What characterizes LIS as a fragmenting discipline?

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Abstract

Purpose – The purpose of this paper is to characterize library and information science (LIS) as fragmenting discipline both historically and by applying Whitley's (1984) theory about the organization of sciences and Fuchs' (1993) theory about scientific change.

Design/methodology/approach – The study combines historical source analysis with conceptual and theoretical analysis for characterizing LIS. An attempt is made to empirically validate the distinction between LIS context, L&I services and information seeking as fragmented adhocracies and information retrieval and scientific communication (scientometrics) as technologically integrated bureaucracies.

Findings – The origin of fragmentation in LIS due the contributions of other disciplines can be traced in the 1960s and 1970s for solving the problems produced by the growth of scientific literature. Computer science and business established academic programs and started research relevant to LIS community focusing on information retrieval and bibliometrics. This has led to differing research interests between LIS and other disciplines concerning research topics and methods. LIS has been characterized as fragmented adhocracy as a whole, but we make a distinction between research topics LIS context, L&I services and information seeking as fragmented adhocracies and information retrieval and scientific communication (scientometrics) as technologically integrated bureaucracies.

Originality/value – The paper provides an elaborated historical perspective on the fragmentation of LIS in the pressure of other disciplines. It also characterizes LIS as discipline in a fresh way by applying Whitley's (1984) theory.

Keywords Research work, Information science, Education, Evolution, Interdisciplinarity, Scientific change
Paper type Article

Introduction

LIS has been long considered as an interdisciplinary field (Saracevic, 1979a; Wilson, 1983). Between the wars and especially after the Second World War the huge growth in the number of scientific publications was an impetus for the representants of various disciplines to develop tools for mastering this growth (Saracevic, 1979a; Wilson, 1983). For this purpose, several scholars from other disciplines migrated into LIS institutions. In other disciplines was also carried out research contributing to LIS and designed educational programs relevant to L&I services (Saracevic, 1979b; Tenopir, 1985). The proliferation of academic homes for LIS education concerned representants of LIS in the 1970s and 1980s. It was felt that this development would pull the field apart and break the weak cohesive bonds (Saracevic, 1979b) due to the lack of clear definition of focus (Tenopir, 1985). Thus, already forty years ago LIS was conceived as having the tendency of fragmentation due to the contribution of other disciplines in academic education, in particular.

Recently, it has been shown that authors from other disciplines contribute increasingly to LIS (Chang, 2019; Chang and Huang, 2012; Lund, 2020; Urbano and Ardanuy, 2020; Vakkari

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et al., 2022a, b, 2023). For example, Chang (2019) found, based on 75 LIS journals, that non-LIS authors had the majority in about 70% of the journals. Chang (2018) also showed that between 2005 and 2014 of research articles in 39 LIS journals almost half were authored by scholars external to LIS. Similarly, Vakkari (Vakkari *et al.*, 2022b) found that in 2015 of research articles published in 31 LIS journals 57% was authored by non-LIS scholars. Vakkari *et al.* (2023) later showed that the proportion of articles by scholars representing LIS has decreased significantly between 1995 and 2015, especially in information retrieval and scientific communication. The share of articles produced by scholars in computer science and business has increased respectively in these two sub-fields. Scholars in LIS produced over two-thirds of the articles in traditional sub-fields like L&I services, and LIS context, while scholars from other fields were responsible for 60–80% of articles in information retrieval, information seeking and scientific communication (scientometrics) (Vakkari *et al.*, 2023).

Both the reports forty years ago and recent empirical findings hint that contributions from other disciplines are fragmenting LIS. Increasing disciplinary incoherence is especially evident in the sub-fields information retrieval and scientific communication in the sense of bibliometrics (scientometrics). In the following we analyze the origin of the fragmentation tendency in these sub-fields emanating from the contributions of other disciplines, and then seek to conceptually interpret the nature of this scientific change in LIS by applying Whitley's (1984) and Fuchs' (1993) theories.

Approach

The aim of this study is to show that the current fragmentation of LIS as indicated by several studies (Chang, 2019; Chang and Huang, 2012; Lund, 2020; Urbano and Ardanuy, 2020; Vakkari *et al.*, 2022a, b, 2023) is based on the long-term interest of other disciplines in its sub-fields information retrieval and scientific communication (scientometrics), in particular. We interpret this fragmentation tendency by characterizing LIS sub-fields using Whitley's (1984) theory on the organization of sciences and Fuchs' (1993) theory on scientific change. Thus, our analysis focuses first on the historical analysis of the fragmentation of LIS using sources which describe education in LIS and in computer science in the 1960′s-90's. After that we characterize LIS using Whitley's (1984) theory distinguishing its subfields as fragmented adhocracies and technologically integrated bureaucracies. Leaning on Fuchs' (1993) theory we show that scientific change differs in these two modes of scientific organization leading to differing fragmentation processes. We seek to answer the following research questions are: 1) What are the historical roots in the fragmentation of LIS between various disciplines? 2) What characterize LIS and its sub-fields as discipline according Whitley's theory? and 3) What is the nature of scientific change in LIS and its sub-fields?

Both Whitley's (1984) and Fuchs' (1993) theoretical ideas are based conceptual argumentation. Both argue and develop ideas by leaning on earlier texts. Thus, their data consists of textual source material. We apply their theoretical ideas by analyzing texts which describe the characteristics of LIS by showing that certain modes of organizing research match with the characteristics of certain subfields in LIS. Thus, our main analysis is conceptual argumentation. In addition, we infer empirical consequences of these characteristics as quantitative operationalizations of ideas by Whitley and Fuchs. The operationalization is based on Järvelin and Vakkari (2022) Table 11 with additional calculations for LIS context and for some strategies due to merging of classes in 2005 and 2015. We do not produce new data but use information in the table with minor additional calculations.

Although it is difficult to find a definition of LIS satisfying all scholars in the field, it is widely accepted that the unifying characteristic of LIS is the study on the provision of access to desired information typically in the form of documents (e.g. Vakkari, 1994; Bates, 1999).

However, this brief definition is challenging to operationalize. A classical way to define a discipline is to characterize what belongs to its study object. The study object of LIS has been typically divided into sub-fields (e.g. Järvelin and Vakkari, 1990, 2022; Zhao and Strotmann, 2021)

LIS as a discipline is long considered to consist of several sub-fields. The number of sub-fields vary depending on the analysis by which they are constructed. The categorization has been based either empirically or conceptually oriented analyses of the field. The former are typically various scientometric analyses producing categorizations of LIS with minimal conceptual backing (e.g. Figuerola *et al.*, 2017; Hou *et al.*, 2018; Zhao and Strotmann, 2021). Bawden and Robinson (2012, p. 5) summarize these findings as typically consisting of components library/archive studies, information retrieval, information seeking, information management and informetrics.

Conceptually informed categorizations are based on conceptual analyses of LIS, which are typically validated by empirical content analyses (e.g. Järvelin and Vakkari, 1990, 1993, 2022; Ma and Lund, 2021; Tuomaala *et al.*, 2014). In the following, our analysis is based on the sub-fields in LIS shaped by Järvelin and Vakkari (1990, 1993, 2022), because their categorization is generic, representative, and widely used hinting to its validity. They divide LIS into main research topics (subfields) LIS context, L&I services, information retrieval, information seeking and scientific communication (Järvelin and Vakkari, 2022). Each of these five subfields are divided into several subclasses providing an ostensive definition of LIS' research object. The classification can be found in Järvelin and Vakkari (2022, Appendix 2). Although scientific communication is conceptually broader than bibliometrics (scientometrics), in the following we will deal with it in the sense of bibliometrics (scientometrics).

Bibliometrics and information retrieval as parts of LIS and of other disciplines

The early development of bibliometrics, later scientometrics, and information retrieval were closely associated with the needs of bibliographic control, the identification, description, analysis, and classification of books and other materials of communication so that they may be effectively organized, stored, retrieved, and used when needed (Shera and Egan 1953). These activities were essential tasks of academic and special libraries, and thus objects of interest to LIS. The rapid growth of recorded scholarly knowledge in the form of books and periodicals from the 1930s onwards created impetus for inventing new means to control and provide access to this mass of information (Saracevic, 1979a). The post-war development of tools and devices for mechanical handling of information, like computers, provided opportunities to develop efficient methods for manipulating information for its optimal acquisition, organization, and use (Shera and Cleveland, 1977; Saracevic, 1992). Together these trends paved way both to bibliometrics and information retrieval as tools to master the growth of knowledge for the effective provision of information for use.

Bibliometrics as a tool for selecting periodicals

After the second world war these new endeavors were called documentation (Bradford, 1948) and later information science (Saracevic, 1992). Bradford (1948, p. 49) defined documentation as "the art of collecting, classifying and making readily accessible the records of all kinds of intellectual activity". He added that "documentation is no more than one aspect of the larger art of librarianship. But it is a special aspect, needing a special study." While librarians are interested in every aspect of the treatment of books, documentalists make available the original information in various records. He continued "because the material is so much more voluminous, its methods must be so much the more precise" (Bradford, 1948, p. 50). Thus,

Bradford conceived documentation as a special branch of librarianship, but due to the nature of the material manipulated and the more precise methods the branch required a new term for indicating its identity.

One of the more precise methods of documentation was statistical bibliography, or bibliometrics as suggested by Pritchard in 1969. Bradford was mathematician and the keeper of Science Library in London. He was interested in the scattering of articles in the periodical literature. Bradford (1934) found out that large proportion of articles on a subject are published in a limited number of periodicals. One formulation is that if journals in a field are sorted by the number of articles into three groups, each with about one-third of all articles, then the number of journals in each group will be proportional to $1:n:n^2$. With this formulation he is one of the pioneers of bibliometrics. However, the main goal of his study was to produce a practical tool for libraries to select "useful" periodicals where most of the articles on a subject were published and discard "poor class" periodicals with only few relevant articles (Bradford, 1948, p. 146). Thus, Bradford's law was created as a method for libraries for selecting useful periodicals containing most relevant articles on a subject.

Bradford's work has inspired many scholars in LIS. Herman Fussler published his classic study Characteristics of the Research Literature Used by Chemists and Physicists in the United States in 1949, where he analyzed the characteristics and use of use literature with the aim to support libraries in the selection of journals and other literature for scientists (Hertzel, 2017). Thus, a more general survey of the literature of a subject served the selection of materials in libraries for effectively serving users. The general bibliometric analysis concerning the characteristics of literature in a field was not an end as such but subordinate to developing library services.

Citation indexes produce scientometrics

An essential step towards citation analysis, and its field of application, scientometrics, was the establishment of citation indexing by Eugene Garfield (1955). When citation index was developed, its primary purpose was information retrieval. It offered a new approach to the subject control of literature in science by listing all articles that have referred to a known article. Its initial purpose was to help researchers to search literature more effectively – citations could work as search terms (Garfield, 1955). In the editorial in the first issue of the journal Scientometrics Garfield (1978) wrote that "when citation index was developed, its primary purpose was information search. Although aware of sociological applications, we never dreamed that the availability of large science citation indexes would spur the development of an entirely new field of scientometrics". The citation index was soon recognized as having great value for the empirical study of the practice of science (Mingers and Leydesdorff, 2015). Unexpectedly, library-oriented use of bibliometrics and citation index was turned into general analysis of science.

Garfield distinguished between three major application areas of citation index: LIS, history of science and sociology of science (Garfield 1970; here Hertzel, 2017, p. 31). The sociological and historical studies of science based on citation index differentiated from bibliometric studies concerning library activities like information retrieval based on citations, or the selection and use of journals and other media of communication. The representatives of the former come mainly from other fields than LIS like Derek De Solla Price or Henry Small, although representants of LIS have also studied sociological and historical aspects of science using citation analysis like Blaise Cronin or Olle Persson.

LIS, other disciplines and scientometrics

Although studies applying citation analysis gain popularity, there were relative few bibliometric articles before 1994. The growth in the number of these articles accelerated with

the advancement of computerized methods for data treatment and the general availability of electronic versions of well-established databases such as SCI. The rapid growth has occurred from the first years of 21st century (Ellegaard and Wallin, 2015). The relative scarce interest in bibliometrics in its first decennia by other disciplines than LIS led to the social institutionalization of bibliometrics in LIS. Although there were neither many academic programs nor chairs or other teacher positions for bibliometrics in LIS schools (Belzer *et al.*, 1975; Saracevic, 1979a), it was anyway associated with and conceived as part of LIS. It was a consequence of the fact that bibliometrics was taught to some extent in LIS schools as a tool for selecting literature in libraries, and more importantly, that Eugene Garfield named himself as information scientist and he was active in the information science community. Garfield has a master's degree in LIS and he had worked as librarian in the 1950s. Information science was continuation of documentation with another name. Harold Borko (1968) for instance, defined in the journal American Documentation information science about the same way as Bradford (1948) characterized documentation in his book Documentation referred above. Thus, mainly the technical machinery developed for citation analysis created by an information scientist attached bibliometrics to LIS.

Despite that bibliometrics was studied by scholars representing other disciplines, there has been outside LIS very few academic programs and teacher positions for scientometrics (Galyavieva and Elizarov, 2017). The lack of interest among other disciplines to socially institutionalize scientometrics at universities has strengthened the position of LIS as home discipline for bibliometrics – scientometrics. The social institutionalization outside LIS has occurred in the form of journals and conferences devoted to scientometrics. However, the social institutionalization of bibliometrics in academic institutions of LIS has been weak as Saracevic (1979a) and later Zhao (2016) noted. Both consider bibliometrics as a quite strong research area in LIS, but weak in education as seen from LIS course offerings. Saracevic (1979a) estimated that in 1977 about 10–15% of library schools offered courses in communication and bibliometrics, which he perceived as insufficient. Thus, although academic education for bibliometrics in LIS has been deficient, there has been enough research interest towards its problems so that LIS has been continuously conceived as home discipline to bibliometrics. The situation has not changed much, although scientometric research output in other disciplines has exceeded the respective output in LIS (Ellegaard and Wallin, 2015; Vakkari *et al.*, 2023). This all explains why bibliometrics – scientometrics as a field of research is considered to belong to LIS.

To sum up, the origin of bibliometrics as part of LIS well out from ideas and methods created for improving library and documentation work, i.e. the selection of periodical literature and information retrieval, which trough citation index somewhat unexpectedly led to more general applications for studying the social and historical development of science. The social institutionalization of bibliometrics in the form of courses and academic positions in LIS has been weak, but it has been weaker in other disciplines. When research output in bibliometrics in LIS has been quite strong, it has kept its position as home discipline for bibliometrics – scientometrics, although the research volume in other disciplines has grown larger.

Information retrieval in various academic settings

Diverging from the development of bibliometrics, other disciplines than LIS, computer science in particular, have been interested in education in addition to research in information retrieval. Surveys on educational programs in information science (Belzer *et al.*, 1971; Saracevic, 1979b; Tenopir, 1985) and in computer science (Curriculum 1968; Curriculum78; Computing Curricula 1991) reveal that courses in information retrieval have been provided by various disciplines.

Information storage and retrieval has been an essential part of LIS from its beginning. LIS community surveyed in 1972 the curricula in information science by a questionnaire study. The target population of the study was not explicated in the article, but it seems that it consisted at least LIS and computer science schools. The report states that "many information science programs are tied closely to computer science and in some instances are precisely that, under an information science label. It is difficult to draw a clear line of demarcation between the two" (Belzer *et al.*, 1975, p. 17). Thus, programs of information science could be organized both by LIS schools and computer science schools. The results of survey indicated that most frequently offered courses were about information storage and retrieval, system analysis, design and evaluation, and theory of classification and indexing. Compared to the year 1968 the major orientation of courses had changed from LIS to computer science (Belzer *et al.*, 1975).

Saracevic (1979b) estimated that in mid-1970s courses and programs in information science were offered within a variety of academic settings. Most of information science programs were in library schools. The second largest number were established in computer science departments, although Saracevic states that in many cases information science is little more than a euphemism for computer science. Information science courses and programs were appearing as an increasingly common part of curricula also in management and business schools. In addition, Saracevic (1979b) mentions that information science courses were provided also in a variety of academic departments from communication to chemistry. The stands by Belzer (Belzer *et al.*, 1975) and Saracevic (1979b) hint that a part of the courses in information science run by the schools of computer science were pure computer science courses. However, these reports confirm that many schools of computer science organized courses on information science in the sense of LIS and on information retrieval. The proliferation of information science education led to the differentiation of the emphasis on topics taught and the general orientation of education between the academic environments. Saracevic (1979b) admitted that some differences are natural but was concerned that profound educational differences diminish the cohesion and coherence of the whole subject. Without common, integrating elements in the programs provided by various academic institutions, information science was in the danger of becoming more fragmented. Thus, Saracevic doubted that the weak bonds between the various notions of information science in various disciplines may become even weaker, and probably lead to the fragmentation of the field.

An analysis of course catalogs for departments running information science programs in the U.S. identified by ASIS SIG/ED (Tenopir, 1985) confirmed the findings in Saracevic (1979b). In the beginning of 1980s half of information science programs were provided by Library Science departments, one-fourth by Computer Science departments, and one eight by Education departments. The content of the programs varied heavily with the parent department. These departments often dictated the focus of the curriculum with a seeming split between the technology-focused departments such as computer science and engineering, and the humanistic-focused departments such as library science (Tenopir, 1985). Consequently, what was conceived as information science, and what was perceived as belonging to information retrieval differed between parent departments. This naturally implied also differing orientation in research on information retrieval. Tenopir (1985) concluded by agreeing with several writers that information science is a field that still is not mature and that has no clear definition of focus. The results hint that (library and) information science is a construct created by the conceptualization of the educational parent institution, and it varies greatly by the disciplinary background of parent institution. The differing notions of information science and its sub-fields like information retrieval likely decreased the cohesion within the field.

Information retrieval as part of computer science

The advancement of computing technologies lured also other disciplines, primarily computer science to design courses in information retrieval. In the 1960s schools of LIS developed typically curricula for information science, whereas schools of computer science named their curricula as information science, information and computer science or computer science. There was no established name for academic programs in computer science which was related to the debate of the existence and justification of the named discipline. To avoid terminological vagueness ACM curriculum committee on computer science decided to use the term computer science programs (Curriculum 1968).

From the 1960s onwards information retrieval has been considered as a part of computer science implying course offerings on information retrieval within the curricula of computer science. ACM curriculum committee included information retrieval as an area of applications in computing (Curriculum 1968). The committee suggested that curricula in computer science should contain courses on information organization and retrieval, large scale information processing including systems for storing and retrieving information. Both bachelor's and master's programs should include information retrieval as an area of specialization.

In the report Curriculum'78 ACM curriculum committee for computer science recommended that all undergraduate programs should include introduction to selected application areas like information retrieval (Curriculum '78). Information retrieval was also mentioned as a topic for service courses intended for students who do not intend to major in computer science.

ACM/IEEE-CS task force based its report Computing Curricula 1991 for undergraduate programs on the definition of computer science as a discipline. This definition divided computer science into nine sub-areas, one of which was Database and Information Retrieval (Denning *et al.*, 1989). The taskforce recommended that programs should offer two courses on Database and Information Retrieval (Computing Curricula 1991).

These recommendations and the definition of computer science as a discipline show that information retrieval has been conceived as part of computer science as discipline at least from 1960s. It is also reflected in the classification system of ACM, which divides computer science into thirteen sub-topics. Information retrieval belongs to the sub-topic information systems. This classification is used, e.g. for indexing research papers into appropriate categories.

The brief history of information retrieval research (Sanderson and Croft, 2012) presents scholars who have contributed essentially to this field. Of the scholars mentioned in the course of time the number of scholars with the background in LIS decreased and those with the background in computer science increased. From 1950s to 1970s scholars representing LIS like Mortimer Taube, Cyril Cleverdon, M.E. Maron, and Stephen Robertson were key figures in creating ideas for information retrieval. Later typically computer scientists like Gerard Salton, Karen Spärck Jones, Keith van Rijsbergen or Norbert Fuhr created decisive inventions for advancing information retrieval. Finally, in the time of the Internet scholars in other disciplines than LIS have contributed most to the research on information retrieval.

The roots of fragmentation

To sum up, the enormous growth in the number of scientific publications and the invent of computers was an impetus to create means for effective access to the mass of knowledge. Information retrieval was a key to solve this task. Knowledge organization for access has been the major goal of libraries. Therefore, it was natural that LIS community participated to developing tools for information retrieval. This task also lured scholars from other disciplines to work either in LIS institutions or in their home institutions, typically in schools of computer science or in large enterprises (Wilson, 1983). Differentiation between the notions of

information science, and of information retrieval occurred first in the educational programs. Computer science emphasized technological orientation in curricula, while LIS community focused more on social science approaches. This difference strengthened also in research on information retrieval. Computer science applied system analytic and statistical approaches, while LIS leaned typically on methods of behavioral sciences (Vakkari *et al.*, 2023).

The social institutionalization of information retrieval in schools of computer science with educational programs and teacher positions lead to cognitive institutionalization, which clearly differed from the cognitive ideals of information retrieval research in LIS. As have been shown (Vakkari *et al.*, 2023) within information retrieval topical and methodological preferences have differed between LIS and computer science. Between 1995 and 2015 computer science has increasingly preferred research on various retrieval methods and emerging topics, while LIS has focused increasingly on metadata and cataloging. Experimental design has been common in both disciplines, while computer science has also preferred system design and mathematical methods.

LIS as fragmented adhocracy

Next, we apply Whitley's (1984) theory about the intellectual and social organization of sciences for characterizing LIS as a discipline. We show that LIS can be differentiated into two main modes of organizing science implying differences in scientific change. Based on these findings, we reflect how scientific change occurs in LIS as conceptualized by Fuchs (1993).

Vakkari and his colleagues (2022a, b) show that the main topics (sub-fields) and associated methodologies of LIS are differentiated by disciplines. Traditional professional topics are cultivated mostly by LIS scholars, while information retrieval, scientific communication and information seeking are mostly contributed by disciplines external to LIS. In professionally oriented topics – LIS context and L&I services – LIS dominated the contributions by a share of two-thirds in 2015. Computer science was responsible for about half of the contributions in information retrieval and LIS about one-fifth. In scientific communication the share of contributions by external disciplines was three-fourths, with business and economics, and computer science as largest ones. In information seeking LIS was the dominant contributor with a share of two-fifths followed by business and economics and computer science with a share of one-fifth each. Their results show also that research strategies preferred by various disciplines differ within subfields.

The previous findings hint that research in LIS is fragmented across various disciplines. Nolin and Åström (2010) claim based on conceptual analysis that LIS is a fragmented adhocracy. According to Whitley (1984) a fragmented adhocracy is characterized by a combination of high task uncertainty and low mutual dependence between scholars. Task uncertainty refers to the degree of uncertainty about intellectual priorities, the significance of research topics and preferred ways of tackling them as well as to the extent to which work techniques are well understood and produce reliable results. Mutual dependence refers to scholars' dependence upon colleagues to make competent contributions to collective intellectual goals and acquire prestigious reputations which lead to material rewards (Whitley, 1984). Thus, in LIS prevails high task uncertainty about what are important research goals and techniques for solving research problems. There is no shared understanding of these issues among scholars within the discipline. This is associated with low mutual dependence as LIS scholars lack consensus about competent and useful contributions in the discipline.

The results by Vakkari and his colleagues (2022a, b, 2023) hint that LIS may be characterized as fragmented adhocracy. There are significant differences between the main research topics in disciplinary orientations, which also lead to essential differences in the

research approaches and strategies applied. This implies a low mutual dependence of scholars between main research topics, when they are uncertain about what are competent contributions in various topics. This disciplinary differentiation also leads to high task uncertainty, when it is challenging to assess what are important research goals and which work techniques produce reliable results.

Two types of scientific fields within LIS

Whitley (1984) remarks that some specialisms may differ from the general characteristics of their parent disciplines. Thus, although as a whole LIS can be characterized as fragmented adhocracy, we claim that the main research topics (fields) in LIS can be differentiated into two types of scientific fields. The research topics (fields) LIS context, L&I services and information seeking are fragmented adhocracies, while information retrieval and scientific communication as understood as scientometrics each belong to technologically integrated bureaucracies. The latter are characterized by low task uncertainty and high mutual dependence (Whitley, 1984). Low task uncertainty means that research work can be planned and coordinated more systematically, and task outcomes are quite predictable and reliable. What important research problems are, and how they should be tackled is widely accepted. Research results are coordinated largely through the research technology which ensures that theory, methods, and phenomena studied are all integrated. Thus, co-ordination of results increasingly takes place through the technical apparatus used to standardize the raw materials and transform them so that the sorts of problems which can be investigated are circumscribed by this apparatus and its presuppositions (Whitley, 1984). Although cognitive objects and problems are more general and theoretically formulated than in adhocratic fields because of the theoretically structured techniques, they are not very abstract and highly removed from empirical details. Such a field produces empirical, specific knowledge (Whitley, 1984).

There are some arguments which suggest that information retrieval and scientific communication are technologically integrated bureaucracies. In information retrieval throughout the years test-collection-based evaluation model has been the paradigmatic conceptual-technical apparatus for research (e.g. Ingwersen and Järvelin, 2005). In this model, information retrieval system consists of a database, algorithms, requests, and stored relevance assessments. The main interest of the research has been in document and request representation and the matching methods of these representations. The goal of research is to develop algorithms to identify and rank topically relevant documents for presentation, given a topical request. Research is based on constructing novel algorithms and on comparing their performance, seeking ways of improving them (Ingwersen and Järvelin, 2005). With the establishing of interactive information retrieval, the goal of research has extended to comparing interfaces and other tools for improving search results and experience. Thus, the research ideal is based on a certain conception of important research problems in information retrieval, and how these problems should be dealt with in the conceptual-technical frame. The co-ordination of results takes place through this paradigmatic apparatus. The paradigm steers researchers to typical research questions and research strategies which produce predictable results. This signifies low task uncertainty and high mutual dependence.

In addition, research problems are not very theoretical and removed from empirical details. On the contrary, the aim is mostly to produce specific, empirical results, which can be used in developing algorithms and search interfaces. This characterization resembles Robertson's (2000) claim in his Salton Award Lecture that the field of information retrieval is not very theoretical one, but very pragmatic driven by practical problems and considerations and evaluated by practical criteria. Robertson (2000) characterizes information retrieval also in the manner which implies low task uncertainty and high mutual dependence: "In this

tradition, we have a well-developed set of methods and rules, procedures, and tools for testing IR systems. . . . Any part of the system stands or falls by its effect on performance measured by an appropriate combination of evaluation measures such as precision and recall." He states explicitly that there is a common goal for research, testing IR systems and that this goal can be met by following certain methods and rules evidently shared by the IR research community. This all hints that information retrieval can be characterized as technologically integrated bureaucracy.

Scientific communication conceived as scientometrics is a data-driven field of research with low interest to theory-driven problem formulations. Mingers and Leydesdorff (2015) state that scientometrics in practice has developed around one core notion – that of citation. It provides the necessary linkages between people, ideas, journals, and institutions to constitute an empirical field that can be analyzed quantitatively. There are large citation databases which contain various measures like h-index automatically available to researchers. These databases cover papers in thousands of journals, conference proceedings, and books. This facilitates the quantitative study of science indicators and their behavior, analysis, and metrication from a positivist perspective (Mingers and Leydesdorff, 2015). Thus, citation databases provide an apparatus which practically frames and steers the scope of possible research questions, research techniques for answering these questions, and the type of research results. It means that although opinions about important research questions may vary somewhat, the scope of possible questions is limited by the data in databases as well as the techniques for answering these questions and acceptable findings. Thus, task uncertainty in this field is low, and mutual dependence high, because scholars are expected to lean on colleagues' research ideas and results. In addition, most of the research results are specific empirical findings characterizing or evaluating some research entity from scholars to nation-wide research system. All this suggests that scientific communication can be characterized as technologically integrated bureaucracy.

Empirical evidence about the nature of LIS

There is lack of empirical evidence concerning conceptual claims about the nature of LIS as fragmented adhocracy or technologically integrated bureaucracy. As far as we know, these claims are based on conceptual reasoning and metatheoretical reflections (e.g. Nolin and Åström, 2010). However, Whitley's (1984) characterization of various scientific fields provides ideas for empirically analyze their differences. Next, we seek to provide some empirical evidence based on the findings by Järvelin and Vakkari (2022) about the nature of LIS as fragmented adhocracy and technologically integrated bureaucracy.

If LIS context, L&I services and information seeking as claimed would be fragmented adhocracies, there are no unanimously shared research goals and procedures for solving research questions within each field. These vary between groups of scholars within each topic due to task uncertainty. Consequently, there is no shared understanding about what important contributions in the field are and thus, low mutual dependence among scholars in the use of each other's results in their own work. In the case of technologically integrated bureaucracies the situation is the opposite: low task uncertainty and high mutual dependence.

The difference between fragmented adhocracies and technologically integrated bureaucracies should occur in the variation of research strategies used. In the former one the variation should be larger than in the latter, because there is no commonly shared view of important research questions and ways to tackle with them like in the latter one. Next, we compare the variation ratios of two most used research strategies between these two types of sub-fields in LIS.

The variation ratio of two largest strategies of all strategies between the sub-fields of LIS does not support this claim in 1985 and 2015, but only in 2005 (Table 1). In 1985 the lowest and highest share of two largest research strategies occur in L&I services and information

Topics/Major strategies	1985 (N = 449)	2005 (N = 718)	2015 (N = 1210)
LIS context	Missing data	Conceptual 28%	Conceptual 33%
		Survey 22%	Survey 26%
L&I services	Conceptual 28%	Survey 45%	Survey 28%
	Survey 25%	Conceptual 17%	Conceptual 18%
Information retrieval	System 31%	Experiment 63%	Experiment 26%
	Conceptual 29%	System 14%	Mathematical 22%
Information seeking	Survey 67%	Survey 46%	Survey 44%
	Conceptual 11%	Conceptual 18%	Qualitative 17%
Scientific communication	Citation 39%	Citation 41%	Citation 43%
	Conceptual 21%	Survey 30%	Survey 20%

Table 1.
The proportion of major research strategies by main topics in 1985–2015 (%)

Note(s): N.B. The table is based on Järvelin and Vakkari (2022) Table 11 (courtesy of Järvelin and Vakkari, 2022) with additional calculations for LIS context and for some strategies due to merging of classes in 2005 and 2015. The figures are percentage distributions of research strategies derived from content analysis of research articles in major LIS research journals

seeking, which are fragmented adhocracies, while the ratios of information retrieval and scientific communication as technologically integrated bureaucracies are between the two formers. Neither in 2015 there is such pattern which could corroborate the proposed hypotheses. Only in 2005 the pattern in the ratio of two largest strategies between the sub-fields supports the claim that as technologically integrated bureaucracies information retrieval and scientific communication each have smaller variation of research strategies compared to LIS context, L&I services and information seeking representing fragmented adhocracies.

Although the previous results do not support the claim of the nature of the sub-fields in LIS, Table 1 indicates clear differences in the popular research strategies between the sub-fields throughout the years. Both information retrieval and scientific communication prefer research strategies which refer to the use of certain conceptual-technical apparatus in research, while the three other sub-fields prefer strategies which do not depend on corresponding technologies. In scientific communication citation analysis is the most common research strategy in each year observed, while in information retrieval system analysis and design, and experimental evaluation share the top position across the years. Citation analysis depends on the use citation databases, while system analysis and design, and experimental evaluation leans on the testing and evaluation of information systems. This pattern at least supports the claim that information retrieval and scientific communication as scientometrics represent technologically integrated bureaucracies.

In general, the patterning of research strategies between the topics confirmed our hypotheses only in 2005. However, within LIS context and L&I services there were significant differences in the use of research strategies by disciplines, while these differences were smaller within other topics (Vakkari *et al.*, 2023). The result means that research strategies preferred by various disciplines in these two topics differ implying high task uncertainty and low mutual dependence between these disciplines. In this case, disciplinary preferences in the use of research strategies were the sources of both task uncertainty and mutual dependence. Thus, this part of empirical evidence supports that LIS context and L&I services are fragmented adhocracies.

Scientific change in LIS and its subfields

By leaning on Whitley (1984) Fuchs (1993) claims that mutual dependence and task uncertainly are two central organizational variables explaining how and why various types

of change occur in various areas of the sciences. We use his conception for exploring how scientific change may occur in LIS and in its main subfields (topics).

The type of scientific change depends on the degree of task uncertainty and of mutual dependence. High task uncertainty and low mutual dependence lead to fragmentation of disciplines and research fields (Fuchs, 1993). Thus, the expected development of fragmented adhocracies like LIS is fragmentation in situations when there is little agreement on anything. There is too much diversity and uncertainty for permanent discovery or orderly cumulation of findings, and so there are serious doubts about very possibility of growth and progress. The separate literatures of such fields are comparatively unfocused and non-interactive. Innovations are not likely to spread throughout the entire discipline, for specialties are fairly autonomous and self-contained (Fuchs, 1993). The perceived incommensurability of conceptions and findings are expected to lead an increasing fragmentation into sub-fields. This seems to be the case in LIS and its sub-fields which are characterized as fragmented adhocracies (Nolin and Åström, 2010).

In general, LIS is a heterogeneous, multi-disciplinary field lacking coherence and citations between the sub-fields (Wilson, 1983; Saracevic, 1992b). According to Järvelin and Vakkari (2022) LIS consist of sub-fields LIS context and services, information retrieval, information seeking and scientific communication. Throughout the years, between these sub-fields interest in research topics has differentiated, research questions have been approached from differing viewpoints, and differing research strategies have been applied in solving preferred research questions (Tuomaala *et al.*, 2014; Järvelin and Vakkari, 2022; Ma and Lund, 2021). Thus, there is not much coherence between the subfields in research questions, methods used to deal with these questions and resulting research results. This self-contained mode of working likely implies that the literatures of these subfields do not discuss with each other, and thus there is not much cross-fertilization of ideas. However, there is not direct empirical evidence supporting this conclusion, although some scholars have suggested that the literatures used within the subfields of LIS do not overlap (Wilson, 1983; Ingwersen and Järvelin, 2005). In addition, findings from studies on the intellectual structure of information science based on author co-citation analysis consistently show a strong differentiation between two camps called knowledge domain analysis (bibliometrics – scientometrics) and information retrieval (Persson, 1994; White and McCain, 1998; Zhao and Strotmann, 2021). The connections between these camps are weak indicating their low mutual dependence.

The characteristics of fragmented adhocracies can be seen, e.g. in information seeking in the differentiation of traditional studies of information seeking and information literacy. When analyzing the topic structure of human information behavior research, i.e. studies on information seeking – Deng *et al.* (2021) found out that information literacy was one of the six distinct topics in this field. Information literacy is the ability to find, evaluate, organize, and use information in various situations typically in educational settings. Information literacy has differentiated from studies on information seeking both cognitively and socially. Its concepts and research focus on skills for advancing information literacy as a part of information seeking typically for educational tasks. The specialty has also created structures of social institutionalization: journals like Journal of Information Literacy, conferences including, e.g. European Conference on Information Literacy, and educational courses and programs devoted to information literacy.

Change in technologically integrated bureaucracies

Technologically integrated bureaucracies are characterized by low task uncertainty and high mutual dependence, which lead to specialization of research fields. When scholars are fairly certain what to do and how to do it, and depend on colleagues' results, that increases the intensity of competition (Fuchs, 1993). Specialization is a way of restricting competition by

claiming a new area of research as intellectual property. The new specialties are different not so much in their paradigmatic commitments, but rather in the substantive areas and topics investigated (Fuchs, 1993). Within LIS low task uncertainty and high mutual dependence are characteristic for information retrieval and scientific communication. These subfields may change by specialization.

An example of scientific change as specialization in information retrieval is the development of interactive information retrieval. In information retrieval test-collection-based paradigm dominated the field for decades ignoring human actors in the research (Ingwersen and Järvelin, 2005). Major conferences in information retrieval favored test-collection-model oriented research. Studies focusing on information searching by humans were not preferred in these conferences. This led to a growing pressure in the field to create a specialty that would include humans in the research program. Ingwersen and Järvelin (2005) provide essential ideas for such a program. A clear sign in the forming of interactive information retrieval as specialty was the establishment of Information Interaction in Context symposium in 2006, and its follower ACM SIGIR conference on Human Information Interaction and Retrieval (CHIIR) in 2016. This form of social institutionalization has strengthened the ties between scholars in the specialty and provided a means for them to build identity as researchers of human search behavior. As a well-known senior scholar said during the first CHIIR conference: "Now I have found my research home". Consequently, interactive information retrieval has grown in importance in the beginning of 21st century. It can be considered as a specialty within a boarder field of information retrieval.

Although bibliometrics – scientometrics can be characterized as technologically integrated bureaucracy, there are only a few signs of specialization. Bibliometrics is a highly multidisciplinary research field with contributions from almost all disciplines. Some studies distinguish contributing disciplines as belonging to the core disciplines information science – library science or disciplines external to these disciplines (Ellegaard and Wallin, 2015; Gonzales-Alcaide, 2021). Some doubts have been expressed about the correct use of bibliometric methods by the disciplines external to LIS (Ellegaard and Wallin, 2015; Gonzales-Alcaide, 2021). This has led to the comparison of these disciplinary groups. The results show that LIS community is more interested in theoretical and methodical problems, while other disciplines prefer more applied, subject based studies (Ellegaard and Wallin, 2015). It has been also shown that there are few collaboration and citation ties between LIS and non-LIS bibliometric research, and that different research groups are widely dispersed (Gonzales-Alcaide, 2021). Thus, there seems to be some specialization within bibliometrics. However, it is not based on competition, but on the difference in the interest in certain types of research problems. Specialization is typically due to the interest in the characteristics and evaluation of research performance within each discipline versus a more general interest in conceptual-methodological problems typically by LIS-oriented disciplines.

Conclusions: the origin of fragmentation

The seeds of disciplinary fragmentation in LIS were already sowed since 1950s. The origin of fragmentation in LIS due the contributions of other disciplines can be traced especially in the 1960s and 1970s. It was an implication of the development in computing for mastering the growing mass of periodical literature for access and use. Other disciplines than LIS, computer science in particular, interested in creating new tools for bibliographic control – the raison *d'*etre of libraries. Scholars from other disciplines migrated to L&I service and research organizations for solving the problems in access to information. They naturally brought with them tools and ideals how to tackle with problems in the bibliographic sector (Wilson, 1983). Thus, the methodological and theoretical assumptions typical in external disciplines have influenced in LIS for decennia. These assumptions and ideals evidently differed from those

shared earlier in the LIS community, in particular in information retrieval and bibliometrics, the subfields mostly interested in by newcomers. The background of these newcomers was typically in natural sciences and computing. One may conclude that fragmentation between and within the subfields was founded in LIS as internal process at least in 1960s and 1970s. From that period onwards fragmentation has been an inherent quality of LIS, especially in information retrieval and bibliometrics.

Other disciplines like computer science and management established from 1960s also academic programs and courses relevant to L&I services, typically in information retrieval in a broad sense. This naturally led to research in respective fields. In addition, information retrieval was and still is conceived as a part of computer science. Research problems relevant to LIS were conceptualized, formulated, tackled, and solved according to cognitive ideals of respective disciplines. Although there is not empirical evidence in the disciplinary differences of research topics and methods in LIS research before 1995 (Vakkari *et al.*, 2023), it is plausible that such differences existed already before that. At least from 1995 onwards disciplinary differentiation in the selection of research topics and methods has increased indicating fragmentation of LIS within and between its subfields (Vakkari *et al.*, 2023). The contributions to LIS by external disciplines have strengthened the inherent fragmentation of LIS by reproducing the differences within and between the subfields.

Internal differentiation within LIS, in bibliometrics in particular, has led to disciplinary fragmentation of the discipline. Bibliometrics in the hands of Bradford and his followers was originally a tool for selecting periodical literature for libraries (Bradford, 1948; Hertzel, 2017). The general description of science as reflected in its literature production or scientific communication as such was not in the interest of scholars in LIS, but those aspects of bibliometrics that could applied in the problems of L&I institutions. For example, Wilson (1983, p. 393) states that "it would have to be admitted that much of the work actually done is of little or no significance (to bibliographic sector)". He associates the techniques used and phenomena investigated to the work done by sociologists and communication scientists. More generally, this type of research can be seen as belonging to sociology of knowledge (Wilson, 1983). Thus, research in bibliometrics has bifurcated into two camps, one interested in the problems of libraries that can be solved by bibliometric methods, and other focusing on the general characteristics of science. The former is cultivated by LIS scholars, while the latter is tackled mostly by scholars external to LIS. Bibliometrics as a creation of LIS scholars has unexpectedly turned from internal undertaking to more general field of research interested by various disciplines.

The fate of citation indexing is analogous to bibliometrics. It was originally developed in LIS as a tool for information retrieval, but scholars from other fields invented its potential as tool for analyzing history and sociology of science. In a sense, a new field of research, scientometrics, was born as a side product of LIS, which was eagerly taken over by scholars in other disciplines. From the 1990s it has lived its life of own cultivated mostly by scholars external to LIS (Ellegaard and Wallin, 2015; Vakkari *et al.*, 2023).

Conclusions: differing subfields

Fragmentation is the joint effect of the subfield structure in LIS and disciplinary contributions to LIS. Scholars in the subfields do not typically use each other's literature. There exists low mutual dependence between the scholars which is based on the high task uncertainty between the subfields or rather difference in the articulation of major research phenomena and research questions, and consequently in the ideal methods to answer to the research questions in these subfields. In addition, scholars belonging to various disciplines active within a subfield prefer differing research problems and consequently research methods, and typically cite contributions of their own discipline (Järvelin and Vakkari, 2023).

This high task uncertainty within a subfield between the disciplines leads to low mutual dependence between the scholars representing different disciplines. This all confirms the claim (Nolin and Åström, 2010) that as a whole LIS can be characterized as fragmented adhocracy.

However, we showed that the subfields LIS context, L&I services and information seeking resemble fragmented adhocracies with high task uncertainty and low mutual dependence, while information retrieval and scientometrics resemble technologically integrated bureaucracies with low task uncertainty and high mutual dependence. The latter are driven by research technology, which integrates the phenomena studied with theory and methodological solutions. In information retrieval the technology is test-collection-based evaluation model and in scientometrics citation databases. In addition to theoretical reasoning, we were able to provide partial empirical evidence about the differences of these two types of scientific fields. More empirical research is needed to operationalize to validate the differences between task uncertainty and mutual dependence between these sub-fields of LIS.

It is evident that contribution from other disciplines is the greater force driving sub-fields of LIS apart compared to the original sub-field structure of LIS. The latter has existed decennia, but almost nobody has been too worried about the low interaction between the sub-fields. It has been taken as natural supposedly due to differing research topics and questions. The strong contributions from other disciplines infuse their own concepts, research questions and methods to the sub-fields of LIS. As such, conceptualizing and solving research questions by methods provided by other disciplines may enrich research in LIS, but at the same time this all determines what ideal LIS research within sub-fields is. It implies that the power to define the rules of cognitive institutionalization in LIS shifts to external contributing disciplines. It is not done by a dictate, but by piecemeal changes in the practice of accepting papers for publication in journals and conferences. This change is strengthened by the social institutionalization of sub-fields like information retrieval in the external disciplines like computer science. They provide courses, programs, and academic positions for studying a sub-field in LIS. This social institutionalization in the academic structure reflects the cognitive ideals of parent discipline (Tenopir, 1985). This development drives information retrieval and scientometrics apart from LIS as Vakkari and colleagues (2022a, b, 2023) have argued.

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