disciplines, and the thickness of the line indicated the strength of the interdisciplinary degree of disciplines (specific values were displayed as labels on each line).

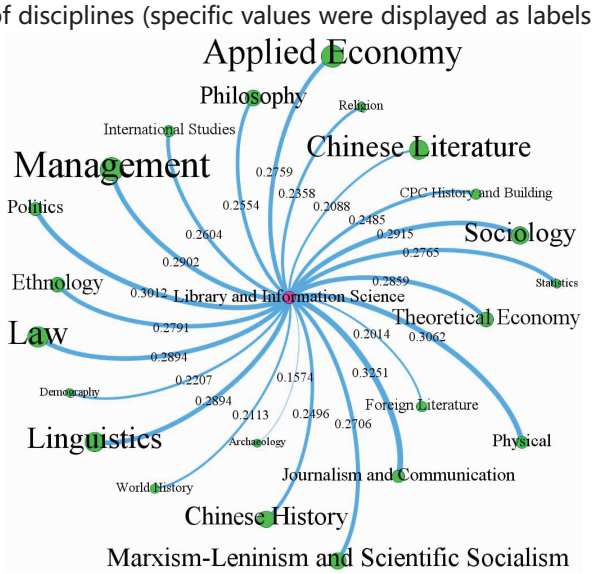

Figure 1 Interdisciplinary degree between LIS and other disciplines

LIS and the other 22 disciplines in the field of H&SS were widely intersected, but there were obvious differences in the interdisciplinary degree. Among them, the discipline with the highest interdisciplinary degree with LIS was Journalism and Communication (0.3251), followed by Physical (0.3062), Politics (0.3012), Sociology (0.2915) and Management (0.2902); The discipline with the lowest interdisciplinary degree with LIS was Archaeology (0.1574).

What was the level of the interdisciplinary degree of LIS? It needs to be comprehensively compared with the situation of various disciplines in the field of H&SS. Based on all the sample data in the past ten years, two sets of interdisciplinary degree indicators were calculated respectively: the first group was the interdisciplinary degree between LIS and 22 other disciplines, which specifically measured the interdisciplinary degree between LIS and other disciplines; the second group was the interdisciplinary degree between 23 disciplines (including LIS), which was used to represent the overall interdisciplinary degree of all disciplines in the field of H&SS. Take the maximum, minimum, average, median and standard deviation of the two groups of indicators for comparison, as shown in Table 1, and then drew a box chart to show the data distribution of the two groups of indicators, as shown in Figure 2.

Table 1 Comparison of the interdisciplinary degree indicators between LIS and all disciplines

Interdisciplinary degree	Maximum	Minimum	Average	Median	Standard deviation
All disciplines	0.5602	0.0797	0.2577	0.2603	0.0763
LIS	0.3251	0.1574	0.2604	0.2733	0.0407

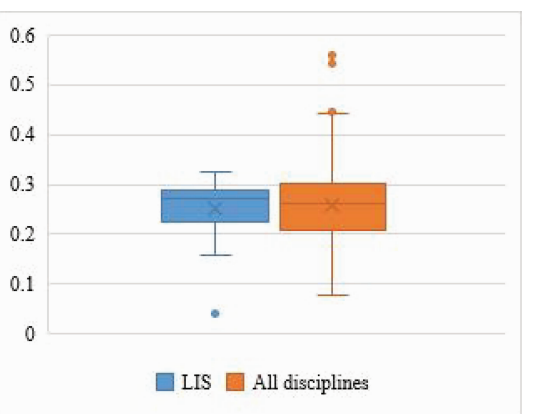

Figure 2 Distribution of data on the interdisciplinary degree between LIS and all disciplines

According to the data in Table 1, the average and median of interdisciplinary degree between LIS and other 22 disciplines were both greater than the average and median of interdisciplinary degree between all disciplines; The maximum value of LIS was far lower than that of all disciplines, while the minimum value of the former was significantly greater than that of the latter; The standard deviation of LIS was less than that of all disciplines. Combined with the data distribution state in Figure 2, compared with all disciplines, the interdisciplinary data distribution of LIS was more centralized, and there were no outliers at both ends of the box chart. According to the comparison of the data distribution positions of the two box charts, the rectangular box of LIS was located above the rectangular box of all disciplines. The upper quartile of LIS was slightly lower than that of all disciplines, but the median and

lower quartile of LIS were significantly higher than that of all disciplines, and the upper edge and lower edge of LIS were lower and higher than that of all disciplines respectively. Based on the above data, it could be judged that compared with the overall situation of 23 disciplines, the interdisciplinary degree of LIS was significantly higher than the average level of the whole field of H&SS, and maintained a medium-high intensity interdisciplinary relationship with the other 22 disciplines, but there were no disciplines with an abnormally high or low interdisciplinary degree.

3.2 A diachronic analysis of interdisciplinary degree of LIS

According to the project and keyword data of each year, we calculated the annual value of the interdisciplinary degree indicators between LIS and other 22 disciplines, and drew a heat map. As shown in Figure 3, the diachronic changes of the interdisciplinary degree between LIS and various disciplines were displayed in the ten-year time window.

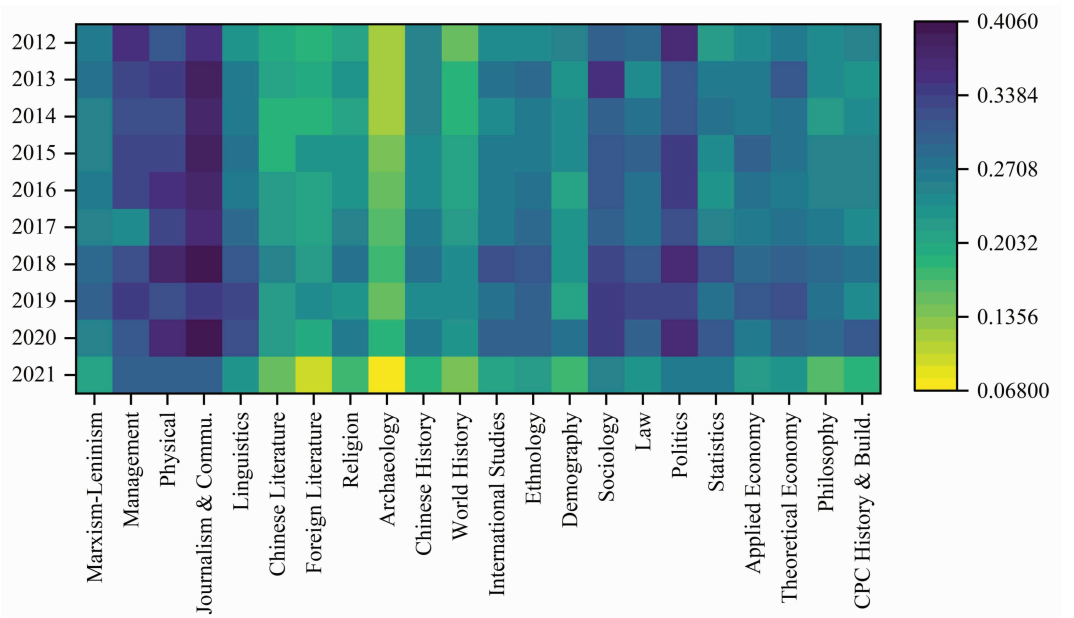

Figure 3 The diachronic changes in the interdisciplinary degree between LIS and various disciplines

From the perspective of the changes over the past ten years, the interdisciplinary degree between various disciplines and LIS fluctuated in different years, but it is clear that among the 22 disciplines, the interdisciplinary degree between any discipline and LIS showed a downward trend. Specific to various disciplines, the disciplines with the highest interdisciplinary degree with LIS were Journalism and Communication, Physical, Politics, Sociology and Management. These five disciplines were all from the category of Social Sciences. The interdisciplinary degree between LIS and them has not shown an overall growth or decline trend in the past decade. The interdisciplinary degree between the six disciplines of Marxism-Leninism and Scientific Socialism, Chinese History, International Studies, Demography, Law and Theoretical Economy and LIS were at a medium level, and the interdisciplinary degree has not shown an increasing or decreasing trend in the past decade. The interdisci-

plinary degree between the other 11 disciplines and LIS has increased in varying degrees, especially some disciplines originally with low interdisciplinary degree with LIS, such as Archaeology, World History, Chinese Literature, Foreign Literature and Religion. The interdisciplinary degree with LIS has increased continuously and significantly. These disciplines belong to the category of Humanities.

To sum up, there was a wide range of interdisciplinary between LIS and 22 disciplines in the field of H&SS, but the interdisciplinary degree has obvious disciplinary differences, which was the case in all years. Generally speaking, the interdisciplinary degree between LIS and disciplines from Social Sciences was generally high, while the interdisciplinary degree with Humanities disciplines was low. LIS itself belongs to the category of Social Sciences, and there is a higher interdisciplinary degree with Social Sciences disciplines, which is also due to the disciplinary kinship. However, from the perspective of the changes over the past ten years, the interdisciplinary degree between LIS and all disciplines has not decreased, and the interdisciplinary degree with half of them has remained stable as a whole; most of these disciplines come from the category of Social Sciences. While the interdisciplinary degree with the other half of the disciplines showed an increasing trend in varying degrees, most of these disciplines belong to the category of Humanities. Judging from the evolution trend, the disciplinary difference of interdisciplinary degree was narrowing. In other words, the interdisciplinary degree between LIS and various disciplines was approaching, especially the difference between Social Sciences and Humanities was gradually decreasing.

3.3 Evolutionary characteristics of the intersections of LIS

Taking two years as an interval, the decade was divided into five time windows. According to the projects and keywords of each two consecutive years, the coupling keywords between LIS and various disciplines were found under each time window, and the coupling frequency was calculated. The keywords with coupling frequency ≥ 10 were regarded as the intersections between the two disciplines (high-frequency coupling keywords), and then an alluvial diagram was drawn according to the number of coupling keywords, coupling frequency and other information. As shown in Figure 4, the left side of the graph of each time window showed which disciplines had intersections with LIS, and each discipline was arranged in descending order according to the number of intersections it has from top to bottom; On the right was the high-frequency coupling keywords representing the intersections of disciplines, which were arranged in descending order of coupling frequency from top to bottom; the lines connecting the disciplines and keywords on the left and right sides represented the intersections between a discipline and LIS. The lines of different disciplines were distinguished by different colors, and the thickness of the lines indicated the coupling frequency between LIS and them. Through the comparison of five time windows, this paper investigated the evolution of the intersections between LIS and 22 other disciplines in the past decade.

The breadth and degree of interdisciplinary between LIS and various disciplines were constantly changing. Generally speaking, there were more and more high-frequency keywords in each time window on the map, indicating that there were more and more intersections between LIS and other disciplines. In the past ten years, Management has always been the discipline with the most intersections with LIS. As a first-level discipline, LIS belongs to the category of Management, and the relationship between the two is evident. The number and ranking of intersections between other disciplines and LIS have changed in different time intervals. Among them, there were relatively many intersections between Applied Economics,

Journalism and Communication, Sociology and LIS. The intersections between LIS and various disciplines were intuitively displayed. For example, the intersections between LIS and Management were very broad. The intersection between LIS and Chinese History, Chinese Literature, CPC History and Building was mainly in "Literature", and the intersections between LIS and Journalism and Communication were mainly in "Media" and "Network". "Technology" and "Model" reflected the frequent intersections of LIS, Management and Statistics in research methods. A number of more active keywords such as "Culture", "Innovation", "Governance" and "Society" reflected the extensive intersections between LIS and multiple disciplines in terms of research pattern, research content and research characteristics.

Through the comparison of five time windows, we can see the dynamic evolution of the intersections of LIS and various disciplines on the time axis. A large number of keywords continued to appear in five time windows, including "Service", "Environment", "Administration", "Network", "Culture", "Literature", "Society", "Knowledge" and "Digitization". As relatively stable intersections between LIS and other disciplines, it not only showed the continuous attention of LIS to these problems, but also reflected the characteristics and trends of LIS research content, research object and research paradigm. For example, based on "Service", with the characteristics of "Culture", facing "Society", with "Literature" and "Knowledge" as the core, the form of "Digitization" carrier is becoming more and more popular, and more attention is paid to "Environment", "Administration", "Network" and other issues.

Some intersections were submerged in the process of evolution, and new intersections continued to emerge. Those submerged intersections, such as "Semantics", "Quality" and

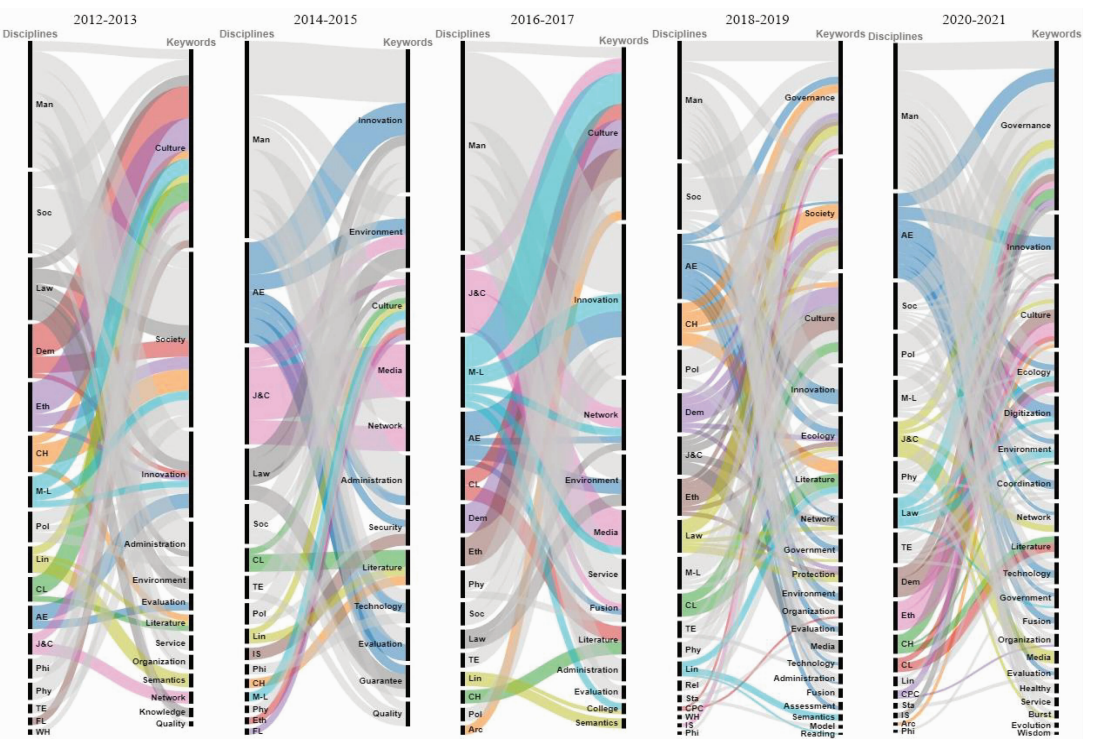

Figure 4 The evolution of the intersections between LIS and various disciplines

"Guarantee", did not mean that these intersections disappeared completely, but were replaced by other emerging intersections due to the reduction of the coupling frequency of these keywords. Compared with the number of new intersections, the number of submerged intersections was only a few. We have captured a large number of new intersections, including "Governance", "Evaluation", "Technology", "Fusion", "Innovation", "Wisdom", "Coordination" and "Ecology". Among them, the number of coupled words of "Innovation", "Coordination", "Ecology" and "Governance" had increased significantly, indicating that the importance and activity of these intersections have increased significantly. In fact, it also reflected some similarities between LIS and related disciplines in the development and evolution of disciplines. For example, pay attention to the dynamic research with "Evolution" as the object, and take "Governance" as an important purpose and means for the discipline to play its functional value.

4 Conclusions and Implications

(1) The interdisciplinary degree of LIS is high, and it is strengthened as a whole.

Contemporary science presents the characteristics of high integration based on high differentiation. Independent discipline division divides the scientific system into branch systems with different characteristics and functions. However, disciplines are still interrelated and promoted in essence, and are not completely bound by the boundary of artificial discipline division (Gu et al, 2020). Whether driven by the driving force of internal development of disciplines or the demand of external economic and social development, the intersection and integration between disciplines is an inevitable development law (Shao et al., 2018). LIS and 22 disciplines maintained different degrees of cross-correlation, and the overall interdisciplinary degree was higher than the average among the 23 disciplines in the H&SS, indicating that the interdisciplinary characteristics of LIS were more significant. In the past ten years, the interdisciplinary characteristics of LIS have been continuously consolidated and strengthened. Among the 22 disciplines, the interdisciplinary degree between half of the disciplines and LIS has increased, and none of the disciplines has weakened.

LIS originally maintained a high-intensity interdisciplinary with Social Science disciplines, such as Journalism and Communication, Physical, Politics, Sociology and Management. However, in the process of development and evolution, the interdisciplinary degree between LIS and these disciplines did not show an increasing trend. On the contrary, those Humanities disciplines with low interdisciplinary degree, such as Archaeology, World History, Chinese Literature, Foreign Literature and Religion, maintained a continuous growth trend with LIS. Although the disciplinary differences of interdisciplinary degree still exist, judging from the evolution trend, the interdisciplinary degree between LIS and various disciplines is approaching, especially the difference between Social Sciences and Humanities is significantly reduced. In other words, the interdisciplinary intersection of LIS was not constantly converging towards one or a few similar disciplines, but more extensive interdisciplinary integration with more disciplines. The interdisciplinary degree between those disciplines with high interdisciplinary degree and LIS remained in a moderate range, while the interdisciplinary degree between those disciplines with low interdisciplinary degree and LIS was increasing. As the interdisciplinary degree approaches, it can be predicted that LIS and other disciplines will maintain extensive and moderate interdisciplinary.

(2) The interdisciplinary and openness of LIS are the fundamental driving force of inter-

disciplinarity.

The fundamental reason why LIS intersects widely with other disciplines lies in its discipline attribute. **Interdisciplinary:** LIS includes many disciplines such as Library Science, Information Science, Archival Science and Philology. It is originally a territory formed by interdisciplinary integration. From the origin of the discipline, it belongs to a typical interdisciplinary. It maintains a deep kinship with many disciplines, such as Management, Sociology, Journalism and Communication. Its boundary with these disciplines is also very vague and there is a wide overlap in research topics, research object, and research content. For example, the common concern of LIS and Journalism and Communication for information exchange and communication, and the common concern of LIS and Linguistics for semantics, databases and other topics constitute the intersections between them. It is precisely because of this inherent cross attribute that LIS is easy to cross with other disciplines. **Openness:** In the process of discipline development, LIS widely absorbs and draws lessons from the knowledge of other disciplines, and constantly enriches, innovates and improves itself. For example, when quantitative research rose, LIS introduced statistical methods and models into its own method system; In order to better meet the needs of society, LIS continues to obtain new inspiration and reference from similar disciplines such as Management, Applied Economy and Sociology, and continues to introduce new theories, ideas, methods and tools; Even if it is a discipline with distant kinship, such as Chinese History, Archaeology, Ethnology and so on, LIS can also form intersections with it in some aspects, such as file management, ancient book protection, document sorting and so on. This open characteristic of LIS promotes its interdisciplinary to be extensive and in-depth. **Diversity:** The interdisciplinary and openness discipline attributes of LIS make its research content, perspective, methods and ideas have significant diversified characteristics, which is not only the result of the continuous cross integration of LIS and other disciplines, but also promotes the further cross-integration of LIS and creates more disciplinary intersections to a certain extent. In a sense, interdisciplinarity has greatly promoted the development and evolution of LIS. Since its birth, LIS has continuously enriched theories, innovated methods, expanded fields and sought breakthroughs in the long-term and extensive interdisciplinary integration, so as to realize the self-development and transformation.

(3) The interdisciplinary forms of LIS are diverse.

The combing analysis and dynamic investigation of the intersections and evolution characteristics between LIS and other disciplines confirm that discipline intersection is a comprehensive scientific activity accompanied by the development needs of society and disciplines (Xu et al., 2015). There are many forms of interdisciplinary: **The first is the intersection of disciplinary attributes**, interdisciplinarity firstly originates from the kinship between disciplines. For any discipline, the discipline with the highest interdisciplinary degree is often the discipline with the closest kinship. For example, the interdisciplinary degree between LIS and Social Sciences is generally greater than that of Humanities, and the deep intersection of LIS and Management, which reflects the direct impact of closeness and distance on the interdisciplinary degree. **The second is the intersection of research objects,** the common concern of various disciplines on hotspots, frontiers, major theoretical and practical issues is one of the important reasons for promoting the interdisciplinarity. On the one hand, focusing on hotspots and chasing frontiers is an endogenous demand for the development of disciplines. Hotspots and frontiers are more likely to stimulate the research interest of scholars, and are necessary means for various disciplines to continuously develop new research contents and

continuously update and improve the knowledge system. For example, under the background of the current wave of big data and the information age, the common concern of various disciplines on information, knowledge, network, technology and other issues has made it a very prominent intersection. On the other hand, social and economic development and changes in the situation at home and abroad have put forward major theoretical and practical problems for the research of H&SS, such as ecology, environment, innovation, health and resources, which has become a hot topic in a certain period of time, requiring all disciplines to participate in it. Although the research perspectives and methods of different disciplines are different, the common research objects and themes still constitute the intersections between disciplines. **The third is the intersection of research paradigms**, some common research concepts, methods and tools prevail in the H&SS, such as empirical, quantitative, application, network, model, collaboration, etc., which are widely used and adopted by various disciplines, further promoting the interdisciplinary integration. **The fourth is the intersection of disciplinary subjects**, in the era of big science, the trend of collectivization and cooperation of scientific research is constantly strengthened, the disciplinary background of researchers and their teams is more diversified, and interdisciplinary knowledge exchange and cooperative research are becoming more and more frequent. This is not only a necessary measure to deal with interdisciplinarity, but also promotes the in-depth development of interdisciplinarity to a certain extent.

(4) There are persistence and expansion of LIS in the interdisciplinarity.

The essence of interdisciplinary is to constantly break discipline boundaries and promote mutual infiltration among disciplines on the basis of recognizing discipline differences (Wang et al., 2019). The interdisciplinary performance of LIS is the coexistence of persistence and expansion, that is, adhering to the discipline core and expanding the discipline boundary. Two findings in the empirical study of this paper can support this view: Firstly, most of the intersections between LIS and various disciplines we identified can not reflect the most core and characteristic research themes or contents of LIS, such as "Service", "Innovation", "Environment", "Culture", etc., which are basically common to all disciplines. Keywords such as "Library", "Intelligence", "Archives", "User", "Atlas", "Knowledge Organization", "Bibliography" and so on can best represent the characteristics of the discipline, but the coupling frequency with other disciplines is very low. It can be seen that the intersections of LIS are mainly the intersections of discipline edges rather than discipline cores. Secondly, from the evolution trend of the interdisciplinary degree indicators between LIS and various disciplines, the interdisciplinary degree between LIS and those disciplines with closer kinship and higher interdisciplinary degree has not increased, but has remained stable in the annual fluctuation. On the contrary, the interdisciplinary degree between LIS and those disciplines with further kinship and lower interdisciplinary degree has maintained an increasing trend year by year. It can be seen that interdisciplinarity is not the infinite convergence of LIS to its similar disciplines, but the wide and moderate interdisciplinary with more disciplines. The boundary of the discipline is becoming increasingly blurred, but the core of the discipline is still clear. Such cross-integration can not only make the field of LIS continue to expand, but also not lose its discipline independence due to excessive convergence. Interdisciplinarity is not a one-way imitation, let alone merger and replacement, but seeking common ground while reserving differences and seeking common ground in differences. "Intimacy but have space, close but have sparse; harmony but different, beauty and common." Perhaps this is the ideal state of interdisciplinary integration.

(5) The influence and penetration of LIS in the interdisciplinary field are not strong.

When comparing the intersections of LIS and various disciplines, we notice that most of these intersections are not original or inherent in LIS. Interdisciplinarity should be a parallel process of knowledge input and knowledge output. Each discipline not only outputs the theories and methods of this discipline to other disciplines, but also widely introduces and draws lessons from the theories and methods of other disciplines. However, LIS mainly introduces and draws lessons from other disciplines in the interdisciplinarity, while the knowledge output is very limited. More often, it uses other disciplines to promote its own development, but can not form a positive impact and promotion on the development of other disciplines. China' s LIS plays a more instrumental and supportive role, with relatively weak integration and penetration into social economy and culture, and insufficient ability to refine theory, provide suggestions, and solve practical problems in social, economic and cultural development (Ma & Li, 2020). LIS did not raise its original theories to the universal expression of social phenomena, did not raise its methods to the method of cross-sectional science, and did not actively spread and infiltrate its theories and methods to other disciplines (Zhang & Yang, 2019). This makes the influence and penetration of LIS to other disciplines weak, and the discipline status can not be effectively improved. In fact, interdisciplinarity is the process in which various disciplines demonstrate their "diplomatic" strength. Only by continuously exporting theories, methods and tools to other disciplines can we obtain a stronger voice and influence, and highlight the strength and status of disciplines. The history of discipline development is a rich history of discipline expansion. Therefore, in the process of discipline development and evolution, especially in the process of interdisciplinary integration, LIS should not only widely learn from and transplant from other disciplines, but also strengthen the external output and penetration, and constantly strengthen its own influence and enhance the discipline status in the mutual exchange and influence with other disciplines.

5 Summary

With the help of the National Social Science Fund projects, this paper calculated the interdisciplinary degree and looked for the discipline intersections based on the keyword coupling method. Through horizontal comparison and diachronic analysis, this paper investigated the evolutionary characteristics of the interdisciplinary degree and intersections between LIS and various disciplines, explored a new dimension and model of discipline intersection research, and obtained some conclusions and findings. However, there are still some problems and deficiencies in the research: firstly, extracting keywords from the projects' name for coupling analysis, and the measurement results are affected by the quality of word segmentation. Although the vocabularies are standardized manually, the quality of keywords still needs to be tested and improved; Secondly, there is also a wide range of interdisciplinary relations between LIS and Mathematics, Computer Science and other disciplines. This paper only investigated the interdisciplinary relations between LIS and 22 disciplines in the field of H&SS within the scope of disciplines covered by the National Social Science Foundation, which can not completely reflect the interdisciplinary panorama of LIS. The third is about the reasons and evolutionary dynamics behind the interdisciplinarity. This paper only made a preliminary discussion, which needs more in-depth and systematic verification and analysis. There are still many unsolved mysteries in interdisciplinary research. In view of the above deficiencies, the follow-up research will expand the number of samples and the scope of disci-

plines, seek a more effective word segmentation scheme, verify the research results, and deeply investigate the evolution path and mechanism of interdisciplinary research.

Acknowledgments

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Appendix

This paper provided the list of keywords in LIS as supplementary information for checking. Considering the huge number of keywords and limited layout, only keywords with total word frequency ≥ 10 in ten years were displayed here.

Table 2 List of keywords in LIS (part)

Keyword	Word frequency	Keyword	Word frequency	Keyword	Word frequency
Library	259	Ancient Books	27	Text	15
Information	252	Public Sentiment	26	Standard	14
Service	241	Assessment	26	Communication	14
Data	217	Heritage	26	Diffusion	14
Knowledge	159	Publish	25	Social Media	14
Archives	143	Humanity	25	Portrait	14
China	124	Risk	25	Knowledge Organiza-	13
Network	113	Shared	23	Cooperation	13
Digitization	105	Security	23	File	13
System	104	Policy	22	Individualization	13
User	100	Nation	22	Performance	13
Literature	95	Value	22	Network Public Opinion	12
Innovation	95	Optimization	22	Memory	12
Environment	93	Ability	22	Integration	12
Culture	88	Community	21	Transformation	12
Technology	84	Evolution	21	Polymerization	12
Evaluation	72	Recommend	21	Experience	12
Behavior	69	Extension	21	Tradition	11
Administration	66	Patent	20	Calculation	11
Reading	60	Socialization	19	Metering	11

Keyword	Word frequency	Keyword	Word frequency	Keyword	Word frequency
Fusion	58	Atlas	19	Retrieval	11
Media	56	Public Library	19	Early Warning	11
Intelligence	55	Spread	18	Platform	11
Society	53	Historical Data	18	Unearthed	11
Organization	49	Internet	18	Paperwork	11
Semantics	46	Enterprise	17	Medicine	11
Quality	41	Documentation	17	Education	11
Model	40	Books	17	Citation	11
Government	39	Industry	16	Children	11
Realization	38	Decision Making	16	Reading Promotion	11
Social Contact	37	History	16	Participate	11
Excavate	36	Dynamic	16	Search	11
College	36	Periodical	16	Design	10
Coordination	35	Competition	16	Service Quality	10
Governance	35	Database	16	Demand	10
Protection	34	Tibetan	16	Cognition	10
Burst	32	Perception	16	Bibliography	10
Wisdom	31	University Library	16	Guide	10
Ecology	30	Social Science	15	International	10
Electronics	29	Emergency	15	Forecast	10
Healthy	28				