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**DOI**

[10.1016/j.csi.2015.02.008](https://doi.org/10.1016/j.csi.2015.02.008)

**Publication date**

2015

**Document Version**

Final published version

**Published in**

Computer Standards and Interfaces

**Citation (APA)**

van de Kaa, G., Vries, H. J., & Baskaran, B. (2015). Citation analysis of computer standards & interfaces: technical or also non-technical focus? *Computer Standards and Interfaces*, 41, 67-71.  
<https://doi.org/10.1016/j.csi.2015.02.008>

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# Citation analysis of Computer Standards & Interfaces: Technical or also non-technical focus?



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## ARTICLE INFO

### Article history:

Received 22 April 2014

Accepted 8 February 2015

Available online 23 February 2015

### Keywords:

Computer Standards & Interfaces

Citation analysis

Standardization research

Journal scope

## ABSTRACT

This paper analyzes to which extent research published in Computer Standards & Interfaces (CSI) has a technical focus. We find that CSI has been following its scope very closely in the last three years and that the majority of its publications have a technical focus. Articles published in CSI constantly cite research from various technical disciplines, but there are also a limited number of references to non-technical literature. Mostly technical journals cite CSI papers, with a few exceptions of non-technical journals. We conclude that CSI stays within its scope of computer standards and interfaces interpreted in a technical sense.

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## 1. Introduction

Computer Standards & Interfaces (CSI) is an international bimonthly journal that provides a platform for publishing research work in the areas of Standards, Information Management, Formal Methods, Software Quality, Software Process, Distributed Systems, Open Systems, E-Topics, Data Acquisition and Digital Instruments Standardization. This scope suggests that the journal has a technical focus, but also covers more general topics such as technical, social, and political aspects of computer standards, market impacts, cost benefit analysis, and relationships between national and international standard bodies. This paper investigates to what extent CSI is a technical journal by analyzing citations in the journal and references to the journal from between 2011 and 2013.

On its homepage, CSI states that the journal: *“provides information about activities and progress on the definition of computer standards, software quality, interfaces and methods, at national, European and international levels; publishes critical comments on standards and standards activities; disseminates user’s experiences and case studies in the application and exploitation of established or emerging standards, interfaces and methods; offers a forum for discussion on actual projects, standards, interfaces and methods by recognised experts; stimulates relevant research by providing a specialised refereed medium”* [1].

Thus, CSI aims to publish papers that are primarily related to computer and software standards and interfaces, and focuses on publishing

research within its specialized scope definition. Therefore, we would not expect articles to cite research from beyond the field of software, computer standards, and interfaces. Similarly, we would not expect articles which are outside the scope of software and computer standards to cite papers from CSI. However, the journal website adds: *CSI also covers general topics concerning the standardisation process, such as technical, political and commercial aspects of standards, their impact on the marketplace, cost/benefit analyses, legislative issues, and relationships among national and international standards bodies* [1]. Most of these topics are non-technical although they may relate to the technical contents of standards. Accordingly, we would expect non-technical papers to be included in the journal.

In this paper, we investigate the balance between technical and non-technical papers in the journal by performing a citation analysis of CSI from 2011 to 2013. We determine the number and types of journals that articles in CSI refer to and vice versa. This includes the journal’s primary field (the first field in the case more than one field is mentioned), the articles’ date of publication, and the name of the journal. We start with a brief introduction of the research field of computer standards and interfaces. Next, we describe our methodology, and then present our results. We conclude with a discussion of the results and the limitations of the analysis.

## 2. Computer standards and interfaces and its position in the field of research

Research on computer standards and interfaces is a subset of the broader domain of research on standards and standardization. De

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Vries [2] has mapped this field of research and the disciplines that study it – both mono-disciplines such as mathematics, physics, psychology and economics, and applied sciences such as engineering, business and medical science. Applied sciences may be related to the topic of standardization (in the case of CSI: software and computer standards or interfaces) or to standards-related activities such as standards development, standards acceptance, and standards implementation. These activities are non-technical and may be studied by other disciplines than those related to the technical contents of standards and interface specifications.

CSI addresses both software and hardware [1]. The term ‘interfaces’ is not defined explicitly but it is stated that hardware and software need well-defined interfaces. Once such interface definitions are intended and expected to be used repeatedly by the intended users, we can call them standards [5]. Standards for interfaces can be classified as compatibility standards [3,4]. CSI also addresses other software and computer-related standards such as quality standards. De Vries [5] shows that standards have in common that they provide criteria for entities because of their relations with other entities. In the case of CSI’s research field, at least one of these entities is computer hardware or software. Within this field, all categories of standards listed by De Vries [4] and Blind [3] apply.

CSI was founded 36 years ago and is by far the oldest standardization journal. Other scientific journals in the field of standardization include the International Journal of IT Standards and Standardization Research (JITSR), the International Journal of Services and Standards, the (Korean) Journal of Standards and Standardization (a new journal with only a few papers in English), and the Journal of ICT Standardization (a mixed scientific and professional journal, also new).

### 3. Methodology

We use Thomson Reuters Web of Science for our citation analysis. Web of Science consists of seven datasets containing information gathered from thousands of scholarly journals, books, book series, reports, conferences, and more. It has indexed journals from all over the world and from a broad variety of disciplines such as agricultural engineering, life sciences, economics, psychology, and computer science. Hence, the databases can be considered to be multidisciplinary. In our analysis, we use two databases: Science and Social Science. Both databases have indexed journals dating back to 1900 and have bibliographic information and citation data.

Not all the articles referenced in CSI are indexed in Web of Science. Moreover, books, conference and proceedings papers are excluded from this analysis. Table 1 lists the total number of references and citations, indexed or non-indexed in Web of Science.

Next, using Web of Science, we determined the discipline of each article and citation and added it to the database. If the journal of the article or citation belonged to more than one discipline, we included only the primary discipline. Thus, we had two databases, one comprising articles, based on their primary discipline, cited in CSI, and one comprising citations, based on their primary discipline, which refer to CSI, and which are indexed in Web of Science. Table 2 lists the datasets that were used to categorize the data.

We limited our analysis to the primary discipline, the source of the references, and the citations. The discipline and the source are sufficient

**Table 1**  
Number of references and citations in CSI articles: indexed and non-indexed in Web of Science.

CSI	2011	2012	2013	Overall
Number of references	1722	1415	2002	5139
Number of references indexed in Web of Science	459	446	387	1292
Number of citations	84	30	3	117
Total number of citations indexed in Web of Science	39	18	3	60

to track the interdisciplinary character of the journal. Table 3 shows the number of cited articles, the number of journals cited, and the number of primary disciplines that were cited. On average, each CSI article had 7.4 references.

Next we collected and categorized the keywords mentioned in each of the articles. We first categorized each keyword in the Science or Social Science category of Web of Science. Secondly, we divided the keywords in the Science and Social Science categories into sub-disciplines, which we identified from the journal’s mission statement [1]. Table 4 shows the list of sub-disciplines and the number of keywords in each sub-discipline. Keywords that could not be categorized into any of the sub-disciplines were categorized as ‘others’.

## 4. Results

### 4.1. Articles cited by CSI

#### 4.1.1. Primary discipline

Once the database was created, we ordered the database based on the number of articles indexed in a discipline, from highest to lowest. Table 5 lists the ten most cited primary disciplines by CSI articles. Out of the 1292 references, 781 references (about 60%) are from the first four most cited primary disciplines shown in Table 4.

If we look at the top ten most cited primary disciplines, only one of them belongs to the Social Science category of Web of Science, namely Business. Forty-five references are from this discipline and five of the disciplines are sub-disciplines of the category Computer Science. The top four most cited disciplines are the most cited for all three years – 2011, 2012, and 2013.

In total, 94 references belong to the Social Science category, and are from 17 primary disciplines (Supplementary material A). Table 6 lists of most cited primary disciplines. Fifty-seven references are from Business and Management disciplines, which account for approximately 61%. Psychology has the highest number of sub-disciplines that were cited.

By analyzing references and their primary disciplines, we observe that CSI focuses on citing articles in its own discipline or closely linked disciplines, which is shown by the number of sub-disciplines of Computer Science in the top ten most cited disciplines. However, CSI also refers to other Social Science disciplines such as Business and Management, which shows that CSI is, to a certain extent, interdisciplinary and sometimes refers to other, non-technical, disciplines.

#### 4.1.2. Source journal

In the next phase of our analysis, we categorized the references based on their source journal to assess the extent to which CSI is multidisciplinary. Table 7 lists the top ten most cited journals. Supporting the primary discipline results, the journals that were most frequently cited belong to the top four primary disciplines.

**Table 2**  
Datasets created to analyze research papers cited by CSI articles and those that cite CSI articles.

Dataset	Description
References_CSI	Research papers cited in CSI articles
Citations_CSI	Research papers that cite CSI articles
References_discipline	Research papers cited in CSI articles, categorized based on discipline
References_journal	Research papers cited in CSI articles, categorized based on journal
Citations_discipline	Research papers that cite CSI articles, categorized based on discipline
Citations_journal	Research papers that cite CSI articles, categorized based on journal

**Table 3**

Data from research papers cited in CSI articles.

CSI	2011	2012	2013
Number of cited articles	459	446	387
Number of journals cited	169	159	162
Number of primary disciplines cited	38	33	36

**Table 4**

Sub-disciplines of keywords in the Science and Social Science category of Web of Science.

Sub-disciplines	2011	2012	2013	Total
Standards, Information Management	26	24	26	76
Software Quality, Software Process	24	22	12	58
Distributed Systems, Open Systems, E-Topics	34	25	28	87
Data Acquisition	18	17	22	57
Digital Instruments Standardization	7	13	13	33
Social Science	26	30	28	84
Others	107	88	90	285
Total	242	219	219	680

Journals with Computer Science & Information Systems as their primary research discipline were cited frequently in 2012. Ninety-one references from 31 journals from this discipline were cited in CSI articles.

After analyzing the journals in the Social Science category, we conclude that most journals that were cited by CSI were from a Business discipline. Combining the results of the previous section, Business is a promising non-technical field for CSI articles, followed by Management and Psychology (Supplementary material C).

In order to determine the consistency of CSI articles citing other disciplines, we divided the cited disciplines based on the number of times each discipline was cited between 2011 and 2013. For example, Computer Science Hardware & Architecture was cited in all three years, whereas Management was only cited in 2011 and 2013. Of the 62 disciplines, 35 were only cited in one year, ten disciplines were cited in

2 years, and only 17 disciplines were cited in all three years. Of these 17 disciplines, Business was the only discipline from the Social Science category, the rest were from the Science category (Supplementary material B).

#### 4.2. Articles that cite CSI

We followed the same procedure to analyze articles that cited CSI research in 2011, 2012, and 2013. CSI was cited 84 times in 2011, with 39 citations indexed in Web of Science, and 34 times in 2012 with 18 citations indexed in Web of Science. Between 2011 and 2013, 171 articles were published in CSI, 60 of which were cited. Half of these were once-only citations. Only one article published in 2011 was cited seven times. Out of a total number of 171 articles, 111 articles were not cited, which means that CSI has a citation percentage of 35%. Seventy-six percent of the articles cited were once-only or twice-only citations (see Table 8). In the next section, we discuss the nature of the primary discipline and the source journal.

##### 4.2.1. Primary discipline

Table 9 lists the ten most primary disciplines that cite CSI articles. The top four are the same top four disciplines that are cited by CSI articles. It shows that CSI is a recognized outlet in its discipline as other journals refer to CSI. Sixty percent of the references to CSI articles come from these four primary disciplines. None of the top ten disciplines belong to the Social Science category of Web of Science. Only three citations belong to the Social Science category of Business, Healthcare Science & Services, and Psychology, Social (Supplementary material D). Apparently, CSI articles are not recognized as a potential source for articles in the Social Science category.

##### 4.2.2. Source journal

In total, 86 articles from 51 journals cited CSI articles in 2011, 2012, and 2013. Table 10 lists the top ten journals that cite CSI articles. Forty-two of the 86 articles (approximately 52%) are in the top ten. Again, all

**Table 5**

Top ten technical primary disciplines of research papers cited in CSI articles.

Primary discipline	# of articles cited in CSI	Median impact factor	Aggregate impact factor	Aggregate immediacy index	Cited half life	Citing half life
Computer Science, Hardware & Architecture	251	0.981	1.238	0.235	9.0	7.3
Computer Science, Information Systems	207	0.922	1.394	0.264	7.0	7.3
Engineering, Electrical & Electronic	186	1.104	1.631	0.271	7.0	7.2
Computer Science, Artificial Intelligence	137	1.236	1.879	0.299	7.5	8.1
Computer Science, Software Engineering	94	1.000	1.142	0.213	7.9	7.5
Automation & Control	65	1.235	1.835	0.277	6.9	8.0
Business	45	1.292	1.689	0.265	>10.0	>10.0
Computer Science, Interdisciplinary Applications	35	1.352	1.814	0.370	6.8	8.4
Computer Science, Theory & Methods	34	0.786	1.158	0.221	9.4	8.3
Operations Research & Management Science	21	1.365	2.769	0.559	5.9	6.6

**Table 6**

Top ten most frequently cited non-technical primary disciplines by articles in CSI from the Social Science category of Web of Science.

Primary discipline	# of articles cited in CSI	Median impact factor	Aggregate impact factor	Aggregate immediacy index	Cited half life	Citing half life
Business	45	1.292	1.689	0.265	>10.0	>10.0
Management	12	1.264	1.739	0.307	>10.0	>10.0
Psychology, Applied	6	1.559	3.235	0.504	5.8	6.9
Psychology, Multidisciplinary	6	1.589	2.815	0.520	6.9	7.3
Psychology, Social	4	1.413	1.719	0.302	>10.0	>10.0
Economics	3	1.000	1.341	0.213	6.3	6.8
Education and Educational Research	3	1.131	1.431	0.217	7.9	8.5
Ergonomics	3	1.676	2.395	0.421	8.6	9.0
Healthcare Science & Services	2	1.641	2.160	0.474	6.6	7.2
Psychology	2	1.969	2.697	0.473	>10.0	9.1

**Table 7**  
Top ten most cited journals in CSI articles.

Source journal	# of articles cited in CSI	Primary discipline
Computer Standards & Interfaces	132	Computer Science, Hardware & Architecture
Communications of the ACM	34	Computer Science, Hardware & Architecture
IEEE Transactions on Instrumentation and Measurement	31	Engineering, Electric & Electronic
Information & Management	20	Computer Science, Information Systems
IEEE Communications Magazine	19	Engineering, Electric & Electronic
MIS Quarterly	19	Computer Science, Artificial Intelligence
Pattern Recognition	19	Computer Science, Information Systems
Computer Communication	18	Computer Science, Information Systems
Expert Systems with Applications	16	Computer Science, Artificial Intelligence
IEEE Transactions on Wireless Communications	16	Engineering, Electric & Electronic

**Table 8**  
Frequency of citations (2011–2013).

Citation count	2011	2012	2013	Total
0	24	34	53	111
1	17	13	1	31
2	7	7	1	15
3	5	1	0	6
4	4	0	0	4
5	3	0	0	3
6	0	0	0	0
7	1	0	0	1
Total number of articles published in CSI	61	55	55	171

belong to the top four primary disciplines. There are no non-technical journals in the top ten.

## 5. Conclusion and discussion

We conducted a citation analysis of CSI articles published in 2011, 2012, and 2013 by collecting data about the primary disciplines and journal sources from the Web of Science database. Our results show that CSI focuses on software and computer standards and interfaces, interpreted in a technical sense. This was determined by analyzing

**Table 10**  
Top ten journals that cite CSI articles (2011, 2012, and 2013).

Source journal	# of articles that cite CSI
Computer Standards & Interfaces	12
Expert Systems with Applications	5
IEEE Transactions on Instrumentation and Measurement	5
Journal of Research and Practice in Information Technology	4
Computers & Electrical Engineering	3
Journal of Systems and Software	5
Journal of Universal Computer Science	3
Measurement	3
IEEE Transactions on Industrial Informatics	2
International Journal of Cooperative Information Systems	2
Sensors	2

citations in CSI articles. Only 97 of a total of 1292 references belong to the Social Science category and the rest are related to the Science category of the Web of Science. References that are specific to the discipline of computer standards and interfaces were cited most, accounting for 61% of the total references. Additionally, CSI cites articles from other disciplines, especially Business and Management, but also from Psychology and its sub-disciplines.

Our keyword analysis confirms the results obtained through our citation analysis. It shows that articles published in CSI use few non-technical keywords, mostly in combination with technical keywords. Only non-technical keywords are rarely used. Hence, we cannot give a complete answer to our second question of whether CSI is interdisciplinary. However, the journal does refer to research from other disciplines. Despite its long history, CSI is not an established source for social science articles.

Meanwhile, information and communication technology is being integrated in all kinds of application areas, from smart grids to agriculture, and from logistics to healthcare. Standards and interfaces apply to all these areas and, as a result, research on computer standards and interfaces can benefit from the interrelation with research disciplines such as electro-technical engineering, agricultural science, business, and medicine. Journals in such fields sometimes address standards and interfaces and CSI needs to decide whether it wants to extend its focus to such application fields. The more it does so, the more non-technical papers it will include. Another argument to include non-technical references is that the technical contents of standards relate to the non-technical process of standards development and that, subsequently, the standard is distributed, accepted, and implemented and leads to impact. Additionally, standards themselves can also be studied from, for instance, a linguistic [7] or a legal perspective [8].

Papers that address these application areas, the standardization process, standards impact, or non-technical characteristics of standards are scarce in CSI but are more often found in the other main standardization

**Table 9**  
Top ten primary disciplines of research papers that cite CSI articles (2011, 2012, and 2013).

Primary discipline	# of articles that cite CSI	Median impact factor	Aggregate impact factor	Aggregate immediacy index	Cited half life	Citing half life
Computer Science, Hardware & Architecture	18	0.981	1.238	0.235	9.0	7.3
Computer Science, Information Systems	15	0.922	1.394	0.264	7.0	7.3
Engineering, Electrical & Electronic	11	1.104	1.631	0.271	7.0	7.2
Computer Science, Artificial Intelligence	9	1.236	1.879	0.299	7.5	8.1
Computer Science, Software Engineering	6	1.000	1.142	0.213	7.9	7.5
Engineering, Multidisciplinary	4	1.284	1.711	0.309	>10.0	>10.0
Chemistry, Analytical	3	1.953	2.892	0.490	6.9	6.8
Computer Science, Interdisciplinary Applications	2	1.352	1.814	0.370	6.8	8.4
Instruments and Instrumentation	2	0.664	0.822	0.129	6.9	9.4
Automation & Control	2	1.235	1.835	0.277	6.9	8.0



journal, the *International Journal of IT Standards and Standardization Research* (JITSR). A recent citation study [9] shows that two-thirds of the citations in this journal are from journals in the field of Business, Management, or Economics while less than one third is from more technical journals (Telecommunications, Information Systems and Library science, and Computer Science, Hardware and Architecture). Despite its title, this journal does not focus exclusively on IT standards but accepts general standardization papers as well. JITSR publishes fewer papers per year than CSI; it publishes two issues per year due to the number of submissions and the low acceptance rate (20%) [9].

The *International Journal of Services and Standards* “presents current practice, models, and theory in both services and standards development, design, management, implementation, and applications. Its objectives are to develop, promote and coordinate the development and practice in services and standards” [6]. This touches CSI's scope in the case of the application of computer standards and interfaces in service sectors. In the past, the *International Journal of Services and Standards* published only a few articles on the application of computer standards and standards, whereas in the last two years, the majority of papers have focused on this subject.

The other standardization journals are too new to have obtained an established position. The *Journal of Standards and Standardization* covers all areas of standards and standardization, with no limitation to a certain technical or business area. So far it mainly serves as an outlet for the growing South-Korean standardization research community. The *Journal of ICT Standardization*'s first issue mixes technical and non-technical papers, of scientific or professional nature. It seems that this journal still has to position itself better, but its scope overlaps both with CSI and the *International Journal of IT Standards & Standardization Research*.

In this landscape of standardization journals, CSI has an established position including an ISI ranking, and a clear focus. The Editorial Board and publisher may want to stick to the mainly technical focus and leave the more non-technical papers to the *International Journal of IT Standards and Standardization Research*. An alternative would be to become more open to those papers or even to merge with the *International Journal of IT Standards and Standardization Research*. It seems that the current research community is too small to justify the existence of all of these journals.

Supplementary data to this article can be found online at <http://dx.doi.org/10.1016/j.csi.2015.02.008>.

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