

Highly cited articles in the Information Science and Library Science category in Social Science Citation Index: A bibliometric analysis

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Dragan Ivanović

University of Novi Sad, Serbia

Yuh-Shan Ho

Asia University, Taiwan

Abstract

This study aims to identify and analyse the characteristics of highly cited articles published in the Information Science and Library Science category in the Social Science Citation Index. Articles that have been cited at least 100 times since publication up to the end of 2012 were analysed. We identified 501 highly cited articles published between 1956 and 2009 in 37 journals. *MIS Quarterly* published 26% of all analysed highly cited articles. The most productive researcher published 11 articles. Six bibliometric indicators were used to evaluate source institutions and countries. The 13 most productive institutions were all located in the USA and Canada. Harvard University in the USA was the most productive institution, ranked number one in the total number of highly cited articles, while the University of Maryland in the USA had the highest publication performance of first and corresponding author articles. Researchers from the USA contributed 67% of highly cited articles.

Keywords

Bibliometric, highly cited articles, information science and library science, Social Science Citation Index, Y-index

Introduction

The ability to measure the science of nations is vital for governments and it should be used for determining scientific priorities and selecting funding (King, 2004). To measure the quantity of science one can use numbers of published research papers and reviews (Abt, 1993), and to measure the quality of science one can use their citations (Brace, 1992). Some researchers suggest that the index of citation of papers is not a direct measure of quality and significance but this measure reflects the visibility and influence of that paper on the scientific community (Baltussen and Kindler, 2004; Furlan and Fehlings, 2006). It is accepted that highly cited articles are associated with high quality research (Levitt and Thelwall, 2009). It was also reported that the metric used to measure the quality of science of a certain country is the ratio of highly cited papers to total papers produced in sequential time frames by researchers from that

country (Kostoff et al., 2008). There are many published bibliometric analyses in various disciplines which report the distribution of highly cited articles per researchers, institutions, journals, and countries. The information science and library science (IS&LS) field is attractive for researchers from various scientific fields (Tang, 2004). IS&LS articles are very often cited in other scientific fields such as computer science, medicine, psychology, the social sciences, and general sciences (Meyer and Spencer, 1996).

This paper presents a bibliometric analysis of highly cited articles published in journals listed in the Web of

Corresponding author:

Yuh-Shan Ho, Trend Research Centre, Asia University, 500 Lioufeng Road, Taichung 41354, Taiwan.
Email: ysho@asia.edu.tw

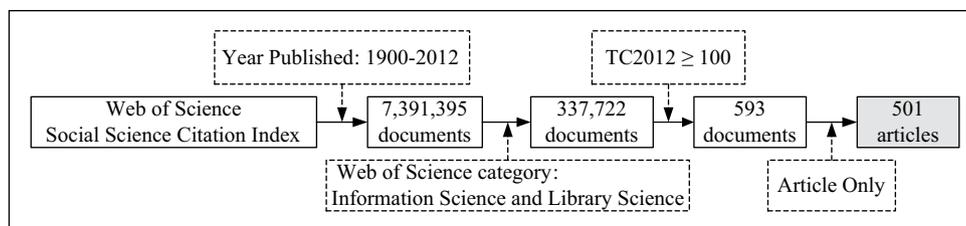


Figure 1. Schematic for searching the highly cited articles.

Science category of Information Science and Library Science. This is not the first paper which analyses highly cited articles in IS&LS. Blessinger and Hrycaj (2010) analysed 32 highly cited articles in IS&LS published in the latter part of the 20th century. Journal and researcher distributions and major subject themes of these articles were discussed and compared to other articles published in IS&LS during the same time period. Levitt and Thelwall (2009) analysed the 82 most highly cited IS&LS articles (the top 0.1%) published prior to 2007 in the Web of Science. That research analysed the disciplinarity of those articles and concluded that the relative frequency of citation of these 82 articles was much lower for articles solely in IS&LS than for those in IS&LS and at least one other subject, suggesting that the promotion of interdisciplinary research in IS&LS may be conducive to improving research quality. Also, Levitt and Thelwall analysed first author citation profiles and concluded that two-thirds of the first authors had an h-index in IS&LS of less than eight, showing that much significant research is produced by researchers without a high overall IS&LS research productivity. Moreover, they researched annual citation patterns and concluded there is a moderate correlation (0.46) between citation ranking and the number of years between peak year and year of publication, indicating that high quality ideas and methods in IS&LS often are deployed many years after being published.

Prior to the current paper, a few bibliometric analyses of highly cited papers in IS&LS was published, but unlike the research presented in this paper, they used different methodologies and bibliometric indicators and did not provide deep insight into the features of contribution. The current paper considers distributions of highly cited articles by publication year, journals, authors, source institutions, and countries. The presented analysis used indicators such as the Y-index which provides deep insight into the features of contribution. The construction of the Y-index with two parameters (j , h), is an attempt to assess both the publication quantity and characteristics of contribution as a single index. Also, we used a bibliometric indicator TC_{2012} which is an invariant parameter, thus ensuring repeatability, in comparison with the index of citation from Web of Science which has been updated from time to time.

Methodology

The analysis provided in this study is based on the Social Science Citation Index (SSCI) database of Web of Science from Thomson Reuters (updated on 26 June 2013). According to Journal Citation Reports (JCR) of 2012, it indexes 3016 journals with citation references across 56 scientific disciplines in the social science edition. There are 84 journals listed in the category of IS&LS in JCR in 2012. The schematic for searching top articles is shown in Fig. 1. A total of 7,391,395 documents from 1900 to 2012 were found in SSCI. Results were refined by selecting the Web of Science category of IS&LS (337,722 documents). $TC_{2012} \geq 100$ was used as a filter to extract highly cited documents (593 documents). TC_{2012} denotes the total citations since publication of the article until the end of 2012 (Chuang et al., 2011; Wang et al., 2011a). The advantage of this indicator is that it is an invariant parameter, thus ensuring repeatability, in comparison with the index of citation from Web of Science which has been updated from periodically (Fu et al., 2012). Therefore, 0.18% of the total documents published in the Web of Science category of IS&LS are regarded as highly cited papers including articles (501; 84%), reviews (77; 13%), proceedings papers (29; 4.9%), editorial materials (7; 1.2%), notes (6; 1.0%), and letters (2; 0.34%). The 501 articles having $TC_{2012} \geq 100$ were retrieved as highly cited articles for further analysis.

We chose articles for analysis because articles contain a description of complete research and results (Ho et al., 2010). Data about those articles and the total annual citations for each article were downloaded. All results were analysed using Microsoft Excel 2007. In subsequent analysis, articles originating from England, Scotland, Northern Ireland, and Wales were classified as being from the United Kingdom (UK). Articles from Hong Kong before 1997 were classified as being from China. Moreover, articles published in *Journal of the American Society for Information Science*, *American Documentation*, and *Journal of the American Society for Information Science and Technology*; *Information Storage and Retrieval* and *Information Processing and Management*; and *Bulletin of the Medical Library Association* and *Journal of the Medical Library Association*; and *International Journal of*

Geographical Information Systems and *International Journal of Geographical Information Science* were classified as being published in *Journal of the American Society for Information Science and Technology*, because those titles are previous titles of the same journal (<http://www.asis.org/jasist.html>); *Information Processing and Management* (<http://www.sciencedirect.com/science/journal/03064573>); *Journal of the Medical Library Association* (<http://www.journals4free.com/link.jsp?l=8210055>); and *International Journal of Geographical Information Science* (<http://www.tandfonline.com/loi/tgis20#.UhYBzNjKpEc>) respectively. For the same reason articles published in *Canadian Journal of Information Science – Revue Canadienne des Sciences de l'Information* and *Online Review* were classified as being published in *Canadian Journal of Information and Library Science – Revue Canadienne des Sciences de l'Information et des Bibliotheconomie* (<http://www.cais-acsi.ca/journal/journal.htm>) and *Online Information Review* (<http://www.emerald-insight.com/products/journals/journals.htm?id=oir>) respectively.

The contributions from institutions and countries were identified by the appearance of at least one author in the publications. Collaboration type was determined from the addresses of the authors. The articles were classified into five types based on the country and institution (Han and Ho, 2011):

1. 'single country article', if the researchers' addresses were from the same country; 'single institution article', if the researchers' addresses were from the same institution;
2. 'internationally collaborative article', if the articles were coauthored by researchers from multiple countries (Chiu and Ho, 2005); 'inter-institutionally collaborative article', if authors were from different institutions;
3. 'first author article', if the first author's address was from the certain country or institution for analysis;
4. 'corresponding author article', if the corresponding author's address was from the certain country or institution for analysis; and
5. 'single author article', if the article has only one author and the author was from the certain country or institution for analysis. *TP*, *IP*, *CP*, *FP*, *RP*, and *SP* are the number of total articles, 'single country articles' or 'single institution articles', 'internationally collaborative articles' or 'inter-institutionally collaborative articles', 'first author articles', 'corresponding author articles', and 'single author article', respectively.

The classifications 'first author articles', 'corresponding author articles' and 'single author articles' provide

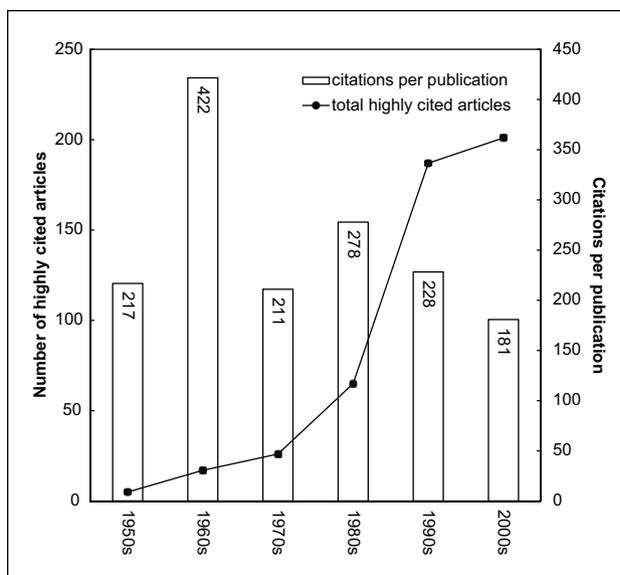


Figure 2. Number of articles and citation per publications by decade.

deep insight into the features of contribution. Original research papers with one author are increasingly rare; usually there are many contributors to research and associated published outputs, but very often it is not easy to tell who did what. There has been some attempt to create contributor-role taxonomy that researchers could use when thinking about submitting a paper for publication, to complement or even replace an authors' list (Allen et al., 2014). Unfortunately, this has not been widely adopted and in the Thompson Reuters Web of Science citation base we just have list of authors and usually information about who is the corresponding author. The corresponding author is labelled as 'reprint author'; however, the research shown in this paper uses the term 'corresponding author'. The first author, corresponding author and single author are not mutually exclusive classifications. In single author articles where authorship is unspecified, the single author is classified as the first author and as corresponding author. Analogous to this, in single institution articles, the single institution is classified as the first author institution and as the corresponding author institution.

Results and discussion

Publication year

A total of 501 highly cited articles ($TC_{2012} \geq 100$) were published in the Web of Science category of IS&LS in SSCI. The articles were published between 1956 and 2009. Minimal value of TC_{2012} is 100, maximal is 3681, and average is 221. Figure 2 illustrates the distribution of these 501 highly cited articles over the decades, and their citations per publication (CPP). No highly cited articles have

yet emerged in the most recent three years (2010–2012). It has been pointed out that recent articles need time to accumulate citations (Picknett and Davis, 1999). A similar result was also found in the top-cited articles in chemical engineering in SCI-Expanded (Ho, 2012) and classic articles on the social work field in SSCI (Ho, 2013a). Five of the highly cited articles were published in the 1950s, while 37% and 40% of the highly cited articles appeared in the 1990s and the 2000s, respectively. The number of highly cited articles increased rapidly from five articles in the 1950s to 201 articles in the 2000s. The increase in highly cited articles might be based on the striking growth in the number of journals, papers, and contributing authors in the library and information science field (Larivière et al., 2012). In particular, the decade of the 1960s with 17 articles had much higher *CPP* (422) which can be attributed to the articles entitled ‘Visual pattern recognition by moment invariants’ by Hu (1962) with $TC_{2012} = 2338$ and ‘Low-density parity-check codes’ by Gallager (1962) with $TC_{2012} = 1568$. The *CPPs* of the other four decades ranged from 181 to 278. The three earliest highly cited articles in the IS&LS category were all published in 1956 in *IRE Transactions on Information Theory* which was not listed in SSCI after 1962. The most recent highly cited article entitled ‘A global map of science based on the ISI subject categories’ (Leydesdorff and Rafols, 2009) was published in 2009 in *Journal of the American Society for Information Science and Technology* with $TC_{2012} = 110$.

Category and journal

A total of 501 articles were published in the category of IS&LS according to our method, and there were another 11 categories which also hold journals listed in the IS&LS category. These 11 categories are computer science – information systems (376 articles; 75% of the total articles; 1956 – the first publication year of a highly cited article); management (232 articles; 46%; 1981), computer science – interdisciplinary applications (78 articles; 16%; 1979), medical informatics (48 articles; 10%; 1994), geography (21 articles; 4.2%; 1991), interdisciplinary social sciences (10 articles; 2.0%; 1974), physical geography (10 articles; 2.0%; 1997), communications (five articles; 1.0%; 1997), computer science – artificial intelligence (one article; 0.20%; 1993), telecommunications (one article; 0.20%; 2003). Computer science, medicine, psychology, the social sciences, and general sciences have also been observed to contribute a significant number of citations to the IS&LS field (Meyer and Spencer, 1996). Apart from the IS&LS category, three computer science-related categories took an overwhelming majority of 81% of the total articles. Furthermore, two major structural shifts in library and information science are revealed in the data of total articles. In 1960, library and information science changed from a professional field focused on librarianship to an

academic field focused on information and use; and in 1990, library and information science began to receive a growing number of citations from outside the field, notably from computer science and management (Larivière et al., 2012).

The highly cited articles were published by 37 journals in the Web of Science category of IS&LS. Four of the 37 journals were not listed in the category of IS&LS in 2012 including *IRE Transactions on Information Theory* with 16 articles; *Drexel Library Quarterly* with two articles; and one in each of *Knowledge Acquisition* and *RQ* respectively. The journal *IRE Transactions on Information Theory* changed title to *IEEE Transactions on Information Theory* in 1963 and this journal has a high impact factor for 2012, $IF_{2012} = 2.621$, but the journal is not in the IS&LS category anymore. The journal is indexed in Science Citation Index Expanded in the categories of computer science, information systems and electrical & electronic engineering. The impact factor for the certain year is defined by JCR as the number of citations in that year of all papers published in the previous two years divided by the total number of papers published in those years, i.e. IF_{2012} is the number of citations in 2012 of all papers published in 2010 and 2011 divided by the total number of papers published in those two years. The journal *Drexel Library Quarterly* ceased in 1986. *Knowledge Acquisition* was incorporated into *International Journal of Human-Computer Studies* in 1995 and this journal also has a high impact factor, $IF_{2012} = 1.415$, but it is indexed in the categories of cybernetics computer science, ergonomics, and multidisciplinary psychology. The journal *RQ* changed title to *Reference & User Services Quarterly* in 1998 and this journal is not listed in Web of Science in 2012.

Of the 501 highly cited articles 20 (4.0%) were published in four previously mentioned journals which are not listed in the category of IS&LS in 2012. The category of IS&LS contains 84 journals in 2012 and IF_{2012} of those journals ranged from 0.050 for *Library and Information Science* to 4.659 for *MIS Quarterly*. Beside *MIS Quarterly*, there is only one journal with $IF_{2012} > 4$ – *Journal of Informetrics*. It was found that 32 journals had impact factors between 1 and 4, and 50 journals had impact factors below one. Table 1 shows the distribution of highly cited articles by journals listed in the category of IS&LS in 2012. Of 84 journals in the category of IS&LS 33 (39%) had at least one highly cited article. *MIS Quarterly* published the most highly cited articles with 132 articles (26% of 501 articles), followed by *Journal of the American Society for Information Science and Technology* with 55 articles, *Journal of the American Medical Informatics Association* with 48 articles, and *Information Systems Research* with 44 articles, while their IF_{2012} are 4.659 (rank 1st of 84 journals), 2.005 (10/84), 3.571 (3/84), and 2.010 (9/84) respectively. The top 10 journals by value of IF_{2012} published 314 highly cited articles (63%), the

Table 1. Characteristics of 33 journals in category of IS&LS in 2012.

Journal	TP (%)	IF2012 (rank)
MIS Quarterly	132 (26)	4.659 (1)
Journal of the American Society for Information Science and Technology	55 (11)	2.005 (10)
Journal of the American Medical Informatics Association	48 (10)	3.571 (3)
Information Systems Research	44 (8.8)	2.010 (9)
Information and Management	36 (7.2)	1.663 (15)
Scientometrics	29 (5.8)	2.133 (7)
International Journal of Geographical Information Science	21 (4.2)	1.613 (16)
Information Processing and Management	21 (4.2)	0.817 (41)
Journal of Documentation	20 (4.0)	1.138 (29)
Journal of Management Information Systems	17 (3.4)	1.262 (25)
Social Science Information Sur Les Sciences Sociales	9 (1.8)	0.167 (75)
Journal of Strategic Information Systems	6 (1.2)	1.500 (19)
Journal of the Medical Library Association	5 (1.0)	0.976 (35)
European Journal of Information Systems	4 (0.80)	1.558 (18)
Information Society	4 (0.80)	1.114 (30)
Journal of Information Technology	3 (0.60)	3.532 (4)
Journal of Health Communication	3 (0.60)	2.079 (8)
Information Systems Journal	3 (0.60)	1.381 (22)
Journal of Information Science	3 (0.60)	1.238 (26)
College and Research Libraries	3 (0.60)	1.016 (34)
Journal of the Association for Information Systems	2 (0.40)	1.048 (33)
Library Quarterly	2 (0.40)	0.743 (43)
Government Information Quarterly	1 (0.20)	1.910 (11)
International Journal of Information Management	1 (0.20)	1.843 (12)
Journal of Computer-Mediated Communication	1 (0.20)	1.778 (13)
Telecommunications Policy	1 (0.20)	1.594 (17)
Library and Information Science Research	1 (0.20)	1.400 (21)
Social Science Computer Review	1 (0.20)	1.303 (24)
Online Information Review	1 (0.20)	0.939 (37)
Health Information and Libraries Journal	1 (0.20)	0.662 (45)
Program-Automated Library and Information Systems	1 (0.20)	0.377 (61)
Data Base for Advances in Information Systems	1 (0.20)	0.341 (65)
Canadian Journal of Information and Library Science - Revue Canadienne des Sciences de l'Information et des Bibliotheconomie	1 (0.20)	0.171 (74)

TP: total number of highly cited articles; IF2012: impact factor for 2012.

journals in the first half by value of *IF2012* (the top 42 journals) published 466 highly cited articles (93%), and the journals in the second half published just 15 highly cited articles (3.0%). As expected, a high percentage of the highly cited articles were published in journals with high *IF2012*, similar to the subject area of anesthetics (Baltussen and Kindler, 2004). The leading journals attracted the classic publications, which in turn maintained the high impact factor of these journals (Schein et al., 2000). Highly cited articles in IS&LS category could also be found in journals with lower *IF2012* such as *Social Science Information sur les Sciences Sociales* (rank 75th, *IF2012* = 0.167) which published nine highly cited articles and *Canadian Journal of Information and Library Science – Revue Canadienne des Sciences de l'Information et des Bibliotheconomie* (rank 74th, *IF2012* = 0.171) which published one article. However, three of the top 10 journals by value of *IF2012*,

such as *Journal of Informetrics* (rank 2nd, *IF2012* = 4.153), *Information Technology & Management* (rank 5th, *IF2012* = 3.025), and *Annual Review of Information Science and Technology* (rank 6th, *IF2012* = 2.174), had no highly cited articles.

Authors and publication characteristics of authors

Bibliometric indicators such as total number of articles, independent articles, collaborative articles, single author articles, first author articles, and corresponding author articles were recently applied to evaluate the publications of authors, institutions, and countries (Fu et al., 2013). Table 2 shows the most productive authors who published five or more highly cited articles. Bates, DW published 11 highly cited articles including four first author, six corresponding

Table 2. Fourteen highly productive authors of five or more highly cited articles.

Author	Institution	Rank (TP)	Rank (FP)	Rank (RP)	Rank (SP)	h	Rank (j)
Bates, DW	Harvard University, USA	1 (11)	5 (4)	1 (6)	N/A	0.9828	2 (10)
Benbasat, I	University of British Columbia, Canada	2 (10)	5 (4)	5 (4)	N/A	0.7854	5 (8)
Straub, DW	Georgia State University, USA	3 (8)	11 (3)	10 (3)	5 (2)	0.7854	10 (6)
Ash, JS	Oregon Health and Science University, USA	4 (7)	1 (5)	1 (6)	N/A	0.8761	1 (11)
Zmud, RW	University of North Carolina, USA	5 (6)	N/A	N/A	N/A	N/A	363 (0)
Kuperman, GJ	Partners Healthcare System, USA	5 (6)	74 (1)	67 (1)	N/A	0.7854	68 (2)
Saracevic, T	Rutgers State University, USA	5 (6)	5 (4)	5 (4)	18 (1)	0.7854	5 (8)
Kraemer, KL	Carolina of California, Irvine, USA	8 (5)	N/A	N/A	N/A	N/A	363 (0)
Wetherbe, JC	University of Minnesota, USA	8 (5)	N/A	N/A	N/A	N/A	363 (0)
Agarwal, R	University of Maryland, USA	8 (5)	5 (4)	5 (4)	N/A	0.7854	5 (8)
Salton, G	Cornell University, USA	8 (5)	1 (5)	22 (2)	N/A	0.7854	23 (4)
Sambamurthy, V	University of Maryland, USA	8 (5)	74 (1)	67 (1)	N/A	0.7854	68 (2)
Small, H	Institute of Information Science, USA	8 (5)	1 (5)	3 (5)	5 (2)	0.7854	2 (10)
Zhu, K	University of California, Irvine, USA	8 (5)	1 (5)	3 (5)	18 (1)	0.7854	2 (10)

TP: total highly cited articles; FP: first author highly cited articles, RP: corresponding author highly cited articles; SP: single author highly cited articles; h and j: parameters of Y-index; N/A: not available.

author (including four articles published as both first and corresponding author), and no single author articles, followed by Benbasat, I from University of British Columbia, Canada. Benbasat is the only author not from the USA in Table 2. The authorship list can be based on contribution, alphabetical order, or reverse seniority, but the approach most often used is ordering by contribution, especially for articles with few authors (Tscharntke et al., 2007). The first author has actually made the most contribution, and should receive a greater proportion of the credit (Riesenberg and Lundberg, 1990; Marušić et al., 2004). The first place by FP is taken by Ash, JS; Salton, G; Small, H; and Zhu, K with $FP = 5$. The corresponding author supervised the planning and execution of the study and the writing of the paper (Burman, 1982). At the institutional level, the institution of the corresponding author might be the home base of a study or origin of the paper (Ho, 2013b). Bates, DW and Ash, JS take the first place by RP ($RP = 6$), followed by Small, H and Zhu, K ($RP = 5$). Bates, MJ published the most single author highly cited articles (4). However, only four of the 14 authors listed in Table 2 published at least one single author highly cited article.

Although a popular indicator, *h*-index (Hirsch, 2005), has never been used to rank influential British researchers in information science and librarianship (Oppenheim, 2007) because of its perceived limitations. The *h*-index may undervalue the performance of unit with an intermediate productivity level but a high impact and a great international visibility (Costas and Bordons, 2007). Collaborative authorship is now the norm, a pattern seen across the social sciences (Larivière et al., 2012). In an era of increasing multiple-authorship when the contribution of authors is diluted, further study was concentrated on only

the first and corresponding author publications. The Y-index (j, h) is related to numbers of first author publications (FP) and corresponding author publications (RP), and might be applied to evaluate authors, institutions and countries, as defined (Ho, 2013a):

$$j = FP + RP \quad (1)$$

$$h = \tan^{-1} \left(\frac{RP}{FP} \right) \quad (2)$$

where, j is publication performance, which is a constant related to publication quantity, and h is publication characteristics, which can describe the proportion of RP to FP. j is the sum of FP and RP. The greater j is, the more contribution the analysed unit makes. Different values of h stand for different proportions of RP to FP. $h > 0.7854$ means more RP; $h = 0.7854$ means the same quantity of FP and RP; $0 < h < 0.7854$ means more FP. When $h = 0$, $j =$ number of first author articles and when $h = \pi/2$, $j =$ number of corresponding author articles.

The fact that only articles with both first author and corresponding author information could be considered is a limitation of this indicator. In SSCI database, the corresponding author is labelled as the 'reprint author', and this study uses the term 'corresponding author'. In a single author article where authorship is not specified, the single author is classified as the first author and the corresponding author. Figure 3 shows the top 67 authors by value of the j parameter of Y-index ($j \geq 3$) ($j \cos h$ and $j \sin h$ are chosen as the x and y coordinate axes). Distance of point from coordinate beginning is directly proportional to the

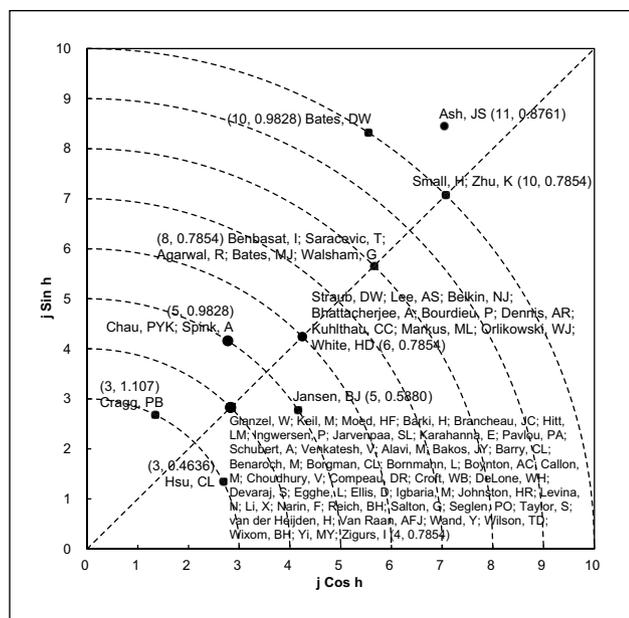


Figure 3. Top 67 authors with Y-index ($j \geq 3$).

value of Y-index j parameter of a certain author. The parameter j is proportional to the total number of first and corresponding author articles, and parameter h differentiates the nature of the leadership role: first or corresponding author role. If the point of the author is above (below) the line $y = x$, value of Y-index h parameter is greater (smaller) than 0.7854, number of highly cited articles where the certain author is the first author is lower (higher) than number of highly cited articles where the author is corresponding author. The highest values of j parameter of Y-index have researchers such as Ash, JS ($n = 11$); Bates, DW ($n = 10$); Small, H ($n = 10$); and Zhu, K ($n = 10$). Points which represent researchers Ash, JS with $h = 0.8761$ and Bates, DW with $h = 0.9828$ are above the line $y = x$ ($h = 0.7854$) which means those researchers have more corresponding author highly cited articles than first author highly cited articles. The advantages of the Y-index are presented in the figure. The distribution of authors by Y-index clearly shows that when one had larger j , it could be found one's Y-index located far away from original of the polar coordinates, that means the author published more first and corresponding author papers; when one had larger h it could be found one's Y-index closed to y -axis, that means the author published more corresponding author articles than first author articles. For example, the j of Bates, DW; Small, H; and Zhu, K are all the same of 10. However h of Bates is 0.9828 but h of Small and Zhu are both the same of 0.7854. Bates has a greater proportion of corresponding author articles to first author articles than Small and Zhu who published the same number of first and corresponding author articles ($h = 0.7854$). In addition, Jansen, BJ and Hsu, CL are the only authors who

published more first author articles than corresponding author articles.

Institutions and countries

Table 3 shows the most productive institutions; those from which authors published 10 or more highly cited articles. All the institutions are located in USA and Canada. Harvard University, USA takes the first place by number of published articles ($n = 22$) and inter-institutionally collaborative articles ($n = 21$), but the University of Maryland, USA takes the first place by number of the first author highly cited articles ($n = 11$) and corresponding author highly cited articles ($n = 10$), followed by Indiana University, USA (nine first author and eight corresponding author articles). University of Maryland and Indiana University also take the first two places by value of j parameter of Y-index. Brigham and Women's Hospital, USA had no single institute articles, Harvard University and University Georgia, USA had only one single institute article. University of California in Irvine, USA published the most single institute articles ($n = 7$). In addition, almost all institutions published the same number of first and corresponding author articles with $h = 0.7854$.

All the countries which published highly cited articles in the category of IS&LS are listed in Table 4. The USA convincingly takes the first place by all shown indicators. Researchers from the USA contributed 337 of the 501 highly cited articles (71%), followed distantly by Canada by total number of highly cited articles ($n = 49$) and the UK whose researchers published six articles less ($n = 43$). University of British Columbia, University of Western Ontario, and Queens University in Canada contributed most of Canada's highly cited articles as they ranked in the top 10 institutions. The UK published more first author articles as well as inter-institutional collaborative articles and single author articles. The UK and Canada have the same value of j parameter of Y-index (66) and share the second place by this parameter. According to the bibliometric indicators shown in Table 4, the publication of highly cited articles in the category of IS&LS is similar for the UK and Canada, but publication characteristics differ.

Citation life cycles of highly cited articles

Citation life cycles of highly cited articles have had much importance attached to them (Aversa, 1985). The citation history of papers gives more details of the impact of the characteristics of articles (Aksnes, 2003; Wang et al., 2011b). In recent years more research concerning the citation life cycles of highly cited articles have been published (Fu et al., 2012; Ho, 2013a). Figure 4 shows the citation life cycles of the top six articles with the highest TC_{2012} . TC_{2012} denotes the total citations since publication of the article up to the end of 2012. The article entitled 'Perceived

Table 3. Characteristics of the 13 most productive institutions ($TP \geq 10$).

Institution	Rank (TP)	Rank (IP)	Rank (CP)	Rank (FP)	Rank (RP)	Rank (SP)	h	Rank (j)
Harvard University, USA	1 (22)	48 (1)	1 (21)	51 (2)	49 (2)	30 (1)	0.7854	49 (4)
University of Minnesota, USA	2 (17)	8 (4)	3 (13)	10 (6)	9 (6)	3 (3)	0.7854	9 (12)
Georgia State University, USA	2 (17)	13 (3)	2 (14)	6 (7)	5 (7)	11 (2)	0.7854	5 (14)
University of Maryland, USA	4 (15)	5 (5)	5 (10)	1 (11)	1 (10)	3 (3)	0.7854	1 (20)
University of British Columbia, Canada	5 (12)	13 (3)	6 (9)	3 (8)	2 (8)	N/A	0.7854	2 (16)
Brigham and Women's Hospital, USA	5 (12)	N/A	4 (12)	6 (7)	5 (7)	N/A	0.7854	5 (14)
Indiana University, USA	7 (11)	2 (6)	21 (5)	2 (9)	2 (8)	3 (3)	0.7854	2 (16)
Rutgers State University, USA	7 (11)	8 (4)	11 (7)	6 (7)	5 (7)	3 (3)	0.7854	5 (14)
University of Texas, USA	7 (11)	24 (2)	6 (9)	3 (8)	5 (7)	11 (2)	0.7854	5 (14)
Drexel University, USA	10 (10)	8 (4)	15 (6)	17 (5)	16 (5)	11 (2)	0.7854	16 (10)
University of Western Ontario, Canada	10 (10)	13 (3)	11 (7)	21 (4)	20 (4)	30 (1)	0.7854	20 (8)
Queens University, Canada	10 (10)	24 (2)	10 (8)	10 (6)	9 (6)	N/A	0.7854	9 (12)
University of Georgia, USA	10 (10)	48 (1)	6 (9)	10 (6)	9 (6)	30 (1)	0.7854	9 (12)

TP: total highly cited articles; IP: single institution highly cited articles, CP: inter-institutionally collaborative highly cited articles; FP: first author highly cited articles, RP: corresponding author highly cited articles; SP: single author highly cited articles; h and j: parameters of Y-index; N/A: not available.

usefulness, perceived ease of use, and user acceptance of information technology' (Davis, 1989) has the highest value of TC_{2012} (3681). This article was the most cited in 2012 in IS&LS category ($C_{2012} = 422$).

The article entitled 'User acceptance of information technology: Toward a unified view' (Venkatesh et al., 2003) takes the second place by number of citation in 2012 and both these papers were published in the most productive journal *MIS Quarterly*. The articles 'A translation approach to portable ontology specifications' (Gruber, 1993) and 'Visual pattern recognition by moment invariants' (Hu, 1962) were published in journals not listed in category of IS&LS in 2012, *Knowledge Acquisition* and *IRE Transactions on Information Theory*. Moreover, the article by Hu is the only highly cited article published in the journal *Knowledge Acquisition*. The article entitled 'An algorithm for suffix stripping' (Porter, 1980) was also the only highly cited article published in the journal *Program: Electronic Library and Information Systems*. This paper presents probably the most famous stemming algorithm for English developed for the needs of information retrieval. Information retrieval has changed considerably since the last years of 20th century with the expansion of the World Wide Web (WWW) and with the advent of modern graphical user interface and mass storage devices (Baeza-Yates and Ribeiro-Neto, 1999). The ability to search and retrieve information from the WWW is necessary for realizing its full potential (Gudivada et al., 1997). WWW search has become a standard and often preferred source of information finding (Manning et al., 2008). These facts are the reason for the sudden increase in citations for Porter's article at the end of 20th century and start of 21st century. Moreover, Porter's article is probably not as highly cited as it could be because Porter's stemmer became so accepted and in common use that its creator is no longer cited. According to the citation life cycles,

curves and publication years of six articles shown in Figure 4, the article published by Venkatesh and colleagues (2003) might become the highest impact article in IS&LS category in the future.

Conclusions

The application of quantitative techniques in the analysis of highly cited articles can improve our understanding of the directions in IS&LS field. Highly cited articles with $TC_{2012} \geq 100$ in the IS&LS category in Social Science Citation Index were distributed over 54 years from 1956 to 2009. The average citation of those articles is 221, while the most cited article has 3681 citations since publication up to the end of 2012. Nearly four-fifths of the highly cited articles appeared in the last decade of the 1990s and first decade of the 2000s. The increase in highly cited articles is consistent with the striking growth rate of all papers in IS&LS field from 1900–2010 (Larivière et al., 2012). The highly cited articles were published by 37 journals and the most productive journal was *MIS Quarterly* (132 highly cited articles). Due to the SSCI database in Web of Science, other important journals in IS&LS might be missed on the condition of the search pattern. Furthermore, pronounced activities in computer science were observed, which is also in line with IS&LS's overall pattern, increasingly citing research in computer science, medicine, psychology, the social sciences, and general sciences 1972–1994 (Meyer and Spencer, 1996), receiving a growing number of citations from outside the field, notably from computer science and management since 1990 (Larivière et al., 2012).

Y-index (j, h) as a newly developed indicator which was recently proposed by Ho (2012, 2013b), is useful for the evaluation both the publication quantity and character of contributing authors, institutions, and countries of IS&LS

Table 4. Characteristics of the all contributing countries.

Country	Rank (TP)	Rank (IP)	Rank (CP)	Rank (FP)	Rank (RP)	Rank (SP)	rank (j)
USA	1 (337)	1 (283)	1 (54)	1 (314)	1 (294)	1 (75)	1 (588)
Canada	2 (49)	3 (25)	2 (24)	3 (34)	2 (33)	4 (4)	2 (66)
UK	3 (43)	2 (30)	3 (13)	2 (36)	2 (33)	2 (22)	2 (66)
Netherlands	4 (24)	4 (15)	4 (9)	4 (17)	4 (17)	3 (9)	4 (34)
China	5 (14)	5 (7)	5 (7)	5 (10)	5 (10)	7 (2)	5 (20)
Australia	6 (13)	5 (7)	6 (6)	5 (10)	5 (10)	7 (2)	5 (20)
Taiwan	7 (7)	5 (7)	N/A	7 (7)	7 (7)	7 (2)	7 (14)
Singapore	8 (6)	N/A	6 (6)	13 (3)	13 (3)	N/A	13 (6)
France	8 (6)	8 (6)	N/A	8 (6)	8 (6)	4 (4)	8 (12)
South Korea	8 (6)	11 (3)	9 (3)	11 (4)	10 (4)	N/A	10 (8)
Denmark	11 (5)	9 (4)	15 (1)	9 (5)	10 (4)	6 (3)	10 (8)
Switzerland	11 (5)	9 (4)	15 (1)	11 (4)	10 (4)	11 (1)	10 (8)
Hungary	11 (5)	12 (2)	9 (3)	9 (5)	9 (5)	11 (1)	9 (10)
New Zealand	11 (5)	17 (1)	8 (4)	13 (3)	13 (3)	11 (1)	13 (6)
Finland	11 (5)	12 (2)	9 (3)	13 (3)	15 (2)	11 (1)	15 (4)
Belgium	16 (4)	12 (2)	13 (2)	16 (2)	15 (2)	11 (1)	15 (4)
Israel	16 (4)	12 (2)	13 (2)	16 (2)	15 (2)	11 (1)	15 (4)
Norway	18 (3)	12 (2)	15 (1)	16 (2)	15 (2)	7 (2)	15 (4)
Germany	18 (3)	N/A	9 (3)	N/A	N/A	11 (1)	26 (0)
Sweden	20 (2)	17 (1)	15 (1)	16 (2)	15 (2)	N/A	15 (4)
Austria	20 (2)	17 (1)	15 (1)	20 (1)	20 (1)	N/A	20 (2)
Kuwait	22 (1)	N/A	15 (1)	20 (1)	20 (1)	N/A	20 (2)
Spain	22 (1)	N/A	15 (1)	N/A	N/A	N/A	26 (0)
Poland	22 (1)	N/A	15 (1)	N/A	N/A	N/A	26 (0)
Ireland	22 (1)	17 (1)	N/A	20 (1)	20 (1)	11 (1)	20 (2)
Cyprus	22 (1)	N/A	15 (1)	20 (1)	20 (1)	N/A	20 (2)
Slovakia	22 (1)	N/A	15 (1)	N/A	N/A	N/A	26 (0)
Italy	22 (1)	N/A	15 (1)	N/A	N/A	N/A	26 (0)
Portugal	22 (1)	N/A	15 (1)	20 (1)	20 (1)	N/A	20 (2)
Brazil	22 (1)	17 (1)	N/A	20 (1)	20 (1)	N/A	20 (2)
India	22 (1)	N/A	15 (1)	20 (1)	N/A	N/A	N/A

TP: total highly cited articles; IP: single country highly cited articles, CP: internationally collaborative highly cited articles; FP: first author highly cited articles, RP: corresponding author highly cited articles; SP: single author highly cited articles; *h* and *j*: parameters of Y-index; N/A: not available.

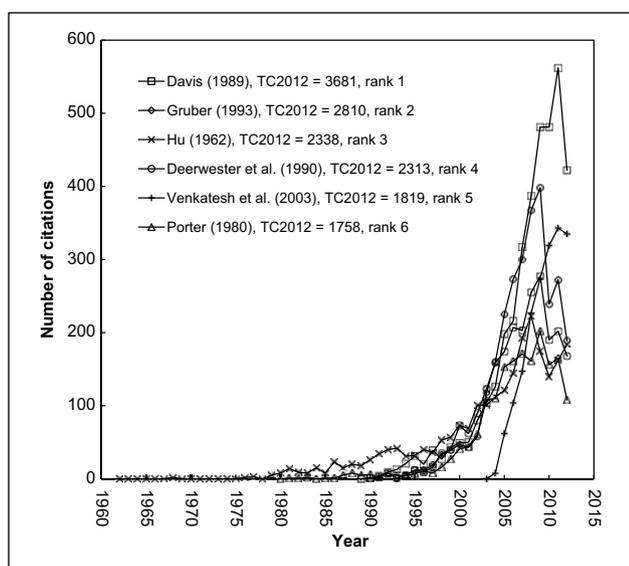


Figure 4. Citation life cycles of the top six articles ($TC_{2012} \geq 1,750$).

field. Bates, DW is the most productive author in the IS&LS category while Ash, JS has highest publication performance of first and corresponding author articles. Harvard University, USA is the most productive institution, ranked top in the total number of highly cited articles, while University of Maryland, USA has the highest publication performance of first and corresponding author articles. Researchers from the USA took the lead, with a majority of more than two-thirds, followed by researchers from Canada, the UK, and the Netherlands. According to the Y-index, the number of first author publications are almost the same as the number of corresponding author publications for institutions and countries. This outcome on a large sample was also observed in previous studies, such as highly cited articles in the chemical engineering field (Ho, 2012), and highly cited articles in the adsorption field (Fu and Ho, 2014). The Y-index provides another appropriate choice and could be adapted for the evaluation of authors, institutions and countries in a wider range of different subject areas.

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Author biographies

Dragan Ivanović has worked at the Department of Computing and Automatics, Faculty of Technical Sciences, Novi Sad in the position of Assistant Professor since 2010. Dr Ivanović received his Masters degree in 2006 and PhD degree in 2010 in the field of Computer Science from the University of Novi Sad, Faculty of Technical Sciences. He holds a teaching seminar on the subject of digital archives at the Department of Computing and Automatics. He has published more than 25 scientific papers. He can be contacted at: dragan.ivanovic@uns.ac.rs

Yuh-Shan Ho received his PhD (1995) from the University of Birmingham, UK. He is the Director of the Trend Research Centre at Asia University in Taiwan. He has had 30 of his papers cited more than 100 times, one of them more than 2800 times. This paper is the only article with more than 400 and 500 annual citations, and it has been ranked top one in annual citations in the field of chemical engineering since 2008. His research interests are adsorption process for water treatment and bibliometric studies.