A review of Information Science literature: meta-data analysis JASIST, 1988 – 2007

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ASTRACT
The study of metadata in Journal of American Society for Information Science and Technology (JASIST[1]), one of top Library & Information Science journal, could be useful to reflect the research development in IS-field by extracting trends of collaboration and understanding of IS-related disciplines' role. With that purpose in mind, this article studies metadata of articles published in JASIST: we evaluate the trends of authorship, and identified the most prolific authors and keywords. Based on more detailed analysis, we classified, and subsequently compared the top authors' and top keywords' disciplines between 1988 – 1997 and 1998 – 2007. Our results indicate that there is increasing trend of collaboration among researchers, both within organizations and with other organizations, and the corollary of such trend is IS-field has become more multi-disciplinary. Two major ramifications can be drawn from our findings. One, the research community can apprehend the value of collaboration, and improve the quantity and quality of IS literature. Two, the community can identify, and consequently be inspired by the most productive authors. This should have impact on universities, research institutions, researchers, and students.

Author Keywords
Information Science, metadata, trends, collaboration, comparison, IS-related disciplines

INTRODUCTION

The field of Information Science (IS) is vast and rapidly evolving from time to time. The immediate consequence of the subject diversity is an extensive arrays of literature existed. Since the first recorded form of information science literature in 17th century until today, information science papers have grown tremendously. While the overall academics' contributions into numerous scientific journals can be perceived beneficial to the subject, it has reached the point where both the scope and the direction of research papers are hazy, for instance the ever-expanding boundary of Information Science which has become ambiguous.

For the past few decades, many researchers have recognized and therefore attempted to address the ambiguous definition of information science. Diener (1989) argued that information science cannot be understood as summarization of its building block but simply as a discipline of science that studies information. And therefore in order to manage information science literatures, one needs to develop a workable understanding of information. While Diener (1989) work is insightful, it does little to standardize the discipline vast boundaries. Hjorland and Albrechtsen (1995) attempted to rectify this issue. They proposed domain-based perspective to classify the discipline. Building from this perspective, Zins (2007) proposed six models to describe different knowledge domains embodied in the subject. As an application, the six models could function as foundation of "information science knowledge map".

[1] The journal is titled The Journal of American Society for information Science (JASIS), between 1986 and 2000. Since 2001, the journal added suffix technology in its title to become JASIST

To exacerbate the difficulties explained above, scholars' methodology varies in producing findings for IS field. Maxine K.Rochester and Pertti Vakkari (2003) made a comparison of the international library and information science research trend among nations, mainly from two perspectives: social structure and cognitive features. The comparison has shown a remarkable variation of emphases and trends in research in the countries examined. Each has its own research profile, which does not follow very closely the international trends. Thus, there is ever-present need to continuously review and examine IS development and its components. For this very reason, researchers need to identify the top contributors and the research areas that the scholars have covered thus far, and also evaluate the trends and patterns over the years.

In the spirit of introspection of the existing information science literatures, many scholars have also seek to understand the various authors, who has contributed to IS leading journals., White & McCain (1998) shed light on influential authors, structure of authors discipline background, and paradigm shift of information science in 1980s. Another significant work that view information science literature based on authors background and affiliation is Lipetz (1999). His work investigates information science authorship for the last five decades and reveals several important insights, namely, research papers have become more focus and informative, and growing number of authors with academic affiliations after 1950s.

In evaluating IS definition boundary and its development, scholars' past works had explored the existing IS literature from either information science definition perspective, or from authorship perspective. Although both approach are valid and to certain extend, succeeded in revealing new insight, neither can fill the gap of results integration between the two schools-of-thought. The need for holistic approach is direct extension of each approach in obtaining publications patterns or trends. Furthermore, we believe there is lack of quantitative research papers produced to study the breadth of authorship developments and the depth of IS definition, which to certain extent involves establishing IS-related disciplines.

Other than call for unified approach, we also notice that many existing publications focusing on review of information science literature and its development have past their proposed timeframe. For illustrations, with the exception of recent qualitative work, i.e. Zins (2007); Lipetz (1999) research timeframe is from 1955 to 1995, while White & McCain (1998) timeframe is from 1972 to 1995. Another reason is to update past works findings, namely, tendency for authors and organizations to collaborate, which increase complexity of IS (e.g. White and McCain, 1998; Lipetz, 1999), and also indication of multi-disciplinary in IS (e.g. Saracevic, 1999; Morillo, Bordons, & Gomez, 2003).

We would like to continue the tradition of literature introspection and thus update progress made in information science discipline for the last two decade. This purpose can be achieved by examining JASIS, a leading academic journal in information science research, from 1988 – 2007. The examination involves metadata analysis, similar to the work of Palvia and Panjani (2007) in information systems. However, unlike Palvia and Panjani (2007), our main objective is to investigate cooperation, collaboration, and multi-disciplinary in IS and their relationship. To reach our goal, we use integrated perspective, which comprises of analysis of authorship and analysis of top keywords. The analysis of authorship consists of: (i) authors collaboration per article, which involves no collaboration (single author), collaboration within same organizations (internal) and collaboration with other organizations (external); (ii) top authors list and their discipline distribution. While, the analysis of top keywords comprises of: top keywords identification and their discipline distribution.

METHODOLOGY

The starting point for our analysis is journal selection. Given the diversity in various journals missions and objective, we limit our scope of study into one journal, which keep our research focused. Afterwards, we would define the timeframe of our research and means to manage ambiguity in our data collection. Last, we would describe our procedures in analyzing information.

Journal Selection

Due to hundreds of journals available and to ensure the quality of journals, we use ISI web of knowledge, which NTU library subscribed, as means to sort and to identify list of journals that fall under category of information science. The subject category name enlisted in Journal Citation Report Social Science Edition is Information Science & Library Science. While one might argue that the last two words of JCR category name would distort the research focus and thus form bias, the notion of Library Science is actually consistent with Information Science. This claim is consistent with White & McCain (1998) findings, where 70 out of 120 authors listed in 12 journals are from Library & Information Science department (L&IS).

Unfortunately, journals that qualify for condition that we set above are still massive, about 439 journals from 1999 – 2006. Thus, because of our limited resources, we narrow our selection to top two journals, MIS Quarterly and Journal of American Society for Information Science and Technology (JASIST), that have been consistently ranked as either first or second for the past eight years.

JASIST was selected to be the focus of our study because of two reasons. First, JASIST is affiliated with the American Society for Information Science and Technology (ASIST). ASIST acts as knowledge base for information professionals for nearly six decades, and thus its existence is concurrent with the birth of modern information science. Second, JASIST's orientation toward quantitative work is in accordance with our paper objective. Furthermore, its array of topics, namely theories of information science; communication; management, economics, and marketing; applied information science, fit our research profile.

Data Collection

In JASIST, many past metadata studies ended in 1990s, for example: Lipetz (1999) research timeframe: 1955 – 1995; White & McCain (1998) research timeframe: 1972 – 1995. Therefore, it is necessary to conduct investigation between 1980s and 2000s so that the results would be able to capture shifts and trends (if any). Thus our study timeframe: 1988 – 2007. The choice of the beginning year of 1988 is a matter of practicality, it allowed us not only to analyze substantial period in Information Science, but also to observe possible influence of information technology advances to the development of the subject. Among other scholars who either reported findings or began their research in 1980s are Claver et al., 1999; White & McCain, 1998; Buttlar, 1991. While articles in the year 1988 are accessible from beginning to end of the year, the year 2007 has not ended, and thus available only up to August. Hence, our data gathering would end in articles published in August 2007.

Extensive quantitative analysis on JASIST's metadata, provided by Wiley InterScience database, was conducted. In general, Wiley InterScience segmented articles in JASIST into: editorial, book review, and research article. Our research would exclude articles under editorial and book review because both segments do not represent Information Science literature development. Articles under research article have the following meta-information: index terms, which can be safely assumed as keyword; author's name; author's affiliation; article title; publication year; including date, volume, issue, and abstract. This paper would not collect all the metadata, but instead we would collect index terms, authors' name, authors' affiliations, and publication year in accordance to our objectives.

We downloaded 3258 distinct authors, 7092 distinct keywords, 1589 distinct articles into Microsoft Excel spreadsheet. Given the massive collection of data, we manage the data by using pivot table, which able to sort, count unique data according to authors, keywords and articles, and add the total count for each metadata category. Table 1 below summarizes our findings.

Year	Number of distinct authors	Number of distinct keywords	Number of distinct articles
1988	33	108	21
1989	46	153	25
1990	72	210	44
1991	93	349	57
1992	93	307	58
1993	75	221	39
1994	68	205	37
1995	106	273	52
1996	138	3	73
1997	161	785	91
1998	198	502	94
1999	218	567	117
2000	207	572	101
2001	207	596	104
2002	231	585	105
2003	215	575	102
2004	236	540	97
2005	279	269	121
2006	341	0	143
2007	241	272	108
Total	3258	7092	1589

Table 1. JASIST metadata overview, 1988 – 2007

Except for count of articles, unfortunately, author meta-data gathering needs further human interference. For example: Microsoft Excel would not be able to differentiate between authors with full name and the same authors with first name initials, or recognize the difference between authors' departments and authors' universities. To complicate the issue, majority of keywords metadata is missing in the year 1996 and in the year 2006.

To manage authors' metadata ambiguity, three clarifications are required. First, authors name is not always consistent in JASIST. For illustration: in some publications, a certain names were rendered by last name followed by first name initials, while in others publications, those names were rendered by full name. We handle such matter by matching the first name initials with the first letter of full name, if they are the same then we consider them as the same person. Second, authors' department could not always determined, as it is often confounded with authors' universities. For instance: Leo Egghe from Limburgs Universitair Centrum, Universitaire Campus, Universiteit Antwerpen. In such case, we consider the data before the first comma as authors' department, and the remaining as authors' organizations. Thus, Leo Egghe department is Limburgs Universitair Centrum, while his organization is Universitaire Campus, Universiteit Antwerpen. Last, there are instances which, the authors did not state their department name. For example: A. Bookstein from University of Chicago. In this case, we left the department name blank.

Although most of the time, WileyInterScience lists keywords metadata in each article, it appears that in 1996 and 2006, the database ignore the keywords metadata inclusion in almost every article (refer to table 1). Since there is no specific explanation offered in WileyInterScience, it would be unpropitious to speculate. The direct inference is that we should avoid analyzing keywords progressively on yearly basis; instead we should compare the keyword metadata based on equal time periods (9 years), i.e. from 1988 to 1997 and from 1998 to 2007.

Data Analysis

The analysis of the metadata was divided into two sections. First, we studied authors, its collaboration trends. After which, we identified top authors and classified their department into IS-related disciplines. Second, we evaluated top keywords trends, and subsequently we classified the keywords into IS-related disciplines. Our strategic thrust is to analyze whether the top authors discipline distribution and the top keywords discipline distribution is similar, and therefore derive multidisciplinary pattern in IS-field.

Authors

The analysis of authorship can be divided into two stages. First, evaluation of three collaboration trends, namely general collaboration trend, which obtained by dividing number of distinct authors by number of distinct article yearly; internal collaboration trend, which achieved by dividing number of distinct authors, who originated from same organizations, by number of distinct article yearly; and external collaboration trend, which is the ratio of number of distinct authors who originated from different organizations and number of distinct article yearly. These trends would illustrate the breadth and depth of co-authorship tendencies.

Second, to derive an overview of authors' disciplines distribution, we manage the massive data by considering only top 20 authors who have contributed 9 or more articles to JASIST in the past 20 years. Similar method was employed by White and McCain (1998), and Palvia and Panjani (2007). Therefore, it is appropriate for our reflective study of IS-related disciplines development. Afterward, we identified the top authors' departments and classified them into three categories: Core Information Science (e.g. School of Library and Information Sciences); Information Management (e.g. Management Information Systems department); and Information Technology (e.g. School of Computing and Information Technology), as defined by Summers, et.al. (1999). It worth mentioned that in order to obtain meaningful comparison with top keywords discipline distribution, we would segregate the authors discipline distribution into two periods: 1988 – 1997 and 1998 – 2007.

To reduce uncertainties, we use set of keywords (refer to table 2) to classify top authors disciplines into the three categories. Further, we classify authors without departments and authors with departments outside the three categories into others category. For example: centre for Social Informatics, Department of Operation Research. Further, to resolve the equivocal departments, which fall under two or more categories, we adopt various methods like investigating department's affiliations, mission and objectives, program offerings. For instance: department of Computer and Information Science (University of Michigan), which can be collocated under both Information Management and Information Technology. In this case we visit the university' (or institutions') website and check the department affiliations. We found five affiliations: 2 directly related with Information Management: Information Systems Executive Forum (ISEF) and Information Systems Industry Partners (ISIP); while the others: e – Lab, Collaboratory for Research on Electronic Work (CREW), and High-Tech / Telecom club are indirectly related with either Information Systems or Information Technology. Thus, since majority of the department affiliations are related with Information Systems, then it is classified under Information Management.

Keywords

Core Information Science	Information management	Information Technology

Communication Documentation Library Information Science Information Studies	Information systems Management	Information Technology Science & Technology Computer Science

Table 2. Keywords to classify Authors' department

Top Keywords

As explained above, we only consider top keywords for our analysis and we would compare the findings between two periods: 1988 – 1997 and 1998 – 2007. To ensure consistencies, we employ set of sub-categories (refer to table 3) to classify article-keywords into disciplines, according to Hawkins' (2001) information science map. For example: we consider information retrieval in Information Access sub-category, user studies in Behavioral Science sub-category. Various means were used to deal with uncertainties. Some were resolved by making sense of the overall contents orientation. Others were resolved with common opinion.

Number	Disciplines	Sub-Categories
1	Core Information Science	Properties of Information; Information Access; Information Industry/Markets/players; Knowledge Organization; Publishing; Information Market/Economics; Database Production; Electronic Information System; Online Searching; Current Awareness; Database Design; History
2	Computer Technology	Software; Hardware; Storage; Electronic mail; Multimedia; Document Management; Security, access control; Voice recognition; Machine translation; AI, expert system; Fuzzy logic, NLP; Internet, WWW
3	Law & Government	Copyright; Privacy; Contracts
4	Communication	Speech; Text; Video; Editing; Writing; Linguistics; Networking; Equipment; Telecommunication technologies; Regulation
5	Behavioral Science	Ergonomics; Human-computer interface; Human factors; Psychology
6	Librarianship	Types of libraries; Systems; Consortia/networks; Educations/training; Digital libraries; Library operations; Library management; Personal issues; Buildings/furnishings
7	Statistics	Bibliometrics; Scientometrics; Citation analysis
8	Other Subject Disciplines	Information coverage; Subject-specific search strategies; Biology; Business; Chemistry; Education

Table 3. Information map according to Hawkins (2001).

To ensure uniformity and reduce inconsistencies, the data in both authors and keywords analysis was classified by three master students individually and inconsistencies were straightened through consensus among the students.

Such method was not uncommon, for example: Palvia and Panjani (2007). Table 4 presents the results for inter-coder reliability, which close to the 90% level recommended in literature.

Coder	1	2	3
1			
2	88.63%		
3	92.57%	95.34%	

Table 4. Inter-coder reliability table

RESULTS

To present systematic findings, we use two-pronged approach: overview of collaboration trends among authors, and disciplines patterns among most productive authors' department and top keywords. Our main objective is to inquire the relationship between collaboration and multi-disciplinary in IS. The analysis of the data was divided into three parts. The first provides an overview of authors' collaboration trends. The second and third lists most productive authors and top keywords, and evaluates their disciplines distribution respectively.

We did not analyze all keywords trends because of missing set of metadata in 1996 and 2006. Further, it is not manageable to do so, unless data mining is applied. In addition, for simplicity, we consider the following assumptions: most prolific authors and keywords as a good sampling set; authors' department reflects authors' discipline (White & McCain, 1998); and collaboration among organizations indicates the increase in paper complexity and sign of multi-disciplinary.

There are two terms, which used frequently in the discussion and graph. Some readers may regard these terms as ambiguous; we specified the term "revival points" as one point after decreasing trend of three or more consecutive points, in all instances where it is used. It is significant in our study because we deals with generally increasing trends, and thus, we want to know the point that trigger the upward behavior of the trends. The other term "percentage of increment" is obtained by dividing the difference of the last and first with the first number. For example: in 1988 the number of distinct authors was 33; 20 years later, in 2007 the number of distinct authors is 241. Thus the increase is (241 – 33) / 100 = 6.3 or 630 percent.

Authors' Collaboration Trends

The analysis of authors' collaboration trends was divided into four parts. The first evaluates authors' general collaboration trends. The second, third, and fourth inspects sole authorship, internal and external collaboration trends respectively.

AUTHORS GENERAL COLLABORATION TREND

We analyze authors' collaboration trend based on number of authors per article. An analysis made of number of authors per article is common practice among researchers (e.g. Lipetz, 1999). The count of authors per article is obtained through simple division of total number of authors with total number of articles in a certain year of publication. This analysis would then measure growth rate of co-authorship per article using means explained in methodology section. Our analysis would illuminate issues, like the increasing trend of authors co-authorship. Our finding is depicted in trend graph below:

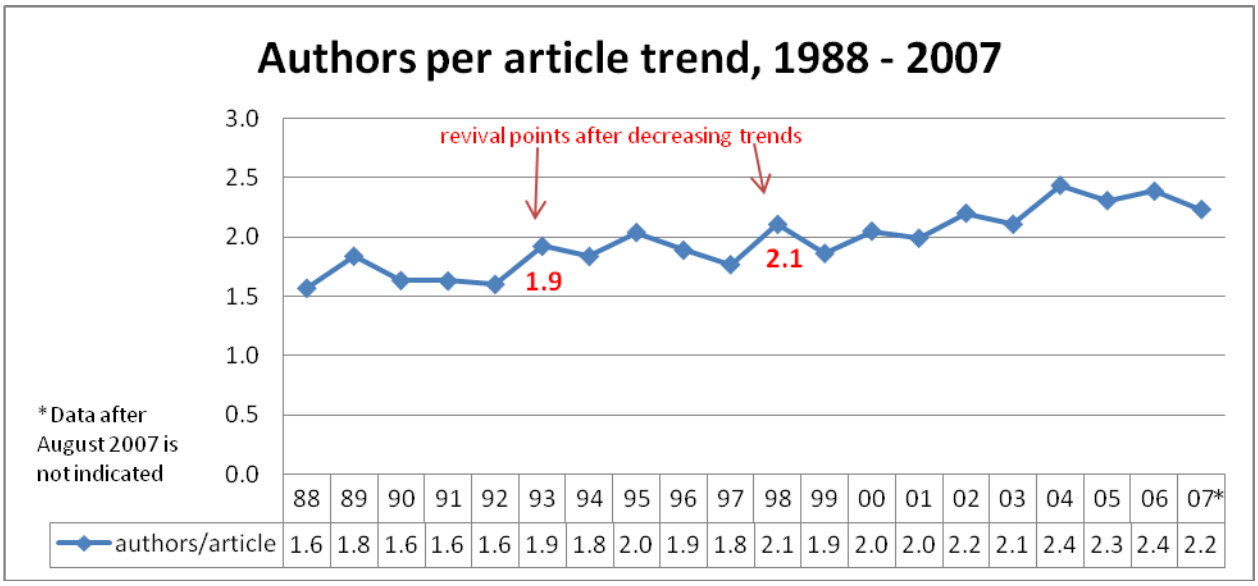


Figure 1. Number of authors per article trend: 1988 – 2007.

From the graph above, it is quite evident that the year 2004 and 2006, 2.4 authors per article, have the highest number of authors collaborating to produce scientific paper. The lowest rate of collaboration, 1.6 authors per article, happened in 1988, 1990, 1991, and 1992. It is also interesting to note that the mean (and median) of authors per article, for the past twenty years, is 2.0. This means that the past five years, from 2002 to 2007, has higher authors per article than average of two decades.

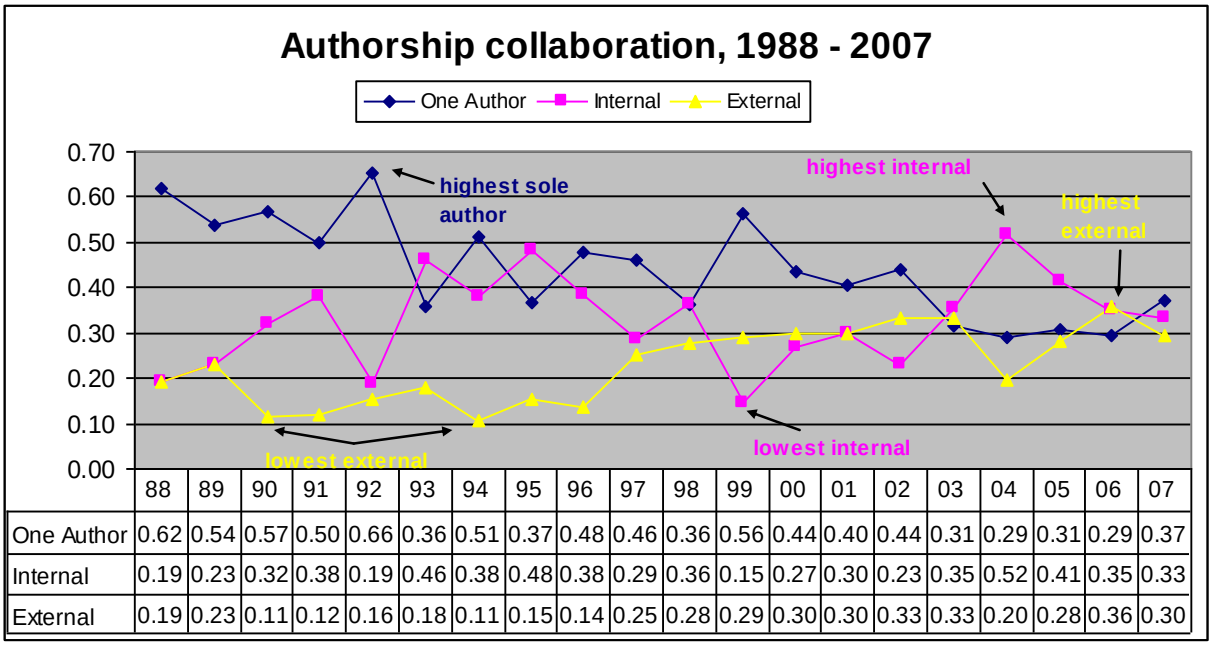
Another important observation is year 1993 and 1998. Both years mark the revival point for declining rate, from 1989 to 1992, which coincide with declining interest in IS pointed by Hawkins (2001), and from 1995 to 1997 respectively. Furthermore from 1998 onwards, the number of authors per article is close to the median (2.0), which implies papers produced by two or more authors have become more common than the earlier years. In general sense, however, there is an increasing trend for scientific paper produced by more than one authors in two ten-year periods.

To measure increment from 1988 to 2007, we take the difference between number of authors per article in 2007 (2.2) and the number in 1988 (1.6), which the result (0.6) divided by 1.6 (the number in 1988). Thus, the increase in collaboration for the past two decades is about 0.375. This implies that presently (2007) there are about 37.5% more chance for papers produced by one or more authors to than previously (1988).

Further, following our methodology and earlier observation that 1998 is a significant revival point, we are going to divide our findings above into two even period, 1988 – 1997 and 1998 – 2007. The percentage of increment in JASIST papers with only one author in between 1988 and 1997 is 28.5 %, while in between 1998 and 2007, the percentage is 17.5%. This means that there is 10.9% increment in co-authorship over the two periods. Thus, we can derive that more authors are collaborating, especially in the last 10 years.

The study of authorship needs to be augmented by the study of authors' affiliations. This is common practice among scholars who analyze IS paper from its authors perspective (e.g. White and McCain, 1998; Lipetz, 1999). Also, since the authors are associated with a certain organizations, a paper by one or more authors from the same organizations (and departments) would indicate collaboration. However, the depth of collaboration may not be sufficiently covered, as it is very likely that several universities have dissimilar niches of expertise (Palvia and Panjani, 2007), and thus a paper with different organizations, regardless of same department name or not, substantiate collaboration among scholars and high chance of multi-disciplinary in IS field.

In order to study collaboration rate among authors, we need to evaluate and compare the rate of no collaboration (single author), internal and external collaboration. Figure 2 below depicted authorship collaboration per article in JASIST, from 1988 to 2007.



	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07
One Author	0.62	0.54	0.57	0.50	0.66	0.36	0.51	0.37	0.48	0.46	0.36	0.56	0.44	0.40	0.44	0.31	0.29	0.31	0.29	0.37
Internal	0.19	0.23	0.32	0.38	0.19	0.46	0.38	0.48	0.38	0.29	0.36	0.15	0.27	0.30	0.23	0.35	0.52	0.41	0.35	0.33
External	0.19	0.23	0.11	0.12	0.16	0.18	0.11	0.15	0.14	0.25	0.28	0.29	0.30	0.30	0.33	0.33	0.20	0.28	0.36	0.30

Figure 2. Authors collaboration rate trend: 1988 – 2007.

SOLE AUTHORSHIP TREND

We measure the single author rate, by dividing number of single authored article with number of total article for a certain year. It is evident from chart above that the year 1992 has the highest single author proportion (0.66). the second highest is the year 1988 at 0.62. In general the first five years, from 1988 to 1992; 1994, and 1999 have high percentage of single author. On the contrary, the last five years, from 2003 to 2007; 1993, and 1995 have low proportion of sole author. However, it worth mentioned that there is indication that the year 2007 (measured until August) is leading upward trend.

Because the fluctuations, it is difficult to determine the overall trend direction. One alternative is to compare the median in 1988 – 1997 and 1998 – 2007. The overall median from 1988 to 2007 is 0.44, while in the earlier ten-year is 0.51, and in the latter ten year is 0.37. Thus, since the median in the latter period is lower than the earlier one then the single author rate is in decreasing trend in the past 20 years.

Further comparison with figure 1, we could derive two common observations: (i) the period from 1988 to 1992 is dominated by single author papers, with low collaboration rate; (ii) the year 1993 marks the first significant drop in single author papers, and the rise of authors' collaboration.

AUTHORS' INTERNAL COLLABORATION TREND

To begin our analysis, we would re-iterate that authors' internal collaboration is defined as two or more authors from same organizations contributing to an article. Therefore in order to measure the internal collaboration rate, we divide number of article co-authored by authors from same organizations, with number of total article for a certain year.

A closer observation on figure 2 revealed that the year 2004 has the highest indication of internal collaboration (0.52) among authors from the same organizations. On the contrary, the year 1999 is the lowest (0.15). The fluctuations impaired our ability to determine the trend direction, therefore we use median comparison method described previously. The overall median from 1988 to 2007 is 0.34, while in the earlier ten-year period is 0.35 and in the latter ten year is 0.34. Thus, since both periods median is almost the same, the authors internal collaboration rate has no dominant trend, instead it is affected by cyclical trends.

Nevertheless, from the chart above, it is important to note that authors' internal collaboration rate, in general, is higher than external collaboration rate. The exceptions are the year 1999, 2000, 2001, 2002, and 2006. Also, it is

interesting to observe that authors internal collaboration is higher than both single author trend and external collaboration trend in the year 1993, 1995, 2003, 2004, and 2005.

Comparisons with previous findings give us further observations: (i) the year 1993 marks the first significant rise of authors internal collaborations; (ii) the year 2004, which indicate the highest authors collaboration rate, is also indicate the highest internal collaboration rate. (iii) the year 1999, which indicate lowest authors internal collaboration is the year where sole authored paper dominant.

AUTHORS' EXTERNAL COLLABORATION TREND

To begin our analysis, we would re-iterate that authors' external collaboration is defined as two or more authors are from different organizations contributing to an article. For common understanding of different organizations, we illustrate using the following example: a paper contributed by three distinct authors from two distinct organizations, is considered to be an external collaboration paper. Therefore in order to measure the internal collaboration rate, we divide number of article co-authored by two or more authors from different organizations, with number of total article for a certain year.

A closer observation on figure 2 revealed that the year 2006 has the highest indication of external collaboration (0.36) among authors from the same organizations. On the contrary, the years 1990 and 1994 are the lowest (0.11). To determine the trend direction, we use median comparison method described previously. The overall median from 1988 to 2007 is 0.24, while in the earlier ten-year period is 0.15 and in the latter ten year is 0.30. Thus, since the median in the latter period is higher than the earlier one then the external collaboration rate is in increasing trend in the past 20 years.

To illuminate the relationship among sole, external collaboration, and internal collaboration authorship trends, we conducted correlation analysis. We find that the three trends are negatively correlated, the correlation between sole authorship and external collaboration is -0.49, subsequently between sole authorship and internal collaboration is -0.7, while between external and internal collaboration is -0.26. This means that there is no linear relationship among the three trends that explain the behavior of one trend relative to the others.

With regards to relation with the general authors' collaboration trend, we find that sole authorship trend is negatively correlated (-0.88) with general collaboration trend; while both internal and external collaboration trends are positively correlated, +0.47 and +0.62 respectively. This means that increment in general collaboration trend are attributed especially to the rise in external and internal collaboration, and the fall in sole authorship trend.

Previous observations reveal the following insights: (i) the revival points, 1993 and 1998, are the epitomes of general authorship, sole, external, and internal collaboration trends correlation behavior, which indicated by drop in single authored paper, concurrent with the rise of both internal and external collaboration; (ii) There is likelihood that the rise in authors general collaboration is attributed to significant increment in either internal or external collaboration, such as the year 2004, which is due to high internal collaboration rate, while the year 2006, is because of high external collaboration rate. In both years, single authored papers proportion is relatively low; (iii) in general, the increasing collaboration rate among authors is attributed to the rise of authors' external and internal collaboration rate, and the fall of single authored papers.

Productive Authors and Their Disciplines Distribution

To investigate whether collaboration among authors incite multidisciplinary in IS-field, we study the most productive authors' (top 20) department, which is our best guest to authors' discipline (White & McCain, 1998). The significance of identifying most productive authors based on the assumption that productive authors are leaders who bear the responsibility to redefine IS literature boundaries. The implication is if productive authors from different departments, then the field (IS) is indeed multidisciplinary.

For assessing research productivity of authors, the normal count approach is used. This count approach used by many researchers: Palvia & Panjani (2007), White & McCain (1998). For illustration: an article with two authors is counted as one article with each of the authors names counted once. This method, however, would result in total number of authors greater than total number of articles.

For reporting purposes, we consider most productive authors if they produced more than eight paper in the period of 20 years, from 1988 to 2007. Table 1 lists the resulting 20 authors, sorted by number of publications along with their departments. L. Egghe is on top of the lists with 28 publications bearing his name. The top 20 authors with nine or more publications are: Leo Egghe, Hsinchun chen, Ronald Rousseau, Amanda Spink, Mike Thelwall, Paul B. Kantor, Charles Cole, Christopher C. Yang, Loet Leydesdorff, Nigel Ford, Andrew Large, Jamshid Behesti, A.F.J. Van Raan, A. Bookstein, Liwen Qiu Vaughan, Michael D. Cooper, Michael D. Gordon, Rob Kling, Robert M. Losee, and Tefko Saracevic. For full list, please refer to below table.

Author Name	Total papers	Department	University
L. Egghe	28	Limburgs Universitair Centrum	Universitaire Campus, Universiteit Antwerpen
Hsinchun Chen	23	Management Information Systems Department	University of Arizona
Ronald Rousseau	20	Speciale Licentie Documentatie-en Bibliotheekwetenschap	University of Antwerp
Amanda Spink	19	School of Library and Information Sciences	University of North Texas
Mike Thelwall	16	School of Computing and Information Technology	University of Wolverhampton
Paul B. Kantor	16	Dept of Operations Research	Case Western Reserve University Cleveland Ohio
Charles Cole	13	Graduate School of Library and Information Science	University of Western Ontario
Christopher C. Yang	12	Department of Systems Engineering and Engineering Management	The Chinese University of Hong Kong
Loet Leydesdorff	12	Science & Technology Dynamics	Amsterdam School of Communications Research
Nigel Ford	12	Department of Information Studies	University of Sheffield
Andrew Large	11	Graduate School of Library and Information Studies	McGill University
Jamshid Beheshti	11	Graduate School of Library and Information Studies	McGill University
A. F. J. van Raan	10	Centre for Science and Technology Studies	University of Leiden, Wassenaarseweg The Netherlands
A. Bookstein	9	Center for Information and Language Studies	University of Chicago
Liwen Qiu Vaughan	9	Graduate School of Library and Information Science	University of Western Ontario
Michael D. Cooper	9	School of Information Management and Systems	University of California
Michael D. Gordon	9	Computer and Information Systems	University of Michigan, Ann Arbor

Rob Kling	9	Center for Social Informatics	Indiana University
Robert M. Losee	9	School of Information and Library Science	University of North Carolina
Tefko Saracevic	9	School of Comm, Information and Library Studies	Rutgers, The State University of New Jersey

Table 5. Top 20 authors in JASIST, 1988 – 2007.

It is quite evident that the productive authors have different disciplines, and thus, the IS literature is influenced by multi-disciplines. The authors are not necessarily from Library and Information Science (L & IS) department, for example Paul B. Kantor is from department of Operation Research, A. F. J. van Raan is from centre for Science and Technology Studies. In fact, only 10 out of 20 authors are from L & IS department and its variation. The 10 authors are: Ronald Rousseau, Amanda Spink, Charles Cole, Nigel Ford, Andrew Large, Jamshid Beheshti, A. Bookstein, Liwen Qiu Vaughan, Robert M. Losee, and Tefko Saracevic.

To gain further insight on most productive authors' distribution, we are going to further analyse the findings above into two even period, 1988 – 1997 and 1998 – 2007. We would classify departments into disciplines, according to means described in methodology. The authors' disciplines distribution would then be compared between the two periods. To ensure meaningful comparisons, we count percentage of number of authors in a certain category divided by numbers of authors in all categories. For example: in between 1988 and 2007, 10 out of 20 authors are from core information science. Thus, the percentage of core information authors is 50%. Please refer to figures below for the result of analysis:

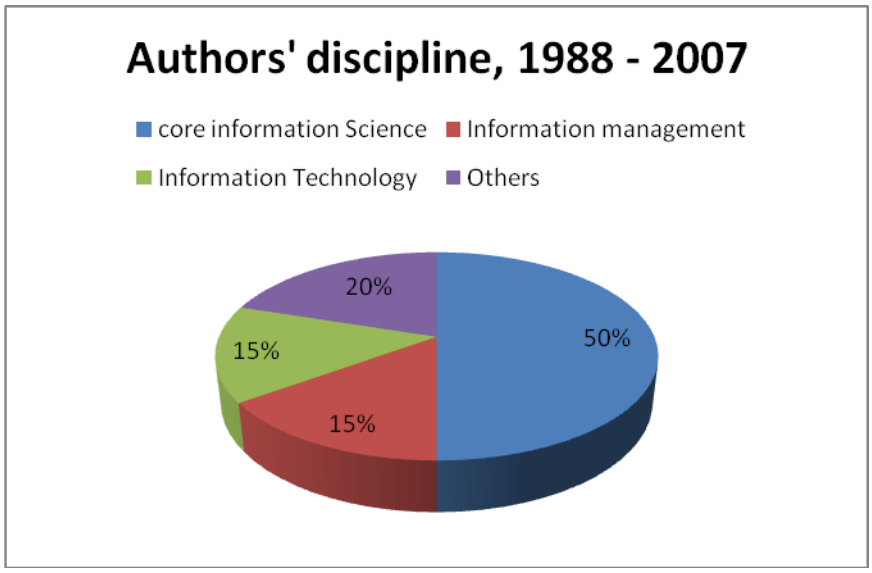


Figure 3. Distribution of authors' background over two ten-years period.

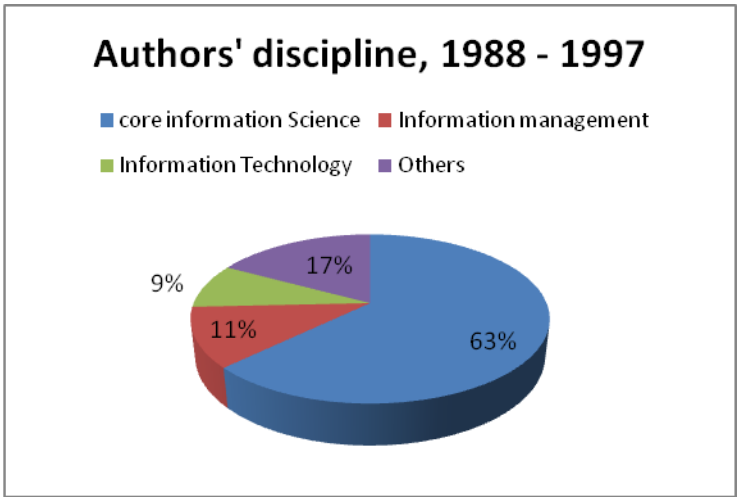


Figure 4a. Distribution of authors' background in earlier ten-year period.

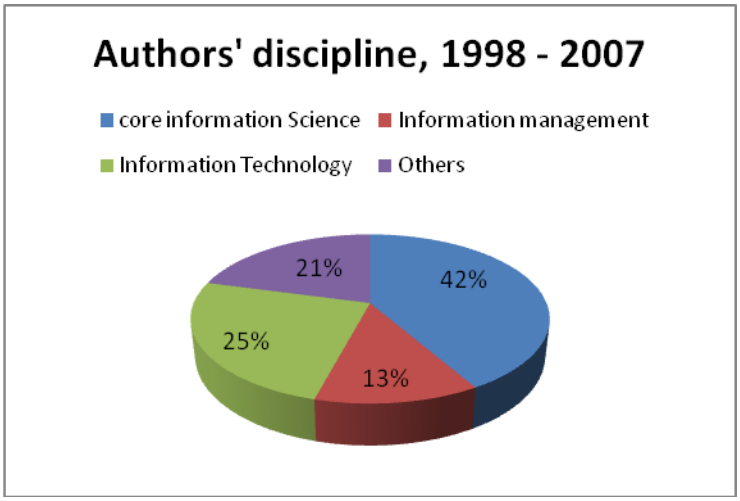


Figure 4b. Distribution of authors' background in latter ten-year period.

From the above charts, there are few observations that we can interpret: (i) the authors from core information science are 21% less in the latter 10-year-period than the earlier decade; (ii) more authors from information technology discipline (16% increment between the two ten-year period) has contributed to JASIST. This is recognized by JASIST, which the proposal to add "and Technology" to JASIS name was recently adopted (year 2000); (iii) the authors from information management background are relatively constant; (iv) the authors background are getting more diverse (about 4% increment in others category).

Clearly, the findings so far indicate that the field of information science has become more multi-disciplinary. Further, we can deduce that there is strong likelihood IS literature is influenced by authors from different background, who collaborate to produce papers. However, these observation need to be supplemented by authors' organization and articles' keywords analysis to examine the nature of collaboration and to attest multi-disciplinary in IS field respectively.

Top Keywords and Their Disciplines Distribution

By the nature of metadata, keyword analysis involves the most voluminous set of data. In our study, we need to manage 7092 entry of keywords. Even if we divide the period of study into two ten-year period, the data is still massive. In the first decade (year 1988 – 1997), there are 2614 keywords, while, in the second decade (year 1998 – 2007), there are 4478 keywords. It is evident that analysing all the keywords appeared in the past two decades in order to identify the IS trend would require extensive time and resources. Further, random appearance of some keywords would add noise, and thus would distort our trend analysis. As what Claver, et.al.(2000) pointed out, the keyword analysis should be drawn based on most frequently appeared keywords, or highly weighted keywords.

To investigate the multidisciplinary in IS field, we would need to classify top keywords into disciplines. Such method of classifying top keywords is common among researchers (e.g. Claver, et.al., 2000; Parvia and Panjani, 2007). The field of IS actually overlaps with a few disciplines (Hawkins, 2001), and thus it is possible to segregate top keywords according to their respective disciplines. Hawkins (2001) further expressed the overlap as a "map", in which the basic subjects comprising information science are shown in a "core" at the center, with related disciplines surrounding the core. The disciplines most closely related to information science are: computing technology, behavioral science, librarianship, statistics, communications, law and government, communication, and other subject disciplines.

To begin our analysis, we would need to identify most frequently appeared keywords (top keywords). However, due to the massive set of data, it is not meaningful to identify high count keywords (e.g. top 20), instead we would identify top 10% (about 70) in 1988 – 1997 and 1998 – 2007 periods. The total counts for top 70 keywords in earlier ten year period is 1105, while in the latter ten year period is 1805. If we measure the percentage of these figures to their respective total keywords, 2614 and 4478, we would obtain 42.27% and 40.3% respectively. This indicates that there are wider range of keywords between 1998 and 2007.

In order to gain further insight whether IS field has become more multidisciplinary, the top 70 keywords (top 10%) from each decade are therefore identified and classified according to means explained in methodology section:

Top 70 Keywords (1988 - 1997)	Count	Disciplines
information retrieval	57	Information Science
document retrieval	40	Information Science
end user searching	35	Information Science
Journals	33	Information Science
online searching	33	Information Science
Evaluation	30	Information Science
Relevance	28	Information Science
Comparison	27	Information Science
citation analysis	26	Statistics
primary literature	24	Information Science
information science history	22	Information Science
analytic models	20	Information Science
usage studies	20	Behavioral Science
Usability	20	Behavioral Science
academic libraries	19	Librarianship
information storage and retrieval systems	18	Information Science
full text searching	18	Information Science
bibliographic citations	17	Statistics
retrieval effectiveness	17	Information Science
query formulation	17	Information Science
biomedical information	17	Other Subject Disciplines
medical science	16	Other Subject Disciplines

Databases	15	Information Science
Bibliometrics	15	Statistics
information use	15	Information Science
Standards	15	Information Science
user studies	15	Behavioral Science
cluster analysis	14	Information Science
Opacs	14	Librarianship
information science	14	Information Science
information needs	14	Behavioral Science
Algorithms	14	Information Science
data distribution	14	Information Science
user behavior	13	Behavioral Science
subject indexing	13	Information Science
Libraries	13	Librarianship
search strategies	13	Other Subject Disciplines
scholarly publishing	13	Information Science
reader services	13	Information Science
Overlap	13	Information Science
Thesauri	12	Librarianship
automatic indexing	12	Information Science
cognitive models	11	Information Science
boolean searching	11	Information Science
Hypertext	11	Computing Technology
electronic documents	11	Computing Technology
cost analysis	11	Information Science
relevance ranking	11	Information Science
Recall	11	Information Science
query processing	11	Information Science
Performance	11	Information Science
information theory	11	Information Science
Authors	11	Statistics
Trends	11	Information Science
index terms	10	Information Science
scientific and technical information	10	Information Science
Probability	10	Statistics
probabilistic retrieval	10	Statistics
information seeking	10	Information Science
impact factor	9	Behavioral Science
economics of information	9	Information Science
statistical methods	9	Statistics
colleges and universities	9	Information Science
search behavior	9	Behavioral Science
scholarly communication	9	Communication
user satisfaction	9	Behavioral Science
user preferences	8	Behavioral Science
SGML	8	Computing Technology
query refinement	8	Information Science

social aspects	8	Behavioral Science

Table 6. Top 10% keywords list, 1988 – 1997

Top 70 Keywords (1998-2007)	Count	Disciplines
information retrieval	86	Information Science
end user searching	78	Information Science
World Wide Web	77	Computing Technology
citation analysis	52	Statistics
online searching	71	Information Science
user studies	51	Behavioral Science
information seeking	41	Information Science
document retrieval	35	Information Science
Relevance	35	Information Science
analytic models	34	Information Science
Internet	32	Computing Technology
biomedical information	31	Other Subject Disciplines
Journals	32	Information Science
scholarly publishing	32	Information Science
Collaboration	30	Behavioral Science
digital libraries	30	Librarianship
information science	30	Information Science
Evaluation	29	Information Science
search behavior	30	Behavioral Science
social aspects	30	Behavioral Science
Trends	30	Statistics
search engines	29	Computing Technology
information needs	25	Behavioral Science
retrieval effectiveness	24	Information Science
scholarly communication	26	Communication
visualization (electronic)	27	Communication
web sites	27	Computing Technology
Algorithms	21	Information Science
Comparison	22	Information Science
impact factor	22	Behavioral Science
information storage and retrieval systems	22	Information Science
query formulation	23	Information Science
search strategies	22	Other Subject Disciplines
bibliographic citations	21	Statistics
Bibliometrics	21	Statistics
Forecasting	19	Information Science
information science history	21	Information Science
links (hypermedia)	20	Computing Technology
Similarity	20	Information Science
user behavior	20	Behavioral Science
Images	19	Computing Technology
information technology	19	Computing Technology
Authors	17	Statistics

co-citation analysis	17	Statistics
data mining	18	Information Science
end users	18	Behavioral Science
individual differences	18	Behavioral Science
Interfaces	19	Information Science
link analysis	19	Computing Technology
non English languages	19	Communication
research methods	19	Information Science
scientific and technical information	19	Information Science
usage studies	19	Behavioral Science
user models	19	Behavioral Science
Classification	16	Information Science
cognitive models	17	Information Science
query by example	17	Information Science
research and development	17	Information Science
search terms	17	Information Science
Children	15	Other Subject Disciplines
image retrieval	15	Computing Technology
information access	16	Information Science
information resources	15	Information Science
maps (graphic representation)	16	Communication
Metadata	16	Statistics
vector space models	16	Computing Technology
legal aspects	15	Law Government
pattern recognition	15	Information Science
Performance	15	Information Science
Usability	15	Behavioral Science

Table 7. Top 10% keywords list, 1998 – 2007.

Further comparison between the two tables above was conducted to determine the discipline distribution in the two decades. In order to obtain clearer dynamics of the past two decades' keywords analysis, two measures are drawn, one based on discipline distribution in top 10%, while the other based on keywords that appeared either in earlier 10-year part of two decades period or in latter 10-year part, but not both. The double measure would guard against inconsistencies, since it is possible that a certain significant keywords are classified under two different category of disciplines. However, the draw-back of this method is we would not be able to interpret, literally, percentage of increase (or decrease) between the two measures, since they are based on unequal base quantity of data.

The first measure: Disciplines' count (weight) distribution comparison in each ten-year periods. The following table articulates the weight of each discipline surrounding IS field, as explained by Hawkins (2001).

Discipline	Count (Weight) in 1988 – 1997	Weight in %	Count (Weight) in 1998 – 2007	Weight in %
Information Science	42	60%	32	45.71%
Behavioral Science	10	14.30%	12	17.14%
Statistics	7	10%	7	10%
Librarianship	4	5.71%	1	1.43%
Computer Technology	3	4.39%	10	14.30%

Other Subject Disciplines	3	4.29%	3	4.29%
Communication	1	1.43%	4	5.71%
Law & Government	0	0%	1	1.43%
Total	70	100%	70	100%

Table 8. Comparison of discipline frequency between 1988 – 1997 and 1998 – 2007.

As what we expected, information science dominates the disciplines distribution table in both ten-year periods, with 60% and 45.71% distribution respectively. It is important to note the dynamics, some of the related disciplines, like Computer Technology, Communication, Law & Government, and Behavioral Science, are experiencing increase in distribution, On the contrary, disciplines like Librarianship and Information Science are experiencing decrease., While, the others, like Statistics and Subjects in other discipline category remain constant. Figure 5a and 5b below depict the discipline percentages in 1988 – 1997 and in 1998 – 2007 respectively.

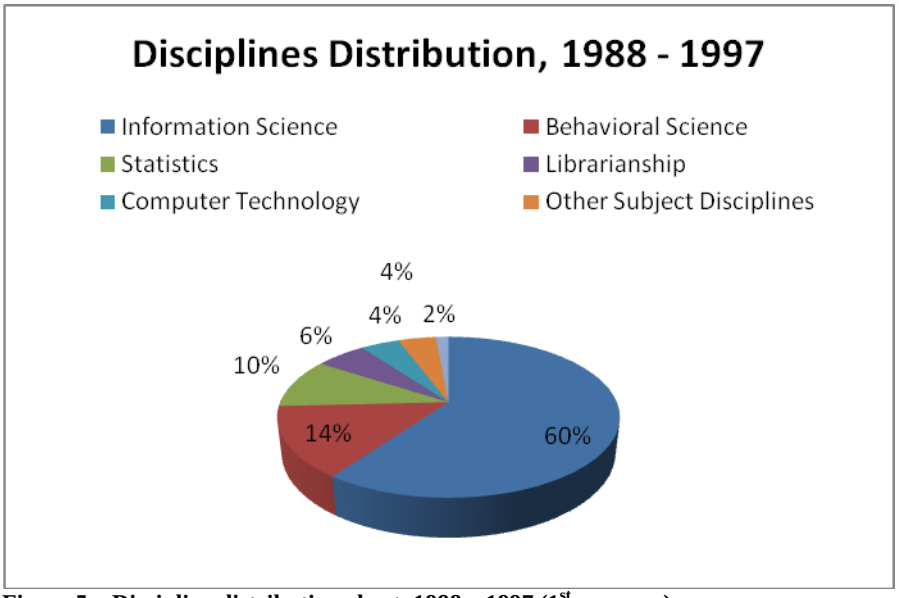


Figure 5a. Discipline distribution chart, 1988 – 1997 (1st measure)

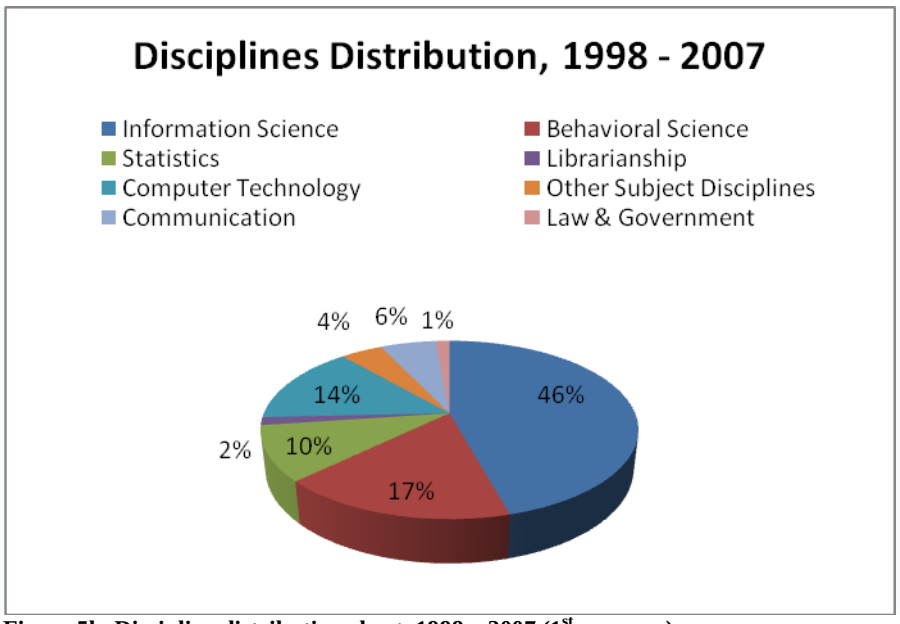


Figure 5b. Discipline distribution chart, 1998 – 2007 (1st measure)

From the two charts above, it is evident that the core discipline, Information Science, has the most significant fall in distribution, around 15%, followed by Librarianship, 4.37%. On the flip side, Computer Technology has the most significant gain in distribution, around 10%, followed by Communication (4.3%), Behavioral Science (2.8%), and Law & Government (1.4%). In essence, Library and Information Science (L & IS) reduced presence in IS field implies that the other disciplines has increased their presence in the IS field. This finding also means that IS field has become more multi-disciplinary and complex. We would further test these findings with second measure, discussed below.

The second measure: we identified top keywords which consistently appeared over period of two decades, and thus we analyze keywords which only appear either in 1988 – 1997 or in 1998 – 2007, but not both (refer to table 10a). Our main intention is to study common top keywords and to compare exclusive keywords, which only appear in the latter ten year period, and subsequently gauge the discipline's distribution (refer to table 10b).

Discipline	Top keywords that consistently appear in 1988 to 1997 and 1998 to 2007	Top keywords that appeared exclusively in 1988 – 1997	Top keywords that only appeared in 1998 – 2007
Information Science	Algorithms, analytic models, cognitive models, Comparison, document retrieval, end user searching, Evaluation, information retrieval, information science, information science history, information seeking, information storage and retrieval systems, Journals, online searching, Performance, query formulation, Relevance, retrieval effectiveness, scholarly publishing, scientific and technical information,	automatic indexing, boolean searching, cluster analysis, colleges and universities, cost analysis, data distribution, database, economics of information, full text searching, index term, information theory, information use, overlap, primary literature, query processing, query refinement, reader services, recall, relevance ranking, standards, subject indexing	classification, data mining, forecasting, information access, information resources, interfaces, pattern recognition, query by example, research and development, research methods, search terms, similarity

	Trends		
Behavioral Science	impact factor, information needs, search behavior, social aspects, usability, usage studies, user behavior, user studies	user preferences, user satisfaction	collaboration, end users, individual differences, user models
Statistics	Authors, bibliographic citations, Bibliometrics, citation analysis	probabilistic retrieval, probability, statistical methods	co-citation analysis, metadata
Librarianship	-	academic libraries, libraries, opacs, thesauri	digital libraries
Computer Technology	-	electronic documents, hypertext, SGML	image retrieval, images, information technology, internet, link analysis, links (hypermedia), search engine, vector space models, web sites, world wide web
Other Subject Disciplines	biomedical information, search strategies	medical science	children
Communication	scholarly communication	-	maps (graphic representation), non-English languages, visualization (electronic)
Law & Government	-	-	legal aspects

Table 9a. Distribution of top keywords according to IS-related disciplines.

It is interesting to note the disciplines' distribution of common top keywords, since these disciplines have not changed over the past twenty years. Although our research timeframe limit our deduction, we could infer that consistent top keywords in JASIST comprise of the following disciplines: Information Science (58%), Behavioral Science (22%), Statistics (11%), Other Subject Disciplines (6%), and Communication (3%). Further, the fact that majority of persistent top keyword is Information Science (Core), attest authors continuous efforts to remain focus on IS-related issue.

It also worth noted that Behavioral Science, Statistics, and Other Subject Disciplines substantial presence in persistent top keywords suggest that their application to IS field is relatively stable. While the absence of Librarianship and Computer Technology in common top keywords, indicate that these two subjects profile in IS field are ever-changing, and influenced by technological advancement. For instance: top keywords libraries in earlier part of ten years morphed into digital libraries on the latter part of ten years, and in the same vein, electronics documents and hypertext merged into websites and world wide web. Further, Communication and Law & Government low presence, in top keywords from 1988 to 1997, suggest that they are recent addition to the group of IS-related disciplines. Figure 6a chart persistent top keywords' discipline over the last two decades.

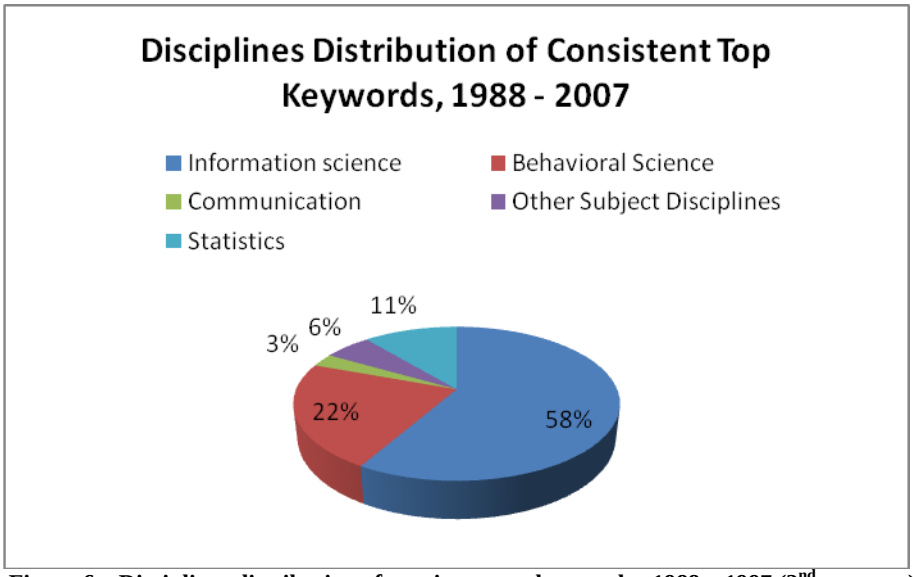


Figure 6a. Disciplines distribution of consistent top keywords, 1988 – 1997 (2nd measure)

As observed, there are 36 common keywords between top 70 keywords in 1988 – 1997 period and top 70 keywords in 1998 – 2007 period. This implies that there are 34 keywords out of each decade top 70 keywords, which appeared only either in earlier decade or in latter decade, but not both. Using the same means to classify the keywords into disciplines as in first measure, we obtain table 10a. Afterwards, we count the frequency and percentage of exclusive keywords in each decade (refer to table 10b). Figure 6b and 6c depicted table 9b percentages.

Discipline	Appearances in 1988 - 1997 but not in 1998 - 2007	Percentage (%)	Appearances in 1998 - 2007 but not in 1988 – 1997	Percentage (%)
Information Science	21	61.76%	12	35.29%
Statistics	3	8.82%	2	5.88%
Behavioral Science	2	5.88%	4	11.76%
Librarianship	4	11.76%	1	2.94%
Other Subject Disciplines	1	2.94%	1	2.94%
Computer Technology	3	8.82%	10	29.41%
Communication	0	0.00%	3	8.82%
Law & Government	0	0.00%	1	2.94%
Total	34	100.00%	34	100.00%

Table 9b. Count comparison of distinct keywords appearance, which appeared exclusively in each decade. .

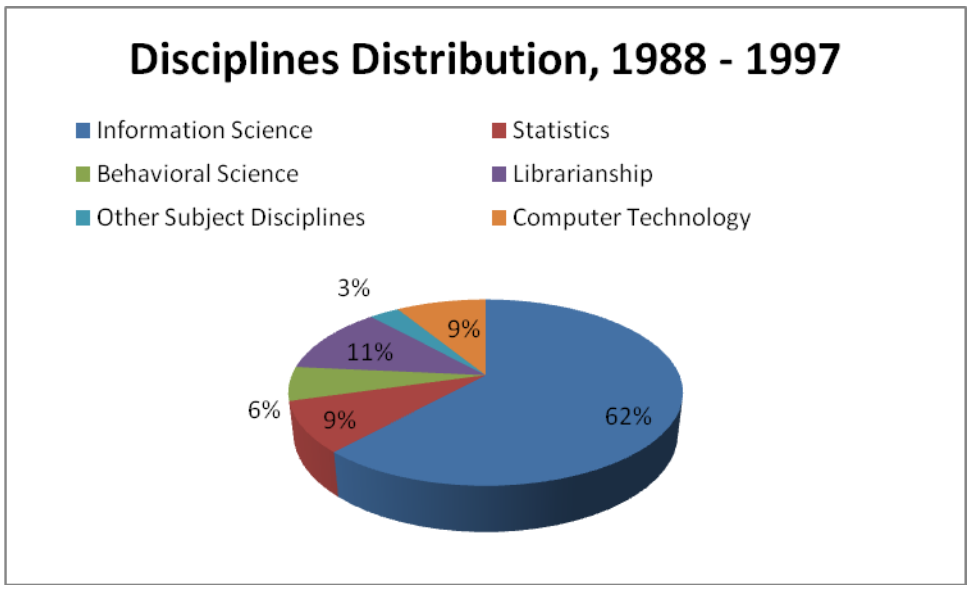


Figure 6b. Disciplines distribution chart, 1988 – 1997 (2nd measure)

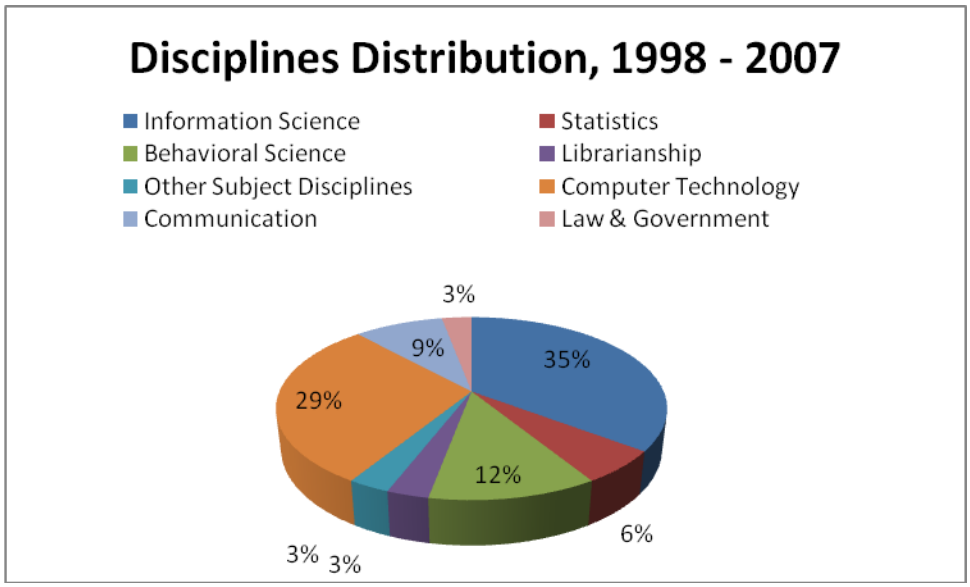


Figure 6c. Disciplines distribution chart, 1998 – 2007 (2nd measure)

It is evident from the chats above that Information Science discipline has reduced its presence greatly in the latter decade (about 26.37% fall), followed by Librarianship (about 8.82% fall), and Statistics (2.94%) respectively. While, on the contrary, Computer Technology has increased its presence significantly in 1998 – 2007 (about 26.47% gain), followed by Communication (8.82%), Behavioral Science (5.88%), and Law & Government (2.94%). Despite the fact that Other Subject Discipline remains at 2.94%, the decrease in three subjects (i.e. L & IS, Stats) is paralleled by the increase in four other subjects (i.e. Comp, Comm, BS, and Law). Thus, the field IS has become more multi-disciplinary in recent 10 years.

The findings from second measure are mostly consistent with the first, and they illustrate proportionate disciplines distribution percentages, except the percentage on the Statistics discipline dynamics. However, since the disparity is small, we consider that the Statistics discipline is relatively constant over two decades.

Our analysis result thus far is consistent with authors' discipline distribution. The findings have impacted both in authors discipline and research papers topics. First, there is significant fall in core information science. Second, there is significant increase in Computer Technology and Communication (Information Technology). Last, there is indication of more disciplines increased their presence in IS field.

LIMITATIONS

While this paper provides an overview of collaboration and multi-disciplinary trends in IS-field over two decades, some limitations need to be noted to avoid possible misinterpretations. First, the findings in this paper should be viewed as indicative and not an authoritative declaration. For researchers who are interested in authoritative declaration study, the scope of data collection needs to be broadened. MIS quarterly, for example, is not included in this paper due to its Information Systems orientation Nevertheless, MIS quarterly is classified by JCR Social Science edition as one of the top ranking journals in Library & Information Science. Thus, its inclusion might have affected some results in this paper. For instance, there is possibility that important researchers (or affiliations) did not publish all of their works in JASIST during our period of analysis. Such probability could make the researcher (or affiliations) less prolific in JASIST, but not necessarily so in IS field. Thus, attempts to interpret metadata analysis into IS field, should exercise caution.

Second, while collecting keywords metadata in Wiley InterScience database, we found missing metadata of keywords in 1996 and 2006 respectively (refer to table 1). Given potential distortion in keyword analysis, we can only claim that our method, to split the twenty years period into 1988 – 1997 and 1998 – 2007, makes the two period comparable (9 years each) and it suited our purpose of indicative study.

Third, the tool that we use to collect data, Microsoft Excel, involves manual entry. It is likely that some human errors, like typo error and missing entry error, affected the accuracy of data collection. To prevent such error from happening, advanced technique like data mining should be applied. However, such technique requires expertise of several doctorates, because of different data mining algorithms may yield different results, resulting in different interpretations. Thus, it is not feasible for this study.

Fourth, while categorizing the authors and keywords disciplines, we adopted Summers, et.al' (1999) and Hawkins' (2001) classification (as well as IS definitions) respectively. As Hawkins (2001) indicated there are various definitions of IS that have been promulgated over the years, and therefore, there are no universally acceptable method to classify metadata into IS-related disciplines. To exacerbate the issue, there is no common understanding on what constitutes boundary of a discipline. Further, different interpretative researchers might apply different categorizing schemes with different scaling justifications, resulting in different outcomes. Given this subtle bias, this paper is a reflective study on JASIST metadata trend, which based on Summers, et.al (1999) and Hawkins (2001) school of thought.

Finally, our analysis is based on quantitative evidence. One might argue that this evidence does not accurately reflect the depth of collaboration or multi-disciplinary in IS. It is possible, for example, that a group of authors did not contribute equally to produce an article, or there is one dominant discipline that influenced the paper. .These scenarios are not reflected in our results. Alternative approaches, such as citation analysis (e.g. White and McCain, 1998), or empirical study (e.g. Zins, 2007) that emphasize quality should also be examined.

CONCLUSION

Although many metadata studies have emerged in their attempts to understand IS and its development, reflective quantitative studies, that trace collaboration trends and distribution of disciplines, appear to be either outdated or inadequate. This paper, therefore, aims to reduce such a deficiency. It is important to recognize that the definition of Information Science is not static, (Hawkins, 2001). Thus, in the tradition of cumulative research, we analyzed

metadata in JASIST from authors, their affiliations and keywords point of view, and updated the timeframe of such quantitative study up to recent decade.

An overview of authors' collaboration trends, during the last 20 years indicates three outcomes. First, there is increasing trend of collaboration among authors (researchers) to produce papers (articles). Second, deeper content analysis on the first outcome, implies that the overall increasing trend of authors' collaboration can be attributed, in general, to the fall of single authored papers and the rise of external, or internal collaboration, or both. Last, in macro-view, the collaboration among authors is largely internal one. These trends show promising lines of inquiry as well as the ones that are neglected and in need of renewed attention.

Further observations in the trends indicate that there are certain years, which marked important development in authorship. With regard to this, the years 1993 and 1998 have general indication that the fall of single authored papers is concurrent with the rise in both internal and external collaboration among researchers. While, the years 2004 and 2006, which are two highest points in the general collaboration trends, implies that the increase in collaboration among authors could be due to increase in internal or external collaboration, but not necessarily both. Nevertheless, the findings infer that there are no patterns in internal collaboration, while external collaboration is in increasing trend, and sole authorship trend in decreasing trend.

To understand repercussion of increased collaboration trends among JASIST authors, either within an organization or with other organizations, we analyzed the most influential organizations profile, most productive authors' (researchers') and top 10% keywords' disciplines distribution. From top 20 organizations profile study, it appears that the collaboration among different organizations in different countries also on the rise, which results in added complexity in collaboration among researchers. Furthermore, most prolific researchers' and keywords' disciplines distribution have similar observations, and both have changed over the two decades. There are indications that core Information Science and Library disciplines has fallen drastically over the years, at the same time, Computer Technology and Communication (or Information Technology) has risen significantly. Further, there are disciplines, like Law & Government, that make new entry to IS field. This corroborate the increase of multi-disciplinary influence in IS field, especially in the last 10 years.

There are several implications for universities (or research institutions), researchers and students, both undergraduate and graduate. First, the research community can easily observe the tendency to collaborate in producing papers. By following the recent trend, the community can be reassured that collaboration would improve their productivity. In addition, by collaborating with authors from different disciplines, the community would be able to address complex issues in IS, and thus enhance the quality of their papers. Second, the community can identify not only most productive authors, but also observe the dynamics of popular research topics. This provides the upcoming researchers to direct their lines of inquiry to the latest topics relevant to IS field. Last, we do not advocate that all should collaborate or inject multi-disciplinary flavor into their papers, but rather upcoming researchers should be aware the value of collaboration, and engage in it only if it is beneficiary.

Finally, given the increased complexity in investigating IS-related problems, we recommend to encourage collaboration among researchers, either within organizations or with other organizations, so that researchers could hasten their proposal to address the issues. Also, the core Information Science disciplines should remain the dominant influence in any collaboration, to prevent IS-field demean into other discipline field, and to achieve optimum balance.

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