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A temporally dynamic examination of research method usage in the Chinese library and information science community

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ABSTRACT

In this paper, we discuss how research methods are used in the Chinese library and information science (LIS) community, a fundamental question in the pursuit of a global overview of this interdisciplinary research domain. We used manual coding to identify research methods mentioned in 2,421 Chinese-language papers written by 53 prestigious Chinese LIS researchers across different generations. For all selected publications, we manually identified and classified methods using a modified version of an established classification scheme for LIS research methods. Moreover, we examined how research methods are used by researchers belonging to different age groups over time. We identified a significant shift in the use of methods among examined publications: quantitative methods are increasingly used over time, driven both by the emergence of newer generations of researchers and by senior researchers gradually adopting newer methods. These findings reflect a major, and heretofore undiscussed, shift in research style in the LIS community in China. Our approach facilitates a new, more dynamic discussion of how research methods are adopted in a research community and will greatly contribute to future studies on this topic.

1. Introduction

The identity and position of library and information science (LIS) in the broader research community have been an ongoing research topic since the mid-20th century [1]. It has been commonly agreed that information science is a highly interdisciplinary field, if not a meta-field [2, 3, 4], which indicates that research approaches and methods in LIS may have different disciplinary origins [5], and that the boundaries between LIS and other neighboring communities have been constantly evolving. This is one source of the anxieties, voiced since the beginning of the 21st century, that LIS may lose its independent status or even vanish altogether [6, 7]. In light of these concerns, it is important to systematically evaluate the theoretical and methodological frameworks of LIS scholarship.

The present study aims specifically to outline how research methods have been used by Chinese LIS researchers over time, a topic that will greatly contribute to ongoing conversations about the position of LIS in the research ecosystem. As an important research community with clear geographical and language boundaries, the Chinese LIS community has been extensively studied using various scientometric methods [8, 9, 10]. However, the present effort to delineate the research methods used in this community will shed fresh

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light on its developments and enrich the global history of this research domain. In particular, by analyzing how methods are used by different generations of researchers, we strive to illustrate, in a more dynamic and granular manner, the evolution of research methods in this community.

What a research method is has been a contentious question over the centuries, for a few major reasons: first, the boundaries between research methods and related objects—especially theories, methodologies, and research techniques—can be very blurry. As the middle ground between theory and data [11, 12], research methods inevitably exhibit an ontological overlap with all these other objects. Second, the concept of a research method is itself highly diverse in terms of its definition and connotation. For instance, there is no clear consensus as to what should be counted or not counted as a research method: numerous theoretical and empirical works [13, 14] have been published to propose and discuss the classification of research methods, especially in LIS.

The present research takes as its starting point the definition of *scientific method* offered in the Merriam-Webster Dictionary: "principles and procedures for the systematic pursuit of knowledge involving the recognition and formulation of a problem, the collection of data through observation and experiment, and the formulation and testing of hypotheses" [15]. This definition has a strong focus on the principles, values, and justification of research methods, a central characteristic of methodologies in existing literature [11]. Consequently, we do not attempt to distinguish methods from methodologies in LIS research in the present investigation.

In this study, we examine how research methods are used as an indication of the existence of paradigms, in the broadest sense of the term[1], in the Chinese LIS community. It has been famously pointed out that no unambiguous definition of the concept of "paradigm" was offered in Thomas Kuhn's landmark work [18]. However, a common consensus holds that a paradigm is an incommensurable set of norms about doing science, of which norms about scientific methods are an indispensable part [19]. Given this clear connection between the use of research methods and the existence of research paradigms or overall styles, we hypothesized that we might use the pattern of method usage in publications to identify such paradigms and observe their emergence and evolution between different generations of researchers over time.

To fulfil the goal of this research, we expanded an established classification system for LIS research methods and applied it to 2,421 Chinese-language research articles written by 53 prominent LIS researchers in China. Two research questions are specifically pursued:

(1) What research methods have been used in information science studies during the past four decades? With this question, we aim to offer a survey of research methods covered by our paper sample in order to illustrate the methodological landscape of Chinese LIS scholarship. Based on the modified coding scheme, we used manual coding to identify and classify research methods from all sampled publications. The results serve as the foundation of the present study and an important baseline scheme for any future research pursuing a similar topic.

(2) How are research methods used by different age groups of Chinese LIS researchers over time? Based on our classification, we further investigated how research methods are used over time. Two levels of temporality are examined: the generation of researchers based on their age, and the publication year of research outputs. Based on these two temporal scales, we are able to show how research methods are used in Chinese-language LIS publications from a more dynamic perspective.

This research offers an important contribution to quantitative science studies by integrating considerations of temporality with empirical studies on research methods. Our results show a significant shift in how methods are used by Chinese LIS researchers over the past decades: quantitative methods have been increasingly used, a trend partly driven by the emergence of new generations of LIS researchers. Our results stand in direct contrast to case studies based on other countries and greatly complement the history of LIS from an international perspective, informing the future of this field.

2. Literature Review

The research methods involved in LIS have received notable attention from scholars in information science and quantitative science studies. The present study specifically contributes to a line of research that focuses on using the content analysis method to identify and classify research methods used and described in scientific publications.

One of the earliest works in this regard is that of Peritz, who listed 11 research methodologies [20]. However, this line of research became considerably more popular when Järvelin & Vakkari published their now heavily-cited work [13], wherein they developed a systematic structure of LIS methods with the following major components: research strategy, data collection method, type of analysis, and type of investigation. A major advantage of this system is that it incorporates different aspects of LIS research methods and thus describes them in a more granular fashion. This classification system was adopted, directly or with slight modifications, in a large number of subsequent empirical works [21, 22, 23].

More importantly, however, Järvelin & Vakkari's work supplies a fundamental terminology for future works to build new LIS research method classification systems. Later works tend to include some, but not all, elements in their system to focus on certain aspects of this topic; examples include Palvia et al.'s 13-item list [24] and Avison's modified 14-item list [25], both of which combine methods with other aspects of LIS publications, such as authorship and themes, to describe broader historical trends within this research field. Taking the same approach, Chu developed a longer list that is composed of 15 methods, a classification system that has

[1] We acknowledge that in Kuhn's original conceptualization, any paradigm is strongly, if not solely, connected to the sciences, which may not totally apply to library and information science [16]. However, this concept has been extensively used to examine the development of various social science domains [17]; we follow suit by using the concept of paradigm in this manuscript to denote to broad research styles in the Chinese LIS community.

had significant impact in its own right [14, 26]. As noted by Chu, there are significant differences among all the existing classification schemes in terms of what should and should not be counted as a method (and especially in terms of the differences among method, methodology, and theory) and how to deal with multiple methods. Underlying such differences is the fact that researchers may use the same name for different methods, and vice versa, due to the subjectivity of human language and the situated nature of methods and their usage in LIS research.

This approach has significantly contributed to an empirical understanding of the LIS community. For example, many empirical works have reported that methodologies adopted in LIS publications are generally more descriptive and qualitative but less quantitative and experimental than their counterparts in the sciences [27, 28]. However, most of these empirical studies are based on English-language publications, even when framed as a comparative or international analysis [28]. Very few studies have analyzed how research methods are used in non-English publications [29], mirroring a strong language bias in today's quantitative science studies [30, 31].

To offer a quantitative examination of a non-English research community, we present a content analysis of research methods used by key Chinese LIS researchers in their Chinese-language publications—a community never yet examined in the above line of research. We have largely followed Chu's classification scheme, as this is the most recent systematic classification scheme on this topic and matches well with the aims of this study.

3. Research Design

3.1. Data Collection and Sampling Strategy

The overall process of data collection is illustrated in Fig. 1, whose major steps are discussed below. We used this specific approach because we aim to examine a representative sample of key researchers in the Chinese LIS community, and review papers are the best source of such information.

STEP 1: Identifying researchers from review papers. The first step is to identify key researchers from literature reviews of Chinese LIS scholarship. In this step, we identified seven important Chinese-language literature reviews from the Chinese National Knowledge Infrastructure (CNKI; the largest academic literature database in China) in which the works of 167 information scientists were reviewed (see Appendix A), focusing on their publications and scientific impacts.

STEP 2: Sampling researchers. From the 167 researchers identified in the previous step, we used a stratified sampling strategy that took into account (1) how many times these researchers are mentioned in the seven reviews and (2) the age group a researcher belongs to. We divided all researchers by birth year (collected manually) into the following 10-year groups: 1930–1939 (*1930s*), 1940–1949 (*1940s*), 1950–1959 (*1950s*), 1960–1969 (*1960s*), 1970–1979 (*1970s*), and 1980–1989 (*1980s*). For each age group, we included researchers in the top 30% based on their frequency of mention in the seven reviews. Our final sample is composed of 53 researchers in total (see Appendix B).

STEP 3: Acquiring publications. The 50 most highly cited papers by each researcher were collected from CNKI. When an author had fewer than 50 articles, all their publications were collected. To avoid any biases induced by author order, we only selected publications in which the targeted researchers were either the first author or the sole author [32]. In all, the full text of 2,421 papers, published from 1980 to 2020, was retrieved and downloaded in December 2020.

3.2. Coding Scheme and Process

To identify and classify research methods in these publications, we used the 15-item classification scheme developed by Chu and her colleagues, as shown in Appendix C [14, 26]. We regard this system as the most appropriate, as it is one of the most recent efforts to develop a comprehensive framework for LIS research methods.

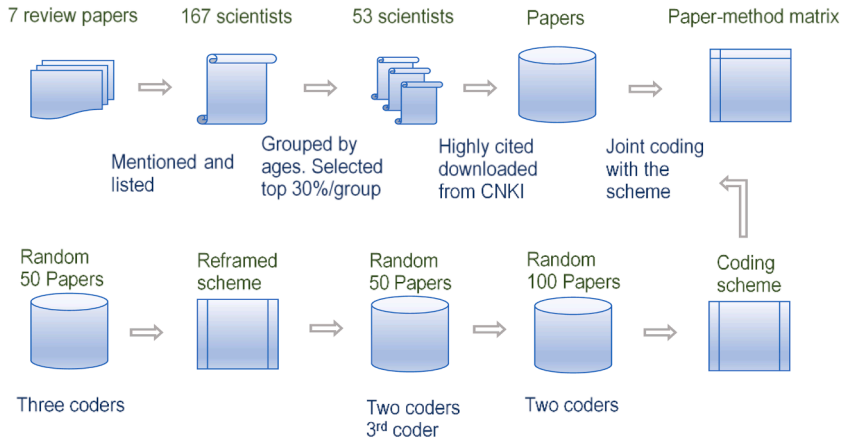

Fig. 1. Research design and data process in this study

We first tested this framework on our data. Three coders independently reviewed 100 randomly selected articles from our final sample to determine the applicability of this system to our corpus and identify any changes needed before this system could be used in manual coding. The following changes were made after this step:

(1) We added the category of "non-research" to refer to non-academic publications (such as those lacking any abstract and/or references).
(2) We added four further categories to the system to accommodate our data.
(3) All involved methods were recorded as-is, instead of having a separate category for the following scenarios.

- Mathematical method: This only applies to studies employing mathematical analysis (e.g., integrals) in this research, not to studies that present statistical calculations and their results.
- Network analysis: These methods "depict relations among actors and […] analyze the social structures that emerge from the recurrence of these relations" [33]. In this study, we use this code only when network analysis was employed as the major method in a paper as distinct from its incidental use in bibliometrics and webometrics.
- Scan: "collects a series of events, policies, actions, research studies to describe a concept, an opinion, a phenomenon, etc." We treat the term "scan" as a new method instead of a generalization of "questionnaire" and as distinct from the methods typical to case studies and literature reviews.
- System and software analysis/design (S&S AD): "development and experimental evaluation of tools, techniques, systems, etc." [34]. To distinguish from the "experiment" method, we define "S&S AD" as more practical and implementation-focused, specializing in system construction and software, system, or interface design.

For each paper with at least one identified research method, we also recorded the general research approach in the paper, following the example of Järvelin & Vakkari [13]. All papers were classified as qualitative, quantitative, or mixed, depending on their approach to analyzing the data. This information was added in order to augment Chu's method list with another aspect of research methods, so as to gain deeper insights into how research methods are used in our paper sample.

Papers without any research method were further classified into the following four categories depending on the nature of the content.

- Case study: "in-depth exploration of an activity, an event, a program, etc., usually using a variety of data collection procedures" [34].
- Literature review: "includes both a mere listing of current and critical advances based on literature and such with important concepts, frameworks, theoretical insights, and limitations and gaps" [35].
- Non-research: This category denotes to papers that do not employ any method; specifically the structure is incomplete, such as the lack of abstract or references.
- Opinion paper: "studies […] characterized by their broader scope and open-endedness to emphasize a particular point of view by facts, statistics, real-life examples instead of presenting research evidence" [35]. Usually, these are sequentially arranged through facts, problem, and proposed solutions.

The above coding scheme (see Table 3) was applied to all sampled papers by two independent coders. The resulting inter-coder reliability was 0.753, a score deemed "excellent" by the standard of Landis and Koch [36]. All inter-coder differences were resolved by these two coders and a third coder before the data was analyzed. A section of our coding results is shown in Table 1.

3.3. Data Analysis

The research questions for this paper involve three objects: time period, researchers, and methods. Our target in inferential analysis is to reveal the relationships (specifically the differences) among these three objects, which we have divided into several variables based on their features. Time period, for instance, is analyzed in terms of publication time, age, career length, and age group. Researchers are analyzed by age, age group, and career length; methods are measured by their novelty, diversity, and overarching types of analysis. However, there are only three types of analysis in our coding scheme (see Table 3); group tests on this variable are therefore excluded. Novelty represents whether a method was considered new at the time it was used in a given paper. Diversity reflects the variety of method usage within a period or a group of researchers. The structure of hypotheses and descriptions of the variables are shown in Table 2.

Table 1
Coding and data samples

Researcher	Age	Group	HCP title	PY	Methods	TA
Ma F.	73	1940s	Historical review of the development of information science with proposing frontier topics	2013	Historical method	Qualitative
Ma F.	73	1940s	Research on students' information literacy in Wuhan	2009	Questionnaire; Delphi	Mixed
Ma F.	73	1940s	The development and future of information science	1996	Theoretical approach	Qualitative
Sha Y.	52	1960s	Research on the relationship between inter-institutional collaboration networks and academic impact of institutions	2017	Bibliometrics; Network analysis	Quantitative
Xu X.	44	1970s	Research on metadata standard and application of intangible cultural heritage digital resources	2014	Experiment	Quantitative

We modeled the distribution of method usage via logistic regression and confirmed the turning point of each method (see Supplement A). After the turning point, a given method is no longer considered new, and its corresponding paper is no longer included in the sample used to calculate the average novelty at a certain time or in a group. The lower the novelty score is, the newer the method being used is.

To meet the requirement of the Kruskal-Whitney H test for novelty, we divided age and career length, respectively, into 11 and 7 five-year intervals; in the test for diversity, we likewise divided age and career length into 13 and 8 groups, respectively. The discrepancy results from the different numbers of papers sampled in the two tests: novelty is only calculated when a paper applies a method that is still new at publication time, which leads to a smaller sample of publications than in the diversity test (see Supplement B). The results are almost equally distributed across these groups, with the only exception of the age group.

In the following results analysis, we use fractional counting to calculate the usage when two or more methods are applied in one paper. When a method appears as the sole method in a paper, it is counted normally.

In the last part of the paper, we use K-means clustering methods to group 53 researchers based on their usage behaviors. The cluster features, which represent types of analysis and methods, are reported numerically based on the annual usage figure across a researcher's entire career length.

4. Results

4.1. Distribution of Research Methods across Papers

4.1.1. Research method usage overview

Table 3 summarizes the distribution of methods and analytical approaches across the paper sample. The most commonly used research methods include theoretical approach (49.38%), scan (10.19%), bibliometrics (7.81%) and system & software analysis/design (6.52%). This distribution differs significantly from that found in previous work. In Spanish journals, for instance, the most commonly used category of method was "descriptive research," which falls under "opinion papers" in the rubric of our study [29]; in an international scenario, questionnaire, content analysis, and theoretical approach were applied the most frequently [26, 34]. Differences in coding strategy make it difficult to perform a precise comparison, but the geographical differences in usage trends are noteworthy nonetheless.

Another notable finding from this table is that qualitative studies predominate in the paper sample. Our sample contains a significantly larger share of qualitative papers than that reported by either Ferran-Ferrer et al. (45%) or Tuomaala et al. (14%) [23, 29].

Among the other papers, 802 (33.13% of all downloaded papers) did not use any identifiable research method. Such papers account for a major proportion of our sample, indicating a distinct "research" tradition within the LIS landscape.

4.1.2. Overlap of research method usage

Fig. 2 depicts the clustering of 1,619 papers across 17 methods using Euclidean distance similarity, Partitioning Around Medoids (PAM), and t-distributed stochastic neighbor embedding (t-SNE) to partition and visualize the clusters as in [37, 38]. The cluster map illustrates the distances among medoids (i.e., the methods in the middle of the cluster), automatically discovered from the coding results, with other individual papers clustered around these medoids. The relative position is indicated by the overlaps between clusters.

Multiple-method usage in a single study appears in 57 papers (3.52% of the total) involving 30 researchers (56.6%). All 17 methods in our coding scheme have been co-mentioned with other methods in at least one publication, which gives a foundation to generate a cluster map as Fig. 2. Furthermore, the distribution of each method gives us a general view of the relationships among them; theoretical approach, for instance, is surrounded by several other major methods, such as scan, S&S AD, experiment, and bibliometrics. Other

Table 2
Description of hypotheses

Hypotheses	Independent Variables	Dependent Variables		Tests
H1a	publication time (P: publication year of a paper)	usage amount	method	correlation analysis
H1b		novelty		
H1c		diversity	type of analysis method	
H1d				
H2a	age (actual age of a researcher at the publication time of a paper)	novelty	method	Kruskal-Wallis test for group test & correlation analysis
H2b		diversity		
H3a	career length (from a researcher's first publication year to the publication time of a paper)	novelty		
H3b		diversity		
H4a	age group (by decade)	novelty		
H4b		diversity		

Usage amount = number of times a method is used
Diversity = number of different methods that have been used at a certain time or by certain people.
First appearance year (F) = first year that a method was used in our dataset
Turning point (T) = year in logistic regression result that distinguishes uptrend and downtrend
Novelty = number of years from F to P ($P \leq T$)

Table 3
Statistical breakdown of coding results

Category		# papers	% papers	# researchers using	% researchers using
Papers with research methods	Theoretical approach	799.5	49.38%	53	100.00%
	Scan	165	10.19%	45	84.91%
	Bibliometrics	126.5	7.81%	31	58.49%
	System & software analysis/design	105.5	6.52%	20	37.74%
	Experiment	87	5.37%	27	50.94%
	Historical method	81	5.00%	28	52.83%
	Questionnaire	65	4.01%	19	35.85%
	Mathematical method	58	3.58%	14	26.42%
	Webometrics	40.5	2.50%	14	26.42%
	Network analysis	36	2.22%	18	33.96%
	Content analysis	35.5	2.19%	22	41.51%
	Interview	8	0.49%	9	16.98%
	Delphi study	6.5	0.40%	8	15.09%
	Focus group	2	0.12%	2	3.77%
	Observation	2	0.12%	3	5.66%
	Transaction log analysis	0.5	0.03%	1	1.89%
	Think aloud protocol	0.5	0.03%	1	1.89%
	Total	1,619	100%	53	100%
Types of analysis	Qualitative	1,153	71.22%	53	100.00%
	Quantitative	431	26.62%	43	81.13%
	Mixed type	35	2.16%	13	24.53%
	Total	1,619	100%	53	100.00%
Papers without research methods	Opinion paper	343	42.77%	48	90.57%
	Non-research	228	28.43%	47	88.68%
	Literature review	150	18.70%	46	86.79%
	Case study	81	10.10%	31	58.49%
	Total	802	100%	53	100%

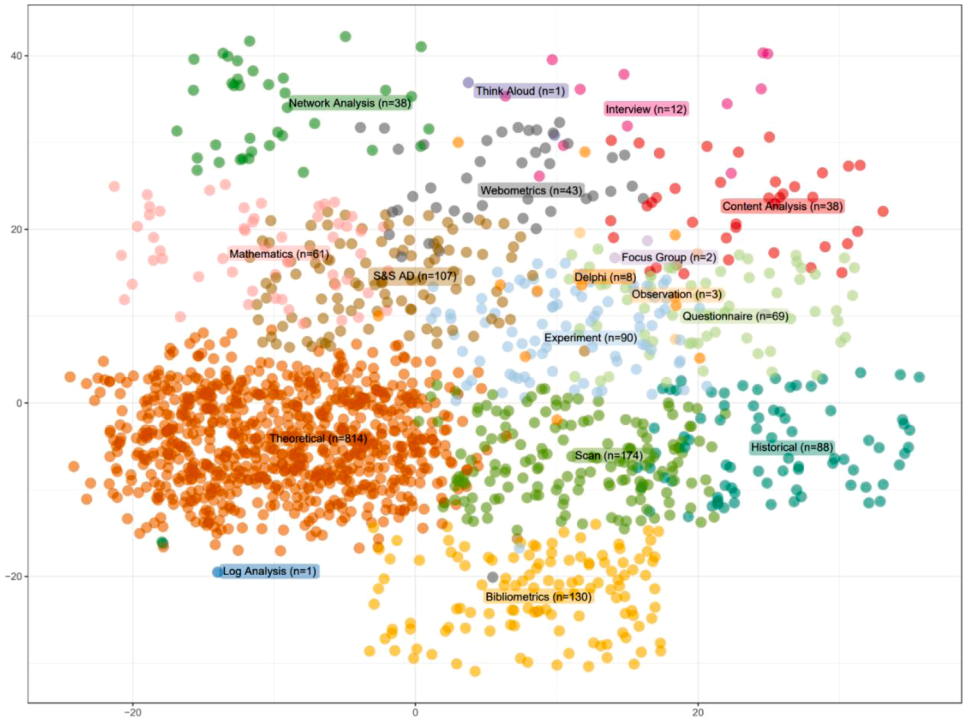

Fig. 2. Cluster distribution of method usage in individual papers (n = usage count)

methods are located according to the nature of their respective analysis types. Generally speaking, methods which were often taken as quantitative (e.g., mathematics, S&S AD, experiment, network analysis, and webometrics) tend to cluster together, while qualitative methods such as questionnaire, observation, and Delphi converge on the right upper corner of the map. Network analysis and webometrics have nodes across the vertical axis of the map due to their overlap with log analysis and bibliometrics.

4.1.3. Usage trend over time

Figs. 4 and 5 provide an evolutionary view of method usage over the past four decades. Three general patterns emerge from the graphs. First, the results of Spearman correlation analysis tell us that all the relationships proposed in H1 are significant. Publication age and method novelty are positively correlated ($R = 0.695^{***}$), and the relationships involving diversity ($R_{typeofanalysis} = 0.563^{***}$, $R_{methods} = 0.892^{***}$) both exhibit a high degree of correlation. This indicates that the newer publications have applied slightly newer methods than older publications. Second, consistent with the overview statistics, a theoretical approach leading other qualitative analysis methods has been the dominant method in our corpus until recently. Third, the usage pattern of all methods and types of analysis shifts over time. In particular, the theoretical approach was the dominant research method until the early 2000s, when the trend reversed; qualitative analysis in general exhibited the same pattern. The temporal pattern can be understood in four stages based on how the patterns are used.

STAGE 1: The emergence stage (1980–1990): The most significant characteristic of this stage is that eight out of nine dominant methods appeared, which may account for the overall skewed distribution. Pearson correlation results show a moderately positive relationship between the overall age of the method (time between first appearance and 2020) and the usage amount ($R = 0.513^{***}$); the earlier a method appears, the more papers adopt it. Moreover, it is very clear that in Fig. 3 quantitative and mixed analysis types make up 20–30% of all papers. Similarly, in Fig. 4(A) and (B), several new methods appear over time. Even though "theoretical approach" outnumbered other methods in almost every year, the trend is unlikely stable.

STAGE 2: The dictator stage (1991–2005): The major feature of this stage is stability. Qualitative analysis was adopted in 90% of all papers in this stage, and theoretical approach overnumbered every other method each year at a rate of 75%. Other methods retained relatively stable proportions of 5–10%. In reality, at this time, the Chinese LIS community was attempting to articulate a certain research paradigm; this process introduced many important theoretical themes, such as the the existing name and key areas in the existing LIS domain in China. According to our study, these conversations are reflected in researchers' methodological choices.

STAGE 3: The transition stage (2006–2011): Things began to change around 2006. In five short years, many methods emerged and revolutionized the skewed distribution seen in previous stages. This phenomenon reached a peak in 2008, where the total number of methods was highest and the greatest diversity appeared. The defining trait of this stage is that publications were increasing across all methods, although theoretical approach still held the largest proportion, and other methods (see Fig. 4(C) and (D)) were introduced into the Chinese LIS community. Methods such as focus group, network analysis, Delphi, log analysis, interview, and observation appeared for the first time at this stage. Meanwhile, the proportion of qualitative analysis decreased year by year as seen in Fig. 3.

STAGE 4: The diverse stage (2012–): Divergent usage is the signature of this stage. Qualitative and quantitative analysis were almost equally distributed (Fig. 3), and the once predominant theoretical approach came to account for only 30% of usage, while other dominant methods increased to around 10–15%. The increasing appearance of minority methods is especially conspicuous; some of these, such as content analysis and webometrics, reached their peak usage during this stage.

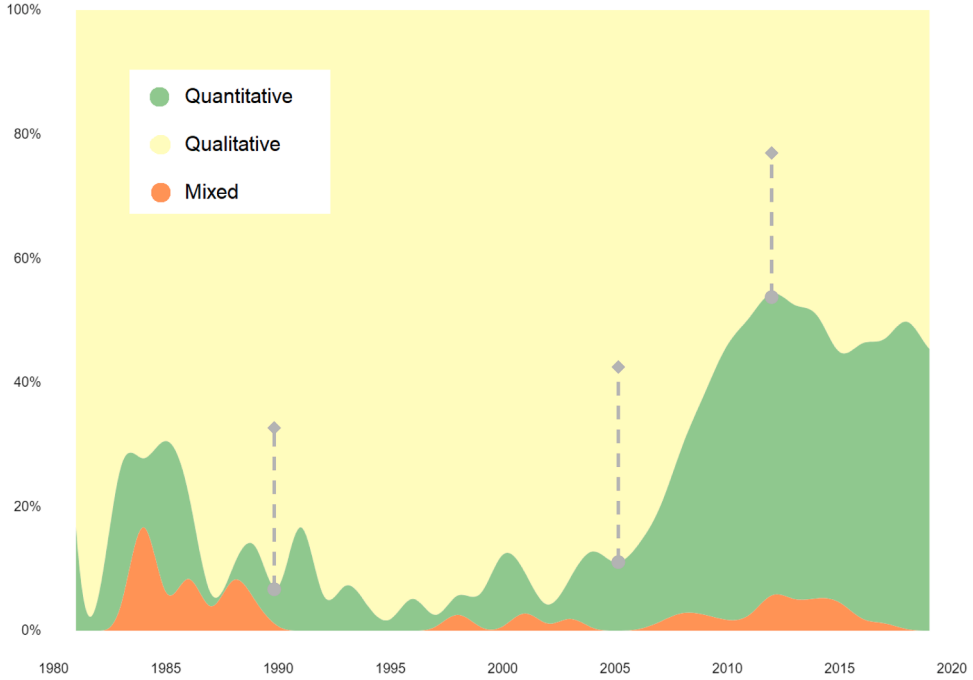

Fig. 3. Timeline view of the ratio of total papers by type of analysis

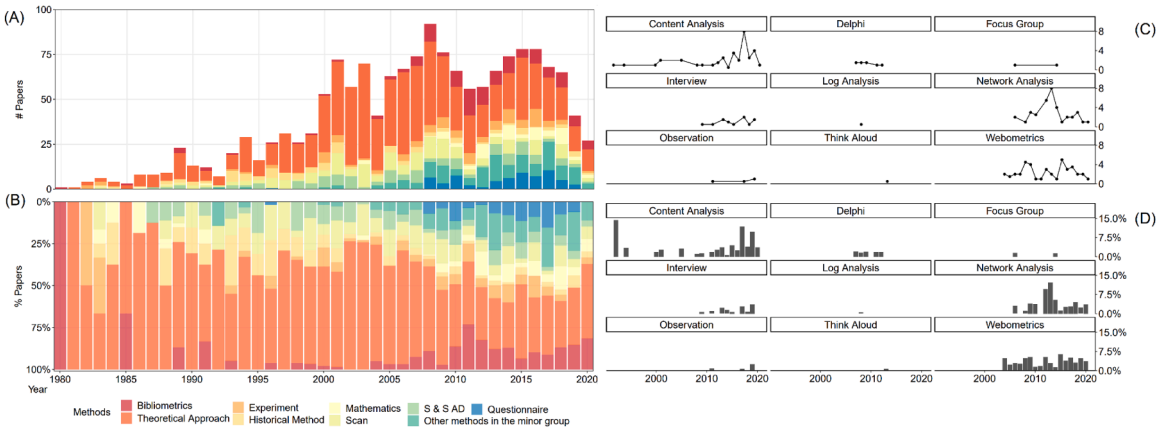

Fig. 4. Timeline view of method usage by year
Note. "Others" are methods used in fewer than 50 papers. (A) Total usage count of methods. (B) Ratio of method usage to annual total. (C) Total usage count of methods in the minor group. (D) Usage ratio of methods in the minor group.

4.2. Distribution of Sampled Researchers

The distribution of the annual numbers of researchers not only illustrates the intergenerational evolution of LIS but also touches on the topic of researchers' academic careers. We introduced two methods to calculate the number of researchers at a certain time. *Active researchers* in a year are those whose career length includes that year; *publishing researchers* are those who published papers in that year. For instance, if researcher A's career spans 1990–2000, A is counted as an active researcher in 1995 regardless of the specifics of A's publishing record. However, if A published papers only in 1990 and 2000, A will be counted as a publishing researcher only in those two years and not in 1995. Each measurement offers a different view of the dynamic evolution of researchers' activity levels.

The distribution of publishing researchers over the 41 years shown in Fig. 5 can be segmented into several 6- to 8-year cycles, each with a significant upward and downward component. The turning points are the years 1985, 1992, 1998, 2004, and 2012. However, the ratio of publishing to active researchers exhibits a different cycle. Since this ratio represents the percentage of researchers publishing actively at a given time, it can tell us a fuller story about researchers' active participation in LIS research. 40–60% of researchers are very active before 1992, but this figure shifts down to 20–50% of researchers 1992 and 2000 before climbing back up to 60–80% during much of the past 20 years. The distributions seem to be highly intergenerationally significant with a ten-year gap, since the trend changes every decade but eventually becomes steady. In particular, the duration of the downtrend during the last decade of the 20th century is in line with the duration of Stage 2 (dictator stage). We associate these two phenomena to demonstrate that homogeneirty of method usage may discourage research enthusiasm.

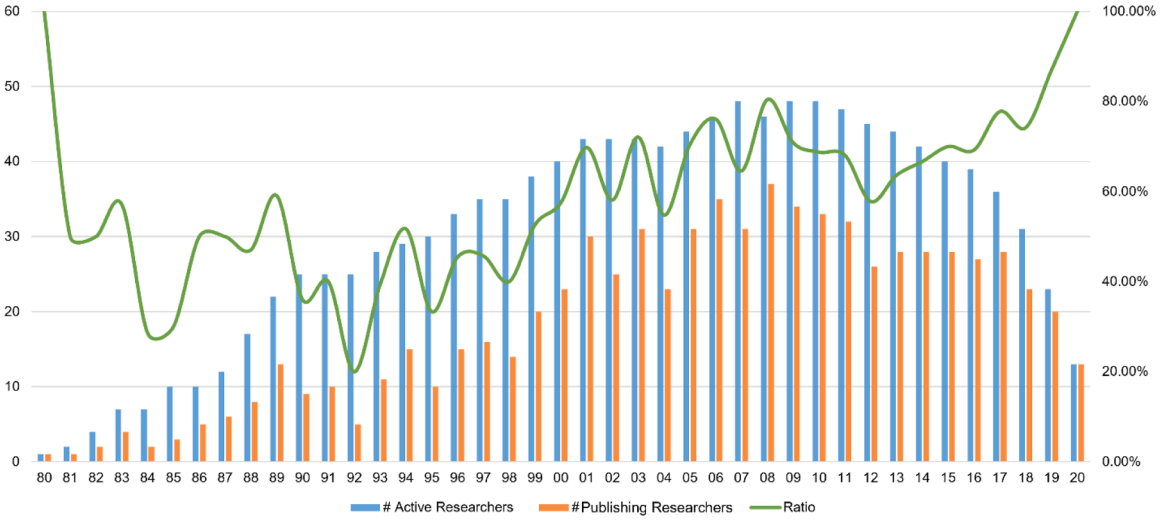

Fig. 5. Timeline view of sampled researchers
Note. "Ratio" is the ratio of publishing researchers to active researchers in a given year.

Fig. 6 shows the distribution of publications in different age groups over the past 40 years. The ups and downs in Fig. 6 are in line with the main tendency seen in Fig. 4. Senior researchers certainly had longer career lengths than junior researchers. Researchers in the 1930s group have almost 40 years' experience of publishing highly cited papers, while those in the 1980s had just started in 2007. On top of that, some groups have reached their publishing peaks. For instance, the highly-cited-paper peaks of the 1930s and 1940s cohorts appeared in 2000 and 2007 respectively; the 1980s cohort, meanwhile, does not yet seem to have reached its peak. In terms of average numbers, however, the 1980s group is very competitive in recent years (2017, 2018). The other three generations' peaks are all in the year 2009, which explains why this year also has the largest total number of publications.

Fig. 6 explains the deceasing publication count seen since 2010 in Fig. 4. The intergenerational distribution is very skewed; ideally, if information science has been progressively moving forward, we should expect similar distributions of publications over time across generations. In this connection, the gap between the peaks of the 1930s and 1940s cohorts (2000 and 2007, respectively) appears to be valid. The gaps between other groups, however, are centered towards 2016. This trend is very heavily influenced by citation window; that is to say, the publications of other generations (1960s, 1970s, and 1980s) have not yet been fully cited. It is highly possible that they have not encountered their highest cumulative citation periods. We can, however, see a rough apparent peak for the 1960s generation in 2018, and it seems likely that this will be the overall peak for this cohort.

4.3. Distribution of Research Methods across Researchers

We further investigated the overall approach taken by researchers in our paper sample. Fig. 7 shows how the three research approaches are distributed across all age groups. It is obvious that junior researchers rely more on quantitative than on qualitative methods; one explanation for this difference, certainly, is that many senior scholars received their research training before the opening-up policy was initiated in China [39, 40], and the norms of that period may differ from the scientific-dominated research norms in the LIS domain of today. Thus, they are less likely than junior researchers to exploit more contemporary techniques such as network analysis and webometrics.

Visualizing different methods' changing popularity among researchers in terms of papers per person (Fig. 8) helps us better understand the evolution seen in Fig. 4. Notably, method usage per person per year is almost evenly distributed, albeit under the condition that the theoretical approach consistently dominates this distribution. Each method has been employed in 1.5 papers on average for each researcher, with the exception of two very strong years for experimental and mathematical methods. The four stages proposed in section 4.1.3 above can also be seen from Fig. 8. First, although the fractional counting method does not highlight theoretical approach as sharply as in Fig. 4, the stability of theoretical approach usage is more consistent than others, horizontally speaking; this is indicative of the leading status of this method. Second, the emergence and divergence are also reflected in this graph. The new entrants in the early 1980s appear at the same time in Stage 1, and the most equal dissemination happens between 2010 and 2016, which is a part of Stage 4. According to [41], the methods are based on the choice of methodology so to the point of research problems. Based on this assumption, it can be inferred that the nature of research is becoming increasingly complicated and diversed during the past few years.

The numbers of researchers vary noticeably by group, which results from the unequal numbers of researchers named in the seven reviews we consulted. The researchers in these reviews were listed and selected by their research performance without respect to age; thus, we selected our researcher samples from a distribution that was already uneven in terms of age. Thus, considering the different scale of researcher samples, the means (e.g. mean papers per person and mean usage count) have been given greater consideration during our analysis. In Table 4, every group in our sample (apart from the 1930s cohort) has published approximately 30 articles per person during the four-decade time window under study. To this end, our dataset is representative.

Every age group displays its own preference with regard to research methods. The diversity of methods applied has become more and more complicated as age difference is taken into account. Based on the results of Kruskal-Whitney H tests, the hypotheses concerning age ($[\chi^2\ (2, n = 756) = 25.666, p = 0.012 < 0.05]$) and career length ($[\chi^2\ (2, n = 756) = 19.369, p = 0.007 < 0.01]$) are rejected, which indicates that method usage diversity varies significantly across different age cohorts. Moreover, correlation analysis between career length and method usage shows a slight positive correlation at a rate of 0.078**. However, the corresponding hypothesis regarding age group by decade does not show a significant difference ($[\chi^2\ (2, n = 53) = 8.952, p = 0.111 > 0.1]$). We assume the unequal numbers in the age groups have an impact on the results. However, in Table 4, the age-group differences in method choice are significant, especially from the perspective of average number of methods used. The 1930s group is the only one that applied less than 60% of the methods; these seven researchers have consistently preferred three methods in their research over the course of their long careers.

Age groups	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
1930s	1			3	3		1	1	4	9	4	3	1	4	6	6	9	10	6	11	22	13	12	9	4	2	6	2	6		1		3			1	1	1	2	1	
1940s			1	3	1	1	2	6	5	1	10	3	5	1	5	2	4	6	7	8	7	6	11	8	15	12	17	15	18	14	9	7	7	5	10	9	6	4	1	2		3
1950s				1	2			1	1	2	3	1	1		3	14	6	7	8	7	8	14	27	17	8	10	11	10	13	13	16	14	10	8	11	9	14	8	14	7	6	2
1960s						1		1	2	1	5	3	5	8	7		4	5	5	4	8	17	15	22	12	19	17	22	37	25	18	20	19	19	29	29	43	22	28	15	9	
1970s																		1		1	3	4	5	16	3	14	19	18	15	19	17	14	13	22	17	22	14	18	14	10	4	
1980s																												1	7	7	9	5	9	4	10	6	8	12	12	9	9
Total	1	1	4	6	4	3	8	8	9	23	13	12	7	20	29	16	26	31	26	31	53	72	57	70	41	63	67	74	92	76	66	56	57	66	74	78	78	68	65	41	27
1930s	0.14			0.43	0.43		0.14	0.14	0.57	1.29	0.57	0.43	0.14	0.57	0.86	0.86	1.29	1.43	0.86	1.57	3.14	1.86	1.71	1.29	0.57	0.29	0.86	0.29	0.86		0.14		0.43			0.14	0.14	0.14	0.29	0.14	
1940s		0.13	0.38	0.13	0.13	0.25	0.75	0.63	0.13	1.25	0.38	0.63	0.13	0.63	0.25	0.50	0.75	0.88	1.00	0.88	0.75	1.38	1.00	1.88	1.50	2.13	1.88	2.25	1.75	1.13	0.88	0.88	0.63	1.25	1.13	0.75	0.50	0.13	0.25		0.38
1950s			0.11	0.22			0.11	0.11	0.22	0.33	0.11	0.11		0.33	1.56	0.67	0.78	0.89	0.78	0.89	1.56	3.00	1.89	0.89	1.11	1.22	1.11	1.44	1.44	1.78	1.56	1.11	0.89	1.22	1.00	1.56	0.89	1.56	0.78	0.67	0.22
1960s						0.06		0.06	0.13	0.06	0.31	0.19	0.31	0.50	0.44		0.25	0.31	0.31	0.25	0.50	1.06	0.94	1.38	0.75	1.19	1.06	1.38	2.31	1.56	1.13	1.25	1.19	1.19	1.81	1.81	2.69	1.38	1.75	0.94	0.56	
1970s																		0.11		0.11	0.33	0.44	0.56	1.78	0.33	1.56	2.11	2.00	1.67	2.11	1.89	1.56	1.44	2.44	1.89	2.44	1.56	2.00	1.56	1.11	0.44	
1980s																												0.25	1.75	1.75	2.25	1.25	2.25	1.00	2.50	1.50	2.00	3.00	3.00	2.25	2.25

Fig. 6. Timeline view of annual papers by age group (total publications in red, average per person in green)
Note. The averages are based on the total number of researchers in the relevant groups.

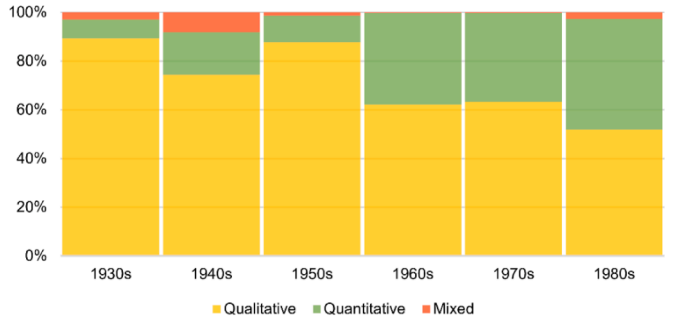

Fig. 7. Distribution of types of analysis by age group

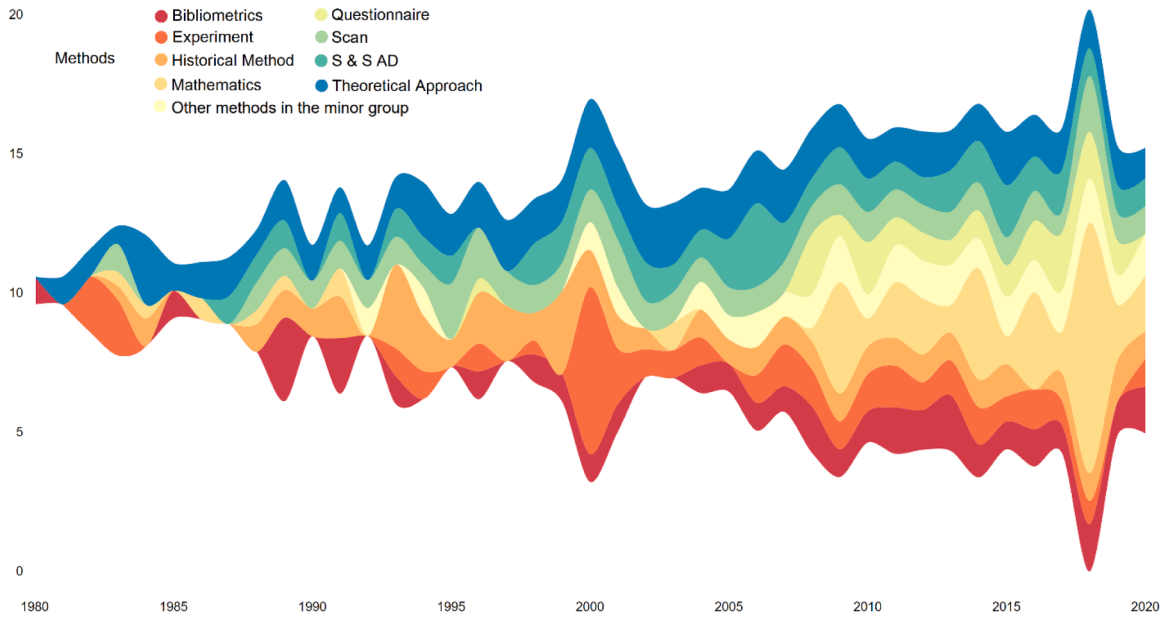

Fig. 8. Timeline view of method usage in annual papers per person
Note. "Others" are defined as in Fig. 4.

Table 4
Variety of method usage by researcher age group

Age group (# members)	# papers		Types of research methods		
	Total	Per person	Total	% methods	Per person
1930s (7)	168	24	8	47.06%	3.43
1940s (8)	257	32.13	13	76.47%	7.00
1950s (9)	307	34.11	11	64.71%	5.11
1960s (16)	496	31	14	82.35%	6.19
1970s (9)	283	31.44	16	94.12%	6.78
1980s (4)	108	27	13	76.47%	6.75
Total	1619	30.54	17	100%	5.91

Table 5 explains what specific methods junior researchers have undertaken. They used *theoretical approach* half or one-third as often as other age groups, but they rely on

system and software analysis/design and *other* methods much more frequently than other age groups. Kruskal - Whitney H test results for novelty further establish the differences based on age ($[\chi^2\ (2, n = 1015) = 64.854, p = 0.000 < 0.005]$), career length ($[\chi^2\ (2, n = 1015) = 78.634, p = 0.000 < 0.005]$), and age group ($[\chi^2\ (2, n = 53) = 18.617, p = 0.002 < 0.005]$). That is to say, there is a significant age-based difference in the choice of research methods. Correlation analyses show the relationships between age difference and method usage are all slightly positive at a rate of $R_{age} = 0.081^{**}$ and $R_{careerlength} = 0.285^{***}$. Furthermore, there appears a pattern of centralization and dissemination in which some methods, such as *experiment* and *scan*, are equally used in every group, whereas others

are characteristic of specific age cohorts. For instance, *bibliometrics* and *mathematics* are mostly undertaken by the 1960s group, and *other* methods are simply adopted by comparatively young researchers. Another important finding is that senior researchers contribute to more publications without any research method, especially *non-research* and *opinion paper* categories. While such publication types have remained acceptable outputs in the Chinese LIS research community, the changing patterns across generations indicate the growing impacts of research methods and the training for such methods within LIS education in China.

To understand these similarities and differences in the context of individual usage, we constructed a cluster map (Fig. 9) that clustered researchers based on their annual usage of each method. We aggregated the methods used in fewer than 50 papers as one method, i.e., *other*, and incorporated eight dominant methods and three types of analysis to produce a 12-dimensional numerical vector representing the usage of each researcher. Using Euclidean distance similarity, K-means, and t-distributed stochastic neighbor embedding (t-SNE) to partition and visualize the clusters, we found eight clusters that attained a manimum rate of 65.5% BSS/TSS. The reason for this low rate of BSS/TSS is that the usage of research methods is only one factor in the entire research process; it is far from an independent measure of the complexity of clustering researchers. Moreover, the choice of research methods depends more on research questions and methodological problems than on the characteristics of researchers' sociodemographic information. We expected that the researchers who applied the most similar methods would cluster together.

The two largest clusters, each containing 17 researchers, are located on the left part of the map. Tracing back to the method usage of individual researchers accordingly, the purple group gathers the researchers who utilize multiple methods but specialize in *theoretical approaches* and *historical methods* in the context of qualitative analysis. The blue-green group collects the researchers who prefer *theoretical approaches* and *scan* in a qualitative context. The right bottom corner shows a cluster of seven researchers who choose *bibliometrics* and *experiment* in quantitative studies; the orange cluster with four researchers represents *questionnaire*, and the light green cluster with another four researchers shows the group of *system and software analysis/design*, both in a quantitative context. The two brown nodes located between the *theoretical approach* and *S&S AD* groups indicate that those are the favored methods of these two researchers. The two isolated nodes show two researchers who intensely applied *historical* and *mathematical* methods, respectively.

Most of the clusters in the map are consistent with the age groups; for instance, many of the 1960s researchers are clustered together in the right bottom corner. More generally, most senior researchers are clustered at the left of the map, favoring a theoretical approach and qualitative analysis, while the questionnaire, experiment, and bibliometrics groups are mainly composed of junior researchers.

5. Discussion and Conclusions

Research methods play key roles in every research area, yet we have very limited knowledge of how research methods are adopted in LIS communities. To address this gap, we manually coded the research methods used in more than 2,000 articles from a sample of 53 key LIS researchers in China to understand how these research methods are used in China and to identify usage trends across time and researcher age.

We found that qualitative analysis has contributed a large proportion of publications in this field. The two dominant methods, *theoretical Approach* and *scan*, have long-lasting significance within our paper sample. Quantitative methods, meanwhile, have been gaining momentum in the LIS community, a trend that is well recorded in the literature [42].

Another important finding from this study is that the use of all the methods undergoes significant changes over time. Four distinct stages were identified from the analysis. In the first stage (1980s), the mix of several methods used in the literature and the relative importance of the theoretical approach starts to appear. The second stage, approximately 15 years in duration, is completely dominated by the theoretical approach. In the third stage, this predominance declines significantly as essentially every other method in our classification increases in prevalence. In the fourth stage, i.e., the last decade, a pattern of stable diversification is observed, though the rise of new methods in quantitative analysis may break the balance in the future.

Based on our results, a reasonable conclusion is that a (semi-)paradigm shift happened in the second stage (1991–2005), whereas the periods before and after are akin to what is described by Kuhn as "normal science" [19]. We acknowledge that there are ongoing debates concerning to what extent, if at all, Kuhn's paradigm theory can be applied to social sciences, or to a meta-field like library and information science [43, 44, 45]. Moreover even among those LIS researchers who accept the applicability of the paradigm concept, there may not be an agreement about what these paradigms are. For example, Hjørland famously introduced five technology-driven "paradigms" of information, including computers and the internet, that are especially relevant to the construction of information theories [1]. Additionally, some researchers suggested that a human-centered paradigm was introduced in the LIS community in the beginning of the 21st century [46, 47]. This diversity of views about paradigms reflects the vagueness of the definition offered by Kuhn himself as well as the multidisciplinarity of LIS research [5]. Naturally, we are not expecting our results to be directly translated into these findings, given the specific geographic and epistemological scopes of our research. However, we do believe that we have found a pattern in how research methods, as an important aspect of the paradigm in LIS scholarship, change over time in Chinese-language publications, a novel perspective that has not been examined in previous studies.

Although there are likely many factors at play, the emergence of junior researchers is at least one of the explanations for the shift discussed above. Our results demonstrate that junior researchers are less fixated on a single method and more likely to use a combination of methods in their publications. The increasing numbers of methodological choices and the expanded groups of multi-method users show the expanding skillsets of Chinese LIS researchers. Moreover, we have also found evidence that junior researchers shifted the style of analysis from qualitative to quantitative. This indicates a globalization process in the Chinese LIS community when compared to the ratio that previous work has reported [29,34]. On the other hand, the strong preference for a theoretical approach and non-research publications among senior scholars implies that the requirements of research methods were

Table 5
Total and average papers published by age groups using different methods

Age group Method	1930s	1940s	1950s	1960s	1970s	1980s
Bibliometrics	1(0.14)	18(2.25)	10.5(1.17)	65.5(4.09)	21(2.33)	10.5(2.63)
Experiment	12(1.71)	14(1.75)	17(1.89)	25(1.56)	17(1.89)	2(0.5)
Historical method	26(3.71)	7(0.88)	19.5(2.17)	22(1.38)	5.5(0.61)	1(0.25)
Mathematics	2(0.29)	4(0.5)	2(0.22)	45(2.81)	3(0.33)	2(0.5)
Questionnaire	0(0)	11.5(1.44)	5(0.56)	13.5(0.84)	23.5(2.61)	11.5(2.88)
Scan	12(1.71)	20.5(2.56)	22.5(2.5)	75(4.69)	24.5(2.72)	10.5(2.63)
System & software analysis/design	9(1.29)	28(3.5)	31.5(3.5)	7(0.44)	12(1.33)	18(4.5)
Theoretical approach	104(14.86)	130.5(16.31)	195.5(21.72)	199.5(12.47)	137(15.22)	33(8.25)
Others	2(0.29)	23.5(2.94)	3.5(0.39)	43.5(2.72)	39.5(4.39)	19.5(4.88)
Case study	2(0.29)	4(0.5)	24(2.67)	40(2.5)	7(0.78)	4(1)
Literature review	9(1.29)	14(1.75)	11(1.22)	59(3.69)	49(5.44)	8(2)
Non-research	87(12.43)	44(5.5)	35(3.89)	46(2.88)	13(1.44)	3(0.75)
Opinion paper	40(5.71)	61(7.63)	57(6.33)	130(8.13)	39(4.33)	16(4)

Note. The average numbers are computed from papers per person in one group. "Others" are defined as in Fig. 4.

Fig. 9. Cluster map of 53 researchers based on their research method usage behavior

very different in this community a few decades ago, but researchers, in general, have strived to adjust to the changing landscape and research norms.

There are two additional observations we would like to address. First, apart from citation window problems and the fact that junior researchers are still too young to be mentioned in the reviews we examined, we presume another reason for the gaps in Fig. 6 is that junior researchers tend to publish in international journals instead of Chinese journals. The changing policies of reward and career promotion in recent years have influenced journal submission preferences in China, which has led to low visibility for junior researchers in the Chinese community [48]. We acknowledge this as one limitation of our paper and suggest that future study is warranted to explore how Chinese researchers choose where to publish their works.

Second, the overlap of method usage in library and information science suggests the complexity of modern research and the uncertainty around the core concept of library and information science. As far as the complexity is concerned, we understand that the interdisciplinary nature of LIS requires the involvement of multiple methods to solve research questions in individual studies. The uncertainty, meanwhile, is in line with the uncertainty of selecting core methods. The use of multiple methods in a single study reflects the fact that one method cannot support and finish the research goal thoroughly. This may be an ongoing challenge for LIS as interdisciplinary research continues to flourish in this field.

In sum, the present paper offers a first systematic examination of how research methods are used in a representative sample of Chinese-language LIS scholarship, especially from a temporal perspective. We find evidence that is consistent with the literature and our knowledge of the progress of the Chinese LIS research community. An equally important contribution of this research is the revised research method classification scheme situated in the Chinese research community. We believe our research is the first step towards solving a significant question, i.e., elucidating the middle ground between research theories and practices, so that we can better understand the making of LIS research from a micro perspective.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ipm.2021.102686.

Appendix A. Data resources and samples in this study

Review papers (in Chinese)	Publication year	Data in a review	# of Researchers in a review
Bibliometrics analysis on information science in China	2012	Highly productive authors (1996-2011)	30
The development and subject structure analysis of information science in China from the scientific collaboration perspective	2015	Highly productive authors (2000-2011)	93
The development analysis of library, information science and document science for the past ten years: national funding analysis	2015	Fund PI (2005-2015)	23
The subjects analysis in LIS in China based on CSSCI journals	2016	Highly productive authors (1998-2016)	50
The analysis of hot topics and trends in LIS in China based on national foundation	2017	Fund PI (1994-2015)	10
Understanding information science and information service in the new era	2018	Selected representatives in 23 institutions	32
Research on research impact of scholars in library and information science in China (2008-2017)	2018	Highly cited authors (2008-2017)	30

Appendix B. Summary of sampled researchers

Age groups	# researchers	Full names of researchers
1930s	7	Bai Guoying, Bao Changhuo, Liu Zhihui, Ni Bo, Wang Yongcheng, Wu Weici, Zhang Qiyu
1940s	8	Hu Changping, Lai Maosheng, Liang Zhanping, Ma Feicheng, Qin Tiehui, Qiu Junping, Wang Zhijin, Zhang Yufeng
1950s	9	Bi Qiang, Gan Liren, Peng Jingli, Shen Guchao, Su Xinning, Wang Shiwei, Wang Zizhou, Xiao Ximing, Zhang Xiaolin
1960s	16	Chu Jiewang, Huang Ruhua, Huang Xiaobin, Li Gang, Li Guangjian, Ma Haiqun, Sha Yongzhong, Sheng Xiaoping, Xia Lixin, Xie Xinzhou, Ye Ying, Yu Liping, Zhao Rongying, Zhou Jiuchang, Zhou Xiaoying, Zhu Qinghua
1970s	9	Deng Shengli, Han Yi, Jia Junzhi, Li Yan, Wang Fang, Wen Tingxiao, Wu Xiaowei, Xiao Yong, Xu Xin
1980s	4	Li Jiang, Wan Wenjuan, Zhang Huiping, Zhang Xingwang

Appendix C

The description of 15 research methods in Chu and Ke (2017)

- Bibliometrics: "Bibliometrics is a method used for collecting publication and citation data."
- Content analysis: "Content analysis refers to collecting data by conducting systematic examination of texts or other passages in the contexts of their use (Krippendorff, 2004, p. 18). This study considers content analysis as a data collection technique, although it can also be used for data analysis."
- Delphi study: "The Delphi method is generally used for collecting data with a questionnaire from a group of experts to address a research problem in order to reach consensus and make forecasts via several rounds of exchanges."

- Ethnography and field study: "Ethnography and field study share many characteristics in data collection. Both can be applied when collecting data using multiple techniques, such as observation and interview, in a natural setting where participants live or work."
- Experiment: "Experiment is an established method for collecting data by following a procedure to test what is studied in either a laboratory or field setting, corresponding to laboratory experiments and field experiments described in Palvia et al.'s (2007) list of research methods."
- Focus group: "As a research method, focus groups refer to data collection via discussion of a research problem between a moderator and a group of participants."
- Historical method: "Historical method refers to collecting data by examining, synthesizing, summarizing, and interpreting existing published and unpublished materials related to a historical research problem."
- Interview: "Interview is a data collection technique where individual participants are asked questions relating to a research problem."
- Observation: "Observation is a method for gathering data via carefully and attentively watching and making notes on the subject being studied. All five senses of the observer need to be used in data collection (Baker, 2006)."
- Questionnaire: "Questionnaire, often known as survey, is a technique for data collection using a predefined list of questions."
- Research diary or journal: "Research diary or journal is a technique used to gather data about events, activities, thoughts, reflections, or other aspects by an individual who keeps the diary over a period of time."
- Theoretical approach: "Theoretical approach, as a research method, is a technique for gathering data through conceptual analysis, theoretical examination, or similar activities."
- Think aloud protocol: "Think aloud protocol is a research method intended to collect data about participants' cognitive activities via the verbal reports of their thoughts, called think alouds, while taking part in an experiment or performing some task (Ericsson & Simon, 1980)."
- Transaction log analysis: "It refers to researchers gathering data by analyzing transaction logs that are automatically captured at either the server or client side."
- Webometrics: "Webometrics is defined as bibliometrics in the web environment, where webpages and websites are generally regarded as publications; with inlinks (i.e., links a webpage or site receives) being considered as citations and outlinks (i.e., links a webpage or site makes to others) being considered as references."

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