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The preferences of Chinese LIS journal articles in citing works outside the discipline

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Abstract

Purpose – The purpose of this paper is to understand how Chinese library and information science (LIS) journal articles cite works from outside the discipline (WOD) to identify the impact of knowledge import from outside the discipline on LIS development.
Design/methodology/approach – This paper explores the Chinese LIS' preferences in citing WOD by employing bibliometrics and machine learning techniques.
Findings – Chinese LIS citations to WOD account for 29.69 percent of all citations, and they rise over time. Computer science, education and communication are the most frequently cited disciplines. Under the categorization of Biglan model, Chinese LIS prefers to cite WOD from soft science, applied science or nonlife science. In terms of community affiliation, the cited authors are mostly from the academic community, but rarely from the practice community. Mass media has always been a citation source that is hard to ignore. There is a strong interest of Chinese LIS in citing emerging topics.
Practical implications – This paper can be implemented in the reformulation of Chinese LIS knowledge system, the promotion of interdisciplinary collaboration, the development of LIS library collection and faculty advancement. It may also be used as a reference to develop strategies for the global LIS.
Originality/value – This paper fills the research gap in analyzing citations to WOD from Chinese LIS articles and their impacts on LIS, and recommends that Chinese LIS should emphasize on knowledge both on technology and people as well as knowledge from the practice community, cooperate with partners from other fields, thus to produce knowledge meeting the demands from library and information practice as well as users.

Keywords Bibliometrics, Interdisciplinary studies, Machine learning, Chinese LIS, Citation preference, Knowledge import

Paper type Research paper

1. Introduction

The approach to knowledge production adopted by contemporary science community is problem driven, blurring links between pure and applied and disciplinary borders and leading to interdisciplinarity (Gibbons *et al.*, 1994; Milojević, 2014). Interdisciplinary research is increasingly significant and widespread (Szostak, 2008; Xu *et al.*, 2016), generating innovation (Cummings and Kiesler, 2005), complementing capabilities (Bidault and Hildebrand, 2014) and addressing real-life problems (Milojević, 2014; Bornmann, 2017) by emphasizing and promoting knowledge exchange and cross-disciplinary collaboration (Liu *et al.*, 2011; Ma *et al.*, 2014). Library and information science (LIS) is commonly defined as an interdisciplinary field (Kärki, 1996; Saracevic, 1999; Prebor, 2010). With the economic reform and opening-up of China

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in 1978, Chinese LIS has been growing at an accelerated pace (Wu and Yuan, 1994; Hu *et al.*, 2011). There have been more LIS articles listed in China National Knowledge Infrastructure (CNKI) database (265,562) than in Library and Information Science Abstracts (195,472) during the same period of 1998-2013. It is fair to say that, in the course of development, there is a golden rule for all disciplines to have themselves as a solid base while strengthening their communication with other disciplines, and there is no exception for Chinese LIS (Chen, 2012).

Since citation is an effective indicator of interdisciplinarity, knowledge exchange and research collaboration across disciplines (Porter and Chubin, 1985; Linderman and Chandrasekaran, 2010; Chang and Huang, 2012; Kodama *et al.*, 2013), there are many studies on LIS' preferences in citing works from outside the discipline (WOD) to explore its relationship with other disciplines (Meyer and Spencer, 1996; Buttlar, 1999; Larivière *et al.*, 2012; Chang and Huang, 2012). While Chinese LIS is an indispensable part of global LIS with huge volume of publications, little attention has been given to such an issue. The existing research works failed to investigate it systematically, and most of those works are based on small-scale citation analysis, thus leaving a research gap about the actual status. To address that gap, this paper aims to offer insight into Chinese LIS knowledge import as well as its impacts on future LIS development. Following questions will be answered:

RQ1. Which disciplines outside LIS do Chinese LIS researchers cite most frequently?

RQ2. What are the characteristics of cited WOD?

RQ3. What are the impacts of the cited disciplines on the development of Chinese LIS?

This paper starts with reviewing and synthesizing previous research works on interdisciplinary knowledge import in LIS field by employing citation analysis. Then, it studies knowledge import across disciplines by processing and analyzing citation data collected and used specifically for this study. Next, it analyzes cited disciplines, citation frequencies, their distribution and trend over time and distribution of disciplines from outside LIS by using subject categories in Biglan (1973a) model. The characteristics of cited documents' authors, subjects, source periodicals, language and currency will also be analyzed. In addition, it studies LIS citation to WOD by analyzing publication type, authors' community affiliations, as well as topic and subject categories to investigate the influence of knowledge from other disciplines. Finally, it will propose recommendations to reformulate knowledge system, cooperate with partners from outside LIS and optimize knowledge import for the promotion of interdisciplinary collaboration and the creation of demand-driven knowledge.

This paper contributes to enhancing and optimizing knowledge import and research collaboration across disciplines, which have implications for the exploration of potentials for innovation in knowledge production, the satisfaction of demands from LIS practice and users, the improvement of capabilities in both developing technologies and serving people and the solution of real-life problems. Moreover, with the high rate of the growth of the data from scientific publications (Larsen and Ins, 2010), statistical techniques from the previous generation and cognitive ability of people are inadequate for the analysis of large amounts of citation data (Glymour *et al.*, 1996; Loh *et al.*, 2003; Uramoto *et al.*, 2004; Guruler *et al.*, 2010). Therefore, data mining becomes more important for discovering knowledge hidden in data (Ho *et al.*, 2003). Supervised machine learning classification technique and unsupervised clustering technique are employed in this study to analyze the authors' community affiliation and subject of citations automatically, and have implications for creating innovative methods in analyzing citation data, especially in large-scale citation analysis.

2. Literature review

Citation analysis is commonly used to study the interdisciplinarity of LIS and the influences it received from outside the discipline (Meyer and Spencer, 1996; Buttlar, 1999; Tang, 2004).

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Researchers have different views on the extent of LIS' dependence on other disciplines by analyzing self-citations of LIS (Huang and Ho, 2007; Larivière *et al.*, 2012) and the disciplines outside LIS that have the greatest impact on LIS are identified based on the citation frequency of those disciplines (Pettigrew and McKechnie, 2001; Tang, 2004). It has been nearly a century since LIS was first taught in Chinese universities, and the practice of knowledge import from outside the discipline started in the 1930s when research methods in fields of advertising, linguistics, statistics and economics began to be applied to library science (Li, 1935; Jiang, 1995). Different disciplines have different influences on Chinese LIS at different times (Chen and Wang, 2010).

2.1 Citation: an indicator of knowledge import and intellectual influence

Although the contents of cited sources cannot be directly measured, researchers still treat the large number of citations as the evidence of intellectual trade (Cronin and Meho, 2008). Researchers conduct research on the status of knowledge imported to a specific discipline by analyzing documents cited by that discipline (Goldstone and Leydesdorff, 2006; Larivière *et al.*, 2012; Yan *et al.*, 2013). Moreover, citation is a reliable indicator of scholarly impact. Researchers regard citation as a valid indicator of the influence of the cited document on the citing document, while citing behavior is not entirely driven by the acknowledgment of intellectual influence (Cole and Cole, 1972; Huang and Ho, 2007; Bornmann and Daniel, 2008; Tomcho *et al.*, 2015). Papers with a large number of citations received from other documents are regarded as research works that have a particular influence on the scientific development (Bauer *et al.*, 2016).

Knowledge import from outside the discipline and its impacts can be revealed by employing citation analysis. Based on the methodologies used in related works, the common methods of analyzing LIS in citing WOD are as follows: analyzing the characteristics of citations outside LIS based on the citation counts in the subject category of "Information Science & Library Science" provided by specific databases, such as Science Citation Index, Social Science Citation Index, Chinese Social Science Citation Index and CNKI, for example Tang (2004); analyzing sample data extracted from some specific journals, for example Chang and Huang (2012); analyzing information sources of sample data from a specific type of works such as doctoral dissertations in LIS, for example Buttlar (1999). Elements such as author, gender, publication format, country/language, currency, journal ranking, subject disciplines, interdisciplinary changes and so on are always been analyzed. Those methods have their strengths. However, the criteria of classification are unclear, as the subject category of a work is entirely classified by a specific database. With the development of interdisciplinary research, the subject category of a work is not entirely equal to the subject category of its source journal. Therefore, citations from LIS journals to non-LIS journals cannot represent that the knowledge imported to LIS from other disciplines. In addition, with the growth of citation data, data mining techniques such as machine learning and statistical approach should be employed to analyze citation preferences efficiently and effectively (Chen *et al.*, 1996).

2.2 Citation analysis: an approach to measuring interdisciplinarity

Citation analysis plays an important role in measuring interdisciplinarity. Citations are regarded as a way of interdisciplinary information transfer (Pierce, 1999). Many researchers conduct citation analysis to identify and investigate the interdisciplinarity which includes the exploration of communication pattern and intellectual structure (Hammarfelt, 2011; Stopar *et al.*, 2016). Scholars tend to cite researches distantly related to their own fields more often than before (Mingers and Lipitakis, 2010; Sun and Xia, 2016).

Researchers discover that there is a positive correlation between interdisciplinarity and disciplinary innovation. Interdisciplinary research may stimulate transformation and innovation in knowledge production while the productivity of knowledge is reduced because

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of the challenges of cognition, collaboration and review process (Yegros-Yegros *et al.*, 2015; Leahey *et al.*, 2016). The promotion of interdisciplinary research in LIS contributes to improving research quality (Levitt and Thelwall, 2008). Researchers treat the rate of self-citation as a measurement of disciplinary independence, demonstrating disciplinary independence and its relationship with knowledge import and nature of disciplines. The rate of self-citation is defined as an index of independence. Discipline with high value of index of independence seeks information within its own discipline rather than depend on other disciplines (Urata, 1990). Disciplinary independence is related to the nature of subjects as basic sciences or applied sciences. Basic sciences such as chemistry, mathematics and physics achieve high self-citing rate above 60 percent, while the self-citation rate of applied science such as agriculture and biotechnology and engineering and food is relatively low, at less than 40 percent (Rinia *et al.*, 2002). The self-citation rate is an indicator of interdisciplinarity (Cheng, 1994). Moreover, the percentage of citations to disciplines outside the field of citing documents is commonly used to measure interdisciplinarity (Tang, 2004; Rafols and Meyer, 2010; Abramo *et al.*, 2012; Larivière *et al.*, 2012).

2.3 Characteristics of WOD cited by LIS

Previous studies have explored the characteristics of disciplinary distribution, author, subject, language distribution and currency of citations from outside Chinese LIS by employing Biglan (1973a) model, Price index and immediacy index and other indicators. The Biglan (1973a) model is a classification system arraying disciplines into eight cells (Bayer, 1987). Academic areas are clustered according to their concern with a single paradigm (hard vs soft), concern with application (pure vs applied) and concern with life systems (life system vs nonlife system) (Biglan, 1973b). The Price index is the proportion of the references that are to the last five years of literature. The cited literatures that are to the last five years of citing literature are defined as literatures which have "immediacy effect." The cited literatures that are over five years of citing literature are defined as archival literatures (Price, 1970). Regarding short-term impact, the immediacy index indicates how quickly journal articles are cited (Buriak, 2015). The fields with higher impacts may have higher immediacies, too (So, 1988).

Researchers reveal the characteristics of knowledge import to Chinese LIS by analyzing the language, publication type, Price index, immediacy index, source discipline of citation (Cheng, 1994; Su and Zheng, 2010; Dai and Li, 2013; Chen and Wang, 2010; Xu, 2016). The findings on distribution of cited disciplines among subject categories in Biglan (1973a) model provide support to the reformulation of knowledge system and direction of knowledge production, suggesting that Chinese LIS should maintain balance between people and technology and focus on knowledge which reflects the demands of practice (Chen and Wang, 2010; Xu, 2016). Researcher noted that LIS citations do not have interdisciplinary characteristics from 1974 to 1993 based on the fact that the self-citation rate increased from 70.30 to 74.54 percent (Cheng, 1994).

3. Methodology

3.1 Data and samples

This paper is based on the data from the CNKI database which is widely used by Chinese researchers from various fields, and covers 98 percent of all Chinese academic publications including journal articles, doctoral dissertations/master's theses, conference proceedings, core newspaper articles, books and yearbooks. Since the data collection for this research was conducted in September 2014, the most recent annual data of Chinese LIS works and their citations available in CNKI were released in 2013. In order to show the knowledge import to Chinese LIS and its changes in a period of 20 years, the data of Chinese LIS works,

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their citations and their subject categories labeled by CNKI from 1994 to 2013 are collected from CNKI as the primary data set. There are 856,426 citations from Chinese LIS publications with 254,296 citations to WOD. Based on the journal impact factors provided by CNKI, 20 LIS journals with the highest impact factors which are also regarded as core journals in the field have been selected from the primary data set as samples for further citation analysis. They have been added with more citation details such as title, author, author's institutional affiliation/nationality, subject, publication year, source title and language of cited documents.

In order to create a data set with only citations to WOD, this paper collects as many international and Chinese LIS periodical titles as possible, and create a list of 150 LIS periodicals. Next, citations from periodicals covered in the LIS list are deleted using a computer program designed specifically for this study, thus leaving 255,926 citations. Since the objective, content, result and purpose of a research are determining factors in identifying its discipline classification, citations are further reviewed by deleting any remaining citations to LIS manually. Citations to LIS are defined as cited documents written by LIS researchers that solve problems within the LIS field and also promote its development.

As a result, the final data set consists of 47,044 LIS citing documents with 182,055 citations to WOD (Table I).

3.2 Data processing and analysis

Researchers from various disciplines employed the Biglan model of using three dimensions to distinguish among disciplines for the demonstration of the influence of disciplinary difference on behaviors (Pike and Killian, 2001; Whitmire, 2002; Favero, 2006; Lam *et al.*, 2014). The Biglan model is used (Table II) to categorize all cited disciplines in this study.

Journal	No. of articles	No. of all citations	No. of articles with citations to WOD	No. of citations to WOD	Percentage of citations to WOD out of all citations
Journal of Academic Libraries	2,250	16,022	1,328	4,076	25.44
Journal of the National Library of China	532	4,559	281	967	21.21
Information Science	5,855	46,171	4,530	19,257	41.71
Information Studies: Theory & Application	3,729	32,680	2,959	12,828	39.25
Journal of the China Society for Scientific and Technical Information	1,992	22,545	1,759	10,688	47.41
Journal of Intelligence	8,265	71,308	6,738	33,617	47.14
Information and Documentation Services	2,393	19,310	1,570	5,026	26.03
Library	2,974	22,497	1,652	5,031	22.36
Library Development	2,567	17,606	1,226	3,382	19.21
Library Work and Study	4,185	22,449	2,170	5,585	24.88
Library Theory and Practice	3,900	18,533	2,028	5,866	31.65
Library Tribune	5,159	35,685	2,989	8,355	23.41
Library Journal	4,710	26,912	2,558	7,982	29.66
Library and Information Service	7,678	70,966	5,506	22,976	32.38
Document, Information & Knowledge	2,281	19,120	1,652	6,352	33.22
Library & Information	2,527	22,231	1,762	8,205	36.91
Journal of Library Science in China	1,966	20,497	1,451	5,962	29.09
New Technology of Library and Information Service	3,059	26,339	2,300	10,518	39.93
Archives Science Bulletin	2,533	11,158	1,589	3,442	30.85
Archives Science Study	1,715	6,827	996	1,940	28.42
Total	70,200	533,415	47,044	182,055	34.13

Table I.
20 selected LIS journals

Dimensions of subject matter	Hard science		Soft science	
	Non-life science	Life science	Non-life science	Life science
Pure science	Non-life natural science	Life natural science	Language and literature Philosophy History Communication Art Geography	Political science Psychology Sociology
Applied science	Engineering Computer science	Agriculture science Horticulture science Medicine	Accounting Finance Economics Laws Management	Education

Notes: "Geography" means human geography; physical geography is classified as "non-life science;" "Non-life natural science" represents disciplines in natural science that are not concerned with life system, such as physics, chemistry and astronomy; "life natural science" represents the disciplines of natural science involving life system, such as biology

Table II.
Disciplines categorized with the Biglan model

For each citing document and cited document, bibliographic data, such as title, author, source journal/publisher, keyword, the institutional affiliation of author and publication year are recorded. To start with, 166 CNKI subject categories (except for two categories belonging to LIS) are reclassified into 22 disciplines using the Biglan model, and the relationships between subject categories and disciplines are taken into consideration. Errors in the disciplinary classification of citations due to the inappropriate subject categories labeled by CNKI are corrected manually according to the nature of cited documents for the analysis of the cited disciplines.

Except for the step above, all the following steps are based on the citation data from the 20 selected Chinese LIS periodicals. As the second step, the frequently cited authors and their characteristics are analyzed by examining their institutional affiliation to further classify them into three communities: academic, practice and public. WEKA 3.6, an effective data mining tool, is chosen to perform the classification by employing machine learning technique.

Next, 5,208 names of various Chinese and international institutions are collected, and their community classifications are labeled manually. At this point, Simple Chinese Word Segmentation (SCWS) system, a scientific tool for word segmentation, is used to segment institutions' names into words. A training set is created to define words in institutions' names as input variables, and the manually labeled community classification as output variables. As the third step, classification function of WEKA (Othman and Yau, 2007) is used to create the classification model by utilizing Naïve Bayes algorithm, which has the highest proportion of correctly classified instances comparing to other algorithms for that training set in several tests. In total, 66 percent of instances under this model are used for training and the rest for evaluation. The correctly classified instances account for 80.01 percent. As the fourth step, SCWS is used to segment the names of source institutions of 103,566 cited authors (only the first institution of the first author for each citation is collected) into words, classifying cited authors' communities and outputting classification results automatically by utilizing the classification model. Finally, classification results are modified manually to ensure the community of each cited author. In order to analyze the nationality of cited authors, cited authors are divided into two types: Chinese and international, according to the language of their names by utilizing a computer program. The results are verified manually.

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Later, cited WOD are examined by analyzing the frequently cited documents and their contents. The titles and keywords of 182,055 citations to WOD are collected and 156,245 instances are obtained successfully. The training set consists of words from titles segmented by SCWS and keywords. In data preprocessing, stop words such as "of," "the" and "to" are excluded. The clustering function of WEKA is used to cluster training instances without supervision by choosing SimpleKMeans algorithm commonly used for clustering (Maia and Souza, 2010; Valsamidis *et al.*, 2012). The number of cluster is defined as 20 which is based on the number of instances as well as the expectation of this study for clustering. The clustering results are checked by observing and analyzing the clustered instances. Citations from mass media as well as those from peer-reviewed journals are counted to analyze the reliability of cited WOD manually. Furthermore, citations written in Chinese and in languages other than Chinese are counted using specially developed computer program to analyze the language distribution of cited WOD, respectively. Finally, another self-developed program is used to analyze the Price (1970) index and immediacy index of citations to WOD to analyze the degree of "immediacy effect" of citations to WOD.

4. Results

4.1 Disciplinary distribution of cited WOD

The results show that from 1994 to 2013, 29.69 percent of Chinese LIS citations are from other disciplines (Table III). The most cited disciplines are as follows: computer science (115,862), education (29,353), communication (26,851), economics (25,246), laws (9,312), management (8,731), medicine (7,973), language and literature (5,533), engineering (4,322) and political science (4,112).

Chinese LIS citations to WOD belong to the following disciplines: computer science (45.56 percent), education (11.54 percent), communication (10.56 percent), economics (9.93 percent), laws (3.66 percent), management (3.43 percent), medicine (3.14 percent), language and literature (2.18 percent), engineering (1.70 percent), political science (1.62 percent), history (1.50 percent), non-life natural science (1.31 percent), philosophy (1.09 percent), sociology (0.85 percent), psychology (0.60 percent), agriculture (0.37 percent), art (0.27 percent), life natural science (0.19 percent), geography (0.17 percent), finance (0.17 percent), horticulture (0.10 percent) and accounting (0.06 percent).The distance between LIS (C23) and cited disciplines such as computer science (C4), law (C21) and geography (C13) represents the frequency of that external discipline being cited by Chinese LIS (Figure 1). The farther the distance is, the lower the frequency.

Computer science has the highest citation frequency in LIS works, contributing to 45.56 percent of all citations to WOD. Computer science, education, communication and economics are four major citation contributors consisting 77.53 percent of all cited WOD. However, disciplines with low citation rate also contribute to the process and cannot be ignored.

The mean, median, inter-quartile range and standard deviations of the cited disciplines data are 11,600, 3,579, 8,234.75 and 24,918.61, respectively. The skewness is 3.833. The distribution is spread out. The histogram with normal curve (Figure 2) indicates that the distribution of data is not normal. The tail of curve is shifted to left side, indicating that the data are positively skewed. Disciplines outside LIS cited by Chinese LIS can be divided into few frequently cited disciplines such as computer science, education, communication and economics, and many less cited ones, such as non-life natural science, finance, horticulture and accounting.

4.2 Changes of citations to WOD over time

The proportions of citations to LIS and WOD from 1994 to 2013 (Figure 3) offers a comparison of changes of these two kinds of citations over time. It is clear that citations

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Table III.
Disciplinary distribution of Chinese LIS citations

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
C1	17	14	17	14	30	32	40	34	66	80	120	113	192	224	311	351	472	482	582	141	3,332
C2	3	1	1	2	4	7	10	14	15	16	61	11	32	35	41	23	59	60	78	14	487
C3	14	21	30	38	31	38	59	49	101	95	203	207	286	311	374	364	532	597	780	192	4,322
C4	108	183	346	627	731	942	1,451	3,149	5,171	5,331	5,966	6,242	7,712	9,384	10,732	11,821	13,320	13,795	15,913	2,938	115,862
C5	8	16	13	12	10	17	14	30	26	21	77	21	69	81	57	63	119	136	128	23	941
C6	4	0	1	0	0	0	0	1	2	12	71	53	1	43	13	4	13	19	17	5	259
C7	34	48	59	57	32	126	136	161	219	281	478	571	500	730	742	770	754	927	1,076	272	7,973
C8	11	24	15	28	30	57	65	70	96	160	224	228	255	368	454	629	757	813	991	258	5,533
C9	10	10	25	22	33	40	42	67	87	63	110	146	247	235	251	264	263	322	443	85	2,765
C10	18	18	9	14	16	42	48	76	86	100	147	151	347	267	357	467	416	494	588	165	3,826
C11	115	142	250	268	298	468	602	873	1,238	1,080	1,364	1,612	1,961	2,074	2,379	2,552	2,699	2,960	3,214	702	26,851
C12	3	2	1	0	0	2	2	4	8	14	15	27	50	43	58	6 6	101	109	155	33	693
C13	0	4	1	3	4	7	10	3	11	20	26	23	21	39	38	48	37	38	39	65	437
C14	6	5	13	30	36	44	30	57	62	68	105	142	228	284	372	476	533	700	757	164	4,112
C15	0	4	1	3	5	6	17	13	19	28	34	70	135	190	162	144	205	199	232	52	1,519
C16	3	5	19	17	18	31	35	46	83	93	97	102	127	147	217	239	239	267	316	54	2,155
C17	48	67	96	101	199	278	341	603	767	872	1,105	1,413	2,003	2,866	3,205	3,360	3,607	3,667	3,903	852	29,353
C18	0	0	0	0	0	0	2	0	3	0	2	3	6	11	8	17	30	31	30	7	150
C19	0	1	4	4	5	4	10	7	17	13	19	22	24	27	20	43	75	48	67	27	437
C20	180	413	461	455	447	596	626	641	948	870	1,003	1,066	1,464	1,627	2,089	2,193	2,480	2,769	3,935	983	25,246
C21	1	7	22	34	48	68	105	153	261	244	402	401	646	1,003	1,005	1,087	1,297	1,144	1,023	361	9,312
C22	125	125	133	150	129	160	184	242	286	310	370	269	508	639	813	832	846	1,054	1,250	306	8,731
C23	1,950	2,865	3,573	5,113	5,843	8,273	11,376	16,169	21,588	23,164	30,537	3,4339	42,296	48,579	56,898	61,889	65,347	67,764	78,549	16,018	602,130
Total	2,658	3,975	5,090	6,992	7,949	11,238	15,205	22,462	31,160	32,935	42,536	47,232	59,110	69,207	80,596	87,702	94,201	98,395	114,066	23,717	856,426

Notes: C1, non-life natural science; C2, life natural science; C3, engineering; C4, computer science; C5, agriculture science; C6, horticulture science; C7, medicine; C8, language and literature; C9, philosophy; C10, history; C11, communication; C12, art; C13, geography; C14, political science; C15, psychology; C16, sociology; C17, education; C18, accounting; C19, finance; C20, economics; C21, laws; C22, management; C23, library and information science. For each discipline, citation frequency from 1994 to 2013 is reported

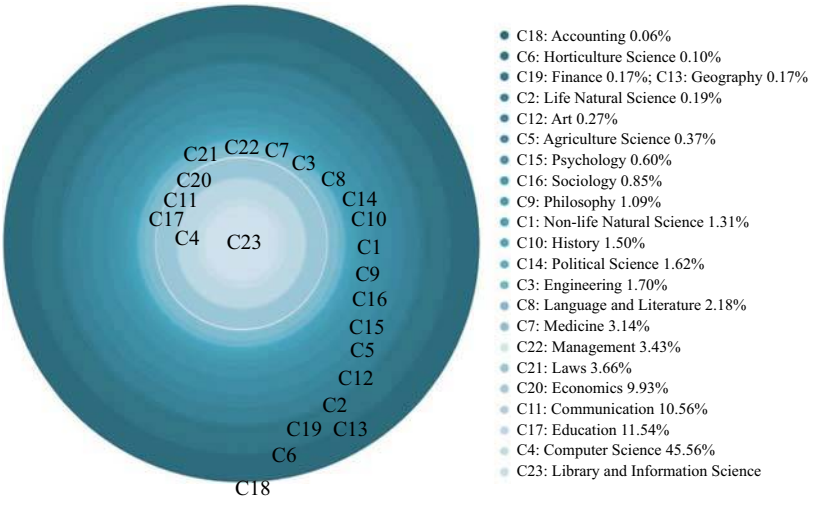

Figure 1.
Disciplines from outside the field most frequently cited by Chinese LIS researchers

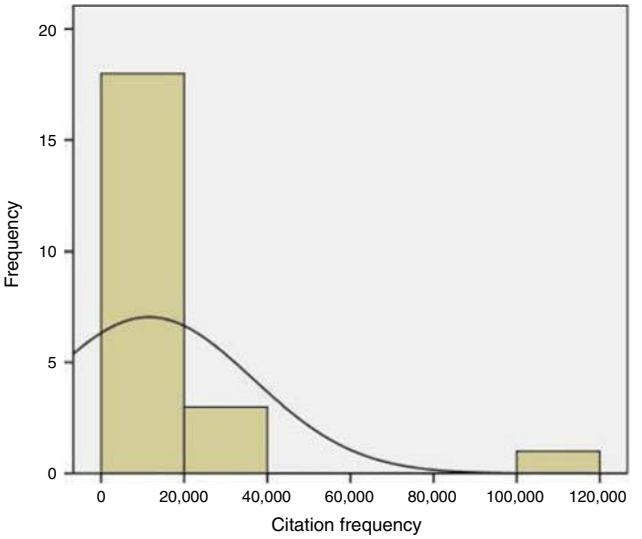

Figure 2.
Histogram with normal curve

within Chinese LIS remain consistently higher, even if their percentage slowly decreases over time (from 73.36 to 67.72 percent). In comparison, the proportion of citations to WOD keeps on increasing (from 26.64 to 32.28 percent).

4.3 The disciplinary characteristics of citations to WOD

The percentage of citations from other disciplines changes over time (Figure 4). Computer science and communication have always been among the most frequently cited disciplines, followed by economics which has a fair number of citations. Since 1998, the citation ranking of education has been increasing, and from 2007 to 2011, it ranks second just after computer science. In general, for Chinese LIS, computer science, education, communication and

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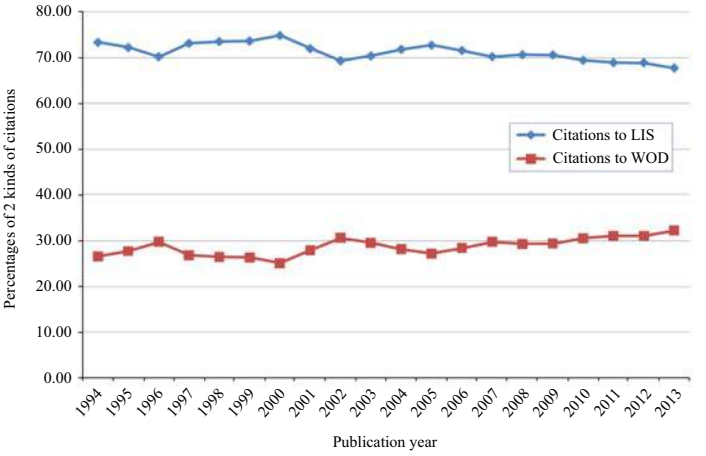

Figure 3.
Changes of percentage of citations to LIS and citations to WOD over time

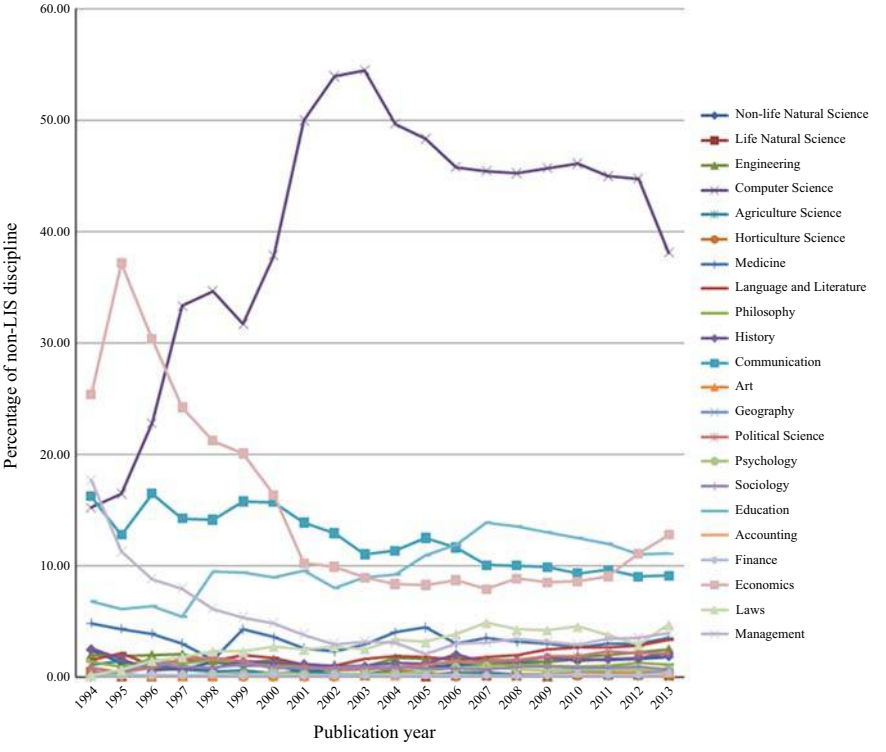

Figure 4.
Changes of cited disciplines over time

economics have been main sources of knowledge borrowed from outside LIS. From 2004, the percentages of many less cited disciplines, for example engineering, history, political science, nonlife natural science increased while percentages of frequently cited disciplines such as computer science, education and communication decreased.

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The citations to WOD in Chinese LIS works during 1994-2013 are classified according to the Biglan model, and the proportion in each dimension is also calculated (Table IV).

Using the "hard science vs soft science" dimension, for Chinese LIS works, citations from "hard science" disciplines account for 52.37 percent of all citations, when "soft science" citations fill the rest 47.63 percent. Knowledge obtained from hard science is in insignificant majority. Using the dimension of "pure science vs applied science," citations from "pure science" disciplines account for 20.33 percent of all citations, while "applied science" citations represent 79.67 percent, which outnumbers the former by a considerable margin. Seen from the dimension "non-life science vs life science," the proportion of citations from life science disciplines is 18.40 percent, while the ones from non-life science disciplines are at 81.60 percent. It is clear that non-life science is the main source of knowledge from other disciplines for Chinese LIS.

4.4 The authorship characteristics of citations to WOD

There are 103,566 authors from other fields cited by Chinese LIS researchers in the 20 selected LIS journals from 1998 to 2013. Frequently cited authors are mainly from the following disciplines: management, economics, computer science, political science, philosophy, history, laws, language and literature, sociology and communication. Here are some of the top cited authors and their research areas: Ikujiro Nonaka (444), knowledge management; Lu Taihong (142), marketing; Gabriel Szulanski (133), knowledge transfer; Karl Marx (234), classical politics and economics; Han Jiawei (223), data mining; Gruber Thomas Robert (160), ontology; Yong Rong (135), literature and history; Wu Handong (149), intellectual property; and Zheng Chengsi (133), intellectual property.

The institutional affiliations of authors from other fields are analyzed which can be classified into three community categories: the academic, the practice and the public. The academic community includes universities, research institutions and organizations with a primary mission to conduct research. The practice community consists of professionals, institutions and industry associations which are involved in the practice and operation of a certain field. The public community includes media, social networks, public organizations and governments which are open to the public. Cited authors are classified based on their nationality.

During the years under survey, the authors from the academic community (147,562, 90.06 percent) receive the most citations, those from the public community receive less citations (11,223, 6.85 percent), while those from the practice community (5,064, 3.09 percent) receive the lowest number of citations. The changes of preference for citations to WOD from authors with different institutional affiliation over time (Figure 5) indicate that, for Chinese LIS, the majority of knowledge from other disciplines is from the academic community.

Chinese authors (109,173, 66.63 percent) receive more citations than international authors (54,676, 33.37 percent). The most frequently cited Chinese authors belong to the academic community (95,543, 58.31 percent). International authors from the academic community (52,020, 31.75 percent) receive fewer citations than the former. The group of authors from other disciplines receive the least citations are international authors from the practice community (979, 0.60 percent). There is an increasing tendency of citations to international authors (Figure 6).

	Hard science		Soft science	
Dimensions of subject matter	Non-life science	Life science	Non-life science	Life science
Pure science	3,332 (1.31%)	487 (0.19%)	40,105 (15.77%)	7,786 (3.06%)
Applied science	120,184 (47.26%)	9,173 (3.61%)	43,876 (17.25%)	29,353 (11.54%)

Note: For each dimension, both citation frequency and its percentage out of total citations are reported from 1994 to 2013

Table IV. Distribution of citations to WOD in Biglan model

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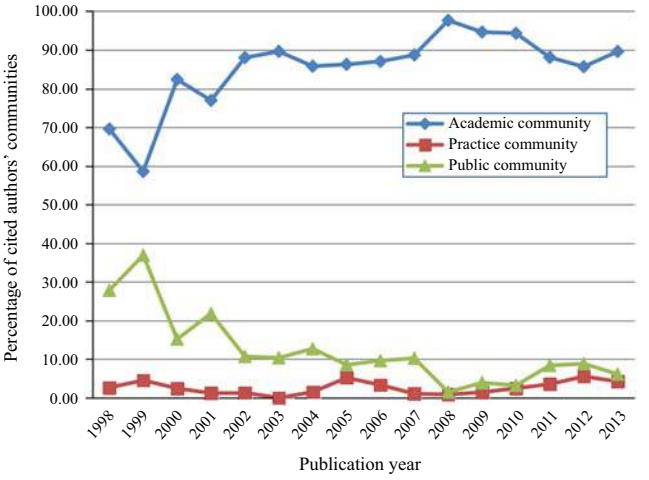

Figure 5.
Changes of cited authors' community affiliation over time

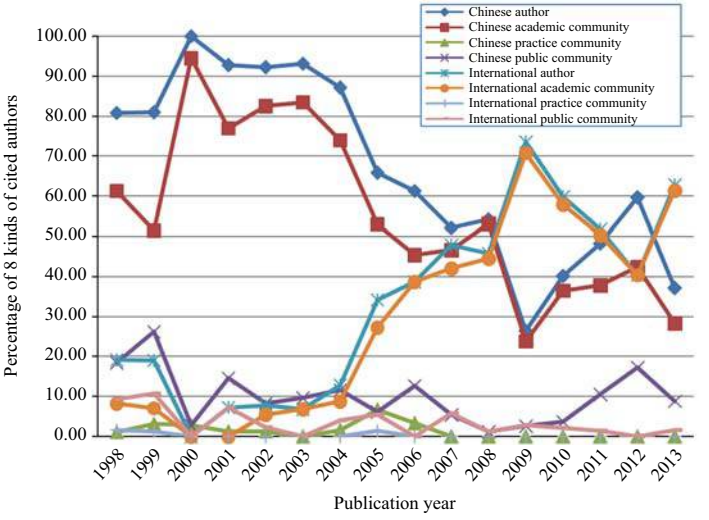

Figure 6.
Citation frequency of cited authors based on their nationality and community affiliation

4.5 The subject characteristics of citations to WOD

According to the clustering results, Chinese LIS researchers prefer citing following subjects (Table V). The subjects of cited WOD have much overlap with research areas of Chinese LIS.

Changes of top ten most frequently cited subjects from 1998 to 2013 (Table VI) indicate that topics such as intellectual property, strategic management, social networks and information economics have attracted temporary interests from scholars. However, they quickly dwindle, and are replaced by emerging subjects.

4.6 The characteristics of citation source

The cited articles are mainly published in journals or newspapers such as *Computer Engineering and Applications* (994), *Computer Engineering* (767), *Science of Science and Management of S&T.* (720), *Studies in Science of Science* (663), *Science Research*

Cluster	Instances	Subjects	Most frequently cited document in cluster
0	59,382 (38%)	Information retrieval	Baeza-Yates and Ribeiro-Neto (1999)
1	36,666 (23%)	Knowledge management	Nonaka and Takeuchi (1995)
5	10,284 (7%)	Information economics	Wu *et al.* (2002)
4	9,436 (6%)	Social networks	Liu (2004)
10	6,374 (4%)	Competitive strategy	Porter (1985)
3	5,602 (4%)	Data mining	Han *et al.* (2006)
7	5,077 (3%)	Literature and history	Sima (1986)
13	4,423 (3%)	Information law	Zheng (1997)
8	3,582 (2%)	Theory of communication	Schramm and Porter (1982)
14	3,479 (2%)	Multidisciplinary works	Yong and Ji (1965)

Table V.
Clusters with most instances

Rank	1998-2001	2002-2005	2006-2009	2010-2013
1	Knowledge economics	Knowledge management	Knowledge management	Knowledge management
2	Information economics	Multidisciplinary works	Ontology	Social networks
3	Multidisciplinary works	Intellectual property	Data mining	Literature and history
4	Intellectual property	Data mining	Strategic management	Strategic management
5	Literature and history	Information economics	Social network	Ontology
6	Marketing	Strategic management	Information economics	Social network
7	Information policy	Literature and history	User service	Random network
8	Information law	Marketing	Multidisciplinary works	Machine learning
9	Multimedia system	Ontology	Semantic web	Organizational trust
10	Basic theory of internet	Electronic commerce	Search engine	Recommender system

Table VI.
Changes of frequently cited subjects over time

Management (656), *Application Research of Computers* (653), *China Soft Science* (652), *Guang Ming Daily* (452), *China Computer World* (362) and so on.

The cited journals are further classified into peer-reviewed academic journals and mass media publications. The latter which is a mix of information, news or persuasion (Vivian, 1998) is generally regarded as a secondary source by international writing guidelines (Turabian, 2013). The proportion of mass media cited by Chinese LIS decrease from 56.67 (1998) to 6.05 percent (2013). This figure shows that there was an accelerated increase of citations from peer-reviewed publications with the percentage of such citations increasing from 43.33 percent (1998) to about 93.95 percent (2013). Chinese LIS researchers are using more peer-reviewed journals, and the materials they use are becoming more specialized and authoritative.

4.7 Distribution of languages and immediacy of citations to WOD

The analysis of languages used in citations to WOD shows that there is a stable increase of such works written in languages other than Chinese, even if most of the cited works are still written in Chinese. In 1998, the percentage of works in languages other than Chinese account for only 17.97 percent of total citations, but it increased to 44.64 percent in 2013.

Both Price index and the immediacy index are used to analyze the distribution of citations to WOD over time. In Chinese LIS, the average immediacy index for the 16-year period is 0.0464, and the Price index is 61.57 percent. Price index of citations to WOD decreases gradually (from 74.84 to 50.16 percent) over time, and their immediacy index remains at a very low level (from 0.0115 to 0.0619). Chinese LIS scholars prefer to cite WOD with "immediacy effect."

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5. Discussion and conclusions

5.1 Chinese LIS researchers prefer citing researches from other disciplines

Chinese LIS researchers prefer to cite disciplines such as computer science, education, communications, economics, law, management, medicine, language and literature, engineering and political science with long tails covering from pure to applied discipline from life to non-life discipline and from science to social science and humanity. The increase of percentage of citations to WOD from 26.64 to 32.28 percent indicates that Chinese LIS researchers are making their efforts to acquire knowledge from a wide range of fields, which in turn help Chinese LIS expand its horizon of knowledge. Knowledge import to LIS shows increasing tendency. In addition, citations to WOD from languages other than Chinese have been increasing at an accelerated pace, indicating that Chinese LIS has more interaction with the international fields outside LIS.

5.2 Chinese LIS researchers prefer to cite mass media and authors from the academic community

In terms of publication type, although mass media is treated as an unreliable citation source with low value of evidence (Carson *et al.*, 2012; Turabian, 2013), it is an indispensable citation source for Chinese LIS researchers. This citation preference may reduce the quality of LIS publications. In addition, citation data reveal that Chinese LIS researchers have the preference of citing authors from the academic and the public community, but rarely those from the practice community. Chinese LIS researchers overlook the theoretical and technological development from the practice community and its close ties to LIS practice, thus further expanding the gap between academic research and real practice.

5.3 Chinese LIS researchers prefer to cite emerging topics

In general, Chinese LIS researchers are sensitive to emerging theories and technologies originating from fields outside LIS. The ranking changes of the most frequently cited subjects (Table V) indicate that many research topics receive large number of citations from Chinese LIS when they emerge. However, Chinese LIS has different preferences in citing emerging subjects at different times. Some emerging topics are ranked high in citation frequency for a long period of time, and attract long-term attention from Chinese LIS, such as information economics, intellectual property, knowledge management and marketing. However, the rest of the emerging topics only receive ephemeral attention from LIS and their citation frequency decreases rapidly after they emerge, such as game theory and contract theory.

5.4 Chinese LIS researchers prefer to cite works from non-life science

Chinese LIS researchers prefer citing knowledge from non-life science (207,497) such as computer science, economics and communications publications but less so from life science (46,799), such as education, political science and psychology publications. The latter have relatively deep degree of involvement with living or organic objects of study (Whitmire, 2002), being beneficial to constructing the system of knowledge about users. Concentrating research on users' information seeking, needs and preferences, as well as related areas is one of the significant LIS contributions to the world (Hahn, 2003). This citation behavior may cause Chinese LIS to lack sufficient knowledge about people, limiting its ability to investigate the mental processes and behaviors of users, which in turn will prevent Chinese LIS from making further contribution to the user community.

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5.5 Discussion and recommendation

As Chinese LIS is changing its traditional approach of relying on self-originated knowledge by importing more knowledge from other fields, Chinese LIS begins to show an increasing trend of interdisciplinarity. Chinese LIS should continue to stimulate innovation and complement its capacities by cooperating with appropriate partners and reformulating knowledge system. In addition, it should enhance the production of demand-driven knowledge to address real-life problems by optimizing knowledge import.

In the current knowledge system, Chinese LIS imports more knowledge on technology than on people, and rarely does so from the practice community, which results in the lack of background knowledge about people to support research on information users, such as users' mental processes and information behavior. In addition, the lack of knowledge created by the practice community indicates that Chinese LIS researchers overlook the knowledge used in practices of other fields. Chinese LIS should keep balance among theories, technologies and people in the knowledge system. In order to reformulate the knowledge system, LIS needs to import more knowledge that meets the demands of conducting research on users and practice in the LIS field, advocating the cultivation of innovative interdisciplinary professionals (Sun *et al.*, 2009) and recruiting faculty and instructors with different knowledge backgrounds.

Regarding interdisciplinary collaboration, Chinese LIS should cooperate with relevant fields such as computer science, communications, economics, education and psychology closely to increases the possibility of achieving successful interdisciplinary research (Yegros-Yegros *et al.*, 2015), and contributes to complement its capabilities in innovating technology and serving users.

In terms of knowledge production, as a professional field, LIS should promote the creation of knowledge that satisfies demands from LIS practice and users. In order to bridge the gap between research and practice in knowledge production, LIS researchers should keep track of research works in other fields that have been proved to be useful for LIS practice. Technologies originating from fields outside LIS should be transferred and modified before their application to LIS. As research trends and directions can be discovered by employing citation analysis (Rothman and Woodhead, 1971; Herther, 2015), citation preferences in borrowing knowledge about technology indicate that the knowledge production of Chinese LIS is pro-tech. In order to enhance the research on information users, Chinese LIS researchers need to acquire adequate and appropriate knowledge from other fields to better understand the information needs of users from a specific field, which is the process that needs to employ theories and methods related to user research created by authors from fields outside LIS.

Recommendations from this research are valuable for the evaluation of interdisciplinary collaboration between LIS and other disciplines, the development of LIS library collection, the reform of LIS education, and the recruitment of faculty and staff. They may also be used to develop strategies to produce knowledge that meets the demands of both the practice and users, and to create more effective interdisciplinary services to the LIS community.

There are two limitations in this study: it employs a relatively simple mathematical statistical method, and does not reflect the characteristics of citing documents which results in the lack of discovery of implicit knowledge and relationship between the citing discipline and cited disciplines. Future research will focus on the knowledge export from Chinese LIS to other disciplines by analyzing the disciplines outside LIS that cite Chinese LIS works and investigating the characteristics of authorship as well as subjects of both citing documents and cited documents to further explore such a relationship.

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