A Study of Citing Patterns of Korean Scientists on Korean Journals

국내 과학기술 연구자의 한국 학술지 인용패턴 연구

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ABSTRACT

A large and reliable citation database is necessary to identify and analyze citation behavior of Korean researchers in science and technology. Korea Institute of Science and Technology Information (KISTI) built *the Korea Science Citation Database* (KSCD), and have provided *Korea Science Citation Index* (KSCI) and *Korea Journal Citation Reports* (KJCR) services. In this article, citing behavior of Korean scientists on Korean journals was examined by using the KSCD that covers 459 Korean core journals. This research dealt with (1) statistical numeric information of journals in KSCD, (2) analysis of document types cited, (3) ratio of domestic to international documents cited and ratio of citing different disciplines, (4) analysis on immediacy index, peak time, and half-life of cited documents, and (5) analysis on impact of journals based on KJCR citation indicators. From this research, we could find the immediacy citation rate (average 2.36%), peak-time (average 1.7 years) and half-life (average 5.2 years) of cited journals in Korea. We also found that the average journal self-citation rate is more than 50% in every field. In sum, citing behavior of Korean scientists on Korean journals was comprehensively identified from this research.

초 록

국내 과학기술 분야 연구자들의 인용행태를 종합적으로 파악하고 분석하기 위해서는 대규모의 신뢰할 수 있는 인용색인 데이터베이스가 필요하다. KISTI는 한국 과학기술 인용색인 데이터베이스인 KSCD를 구축하고 한국과학기술인용보고서(KJCR) 및 한국과학기술인용색인서비스(KSCI)를 제공하고 있다. 본 논문에서는 국내 핵심 학술지 459종의 학술지를 커버하는 KSCD를 활용하여 국내 과학기술분야 연구자들의 한국 학술지 인용행태를 분석 연구를 수행하였다. 연구 범위로는 첫째, 대상 DB 수록 학술지의 통계적 주요 수치정보를, 둘째, 인용문헌의 형태별 분석을, 셋째, 인용문헌의 국내와 해외비율 및 타분야 인용비율을, 넷째, 국내 인용문헌의 즉시인용, 인용절정기, 반감기를 마지막으로 KJCR 인용지표를 통한 학술지의 영향력 분석이다. 국내학술지 인용분석을 통한 연구의 주요 성과로는 국내 인용 학술지의 즉시인용률(평균 2.36%), 인용절정기(평균 1.7년), 반감기(평균 5.2년)의 규명과 모든 주제분야에서 자기학술지 인용률이 평균 50%를 넘는다는 것을 밝힌 것이다. 본 연구를 통해 국내 과학자들의 국내 학술지 인용행태를 과학기술 전분야에 걸쳐 종합적으로 파악할 수 있었다.

Keywords: citation analysis, behavior of citing korea journal, half-life, KJCR
인용분석, 한국 학술지 인용행태, 반감기, KSCD, KSCI, KJCR

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▪ Received : 17 May 2011 ▪ Revised : 24 May 2011 ▪ Accepted : 8 June 2011
▪ Journal of the Korean Society for Information Management, 28(2): 97-115, 2011.
〔DOI:10.3743/KOSIM.2011.28.2.097〕

1. Introduction

1.1 Research goals and needs

Researchers publish their research findings in relevant journals in the form of articles. They normally use the previous research findings from their work by referencing these findings in the new article. This process of referencing has been called "citation", and it is usually placed at the end of journal articles (Kim 1999). On one hand, cited documents represent the official acknowledgement to authors of those works cited by the researchers. Although there could be various reasons for citing other works, researchers have usually cited documents to use them as historical and theoretical bases or to pay homage to previous researchers (Kim 2002; Bonzi & Snyder 1991).

Citation analysis is a method of analyzing a relationship between cited documents and citing documents in order to examine the usage of journal articles. As a research area of bibliometrics, the objective of citation analysis is to characterize resources cited by information creators (Friss 1955). Even though many studies and experiments have been carried out to measure the value of scientific and technical documents and find evaluation methods for them, the most objective and reasonable method could be citation analysis that applies bibliometric methods to cited references (Kim 2002; Bonzi & Snyder 1991).

By analyzing citations quantitatively, it is possible to figure out types, languages, preferences of information used, and the phenomenon of information use (Kim 2003). Reference works that are included in articles act as information resources as well as tools for various analyses on articles or researchers as stated above. In other words, since some cited references have directly influenced the new research findings, they have a value as information resources (Cho 2005).

In this research, citation analysis on Korean science and technology journal articles was performed to understand citing behavior of Korean scientists on Korean journals synthetically. The reason for choosing journal articles (i.e. serials) as the subject of research is that unlike other information resources such as books, journal articles have usefulness in terms of continuity, periodicity, currency, communicability, precise and professional information, multidimentional perspectives, brevity, and quality (Myung 1994).

The ultimate purpose of this research is to understand citing behavior of Korean scientists in Korean science and technology articles through analyzing massive citation data from every area of science and technology, not limited to specific areas, journals or articles. With the information acquired from this analysis, characteristics of information use by users (i.e. researchers) could be understood. Then an efficient way of satisfying user needs can be developed by maximizing the use of Korean scientific information.

1.2 Research method and scope

This research utilizes *the Korea Science Citation Database* (KSCD) and *the Korea Journal Citation*

Reports (KJCR) of *the Korea Institute of Science and Technology Information* (hereafter: KISTI). KSCD is the database supporting services of Korean scientific information services (i.e., NDSL, KSCI, Korea Society Community of Science and Technology, KoreaScience), which have core journals of Korean science and technology and other scientific information. KJCR provides citation indicators for Korean journals calculated by the *Journal Citation Reports* (JCR) indicators via the KSCI website. For the scope of this research, 459 kinds of Korean journals in science and technology published from 2005 to 2009 were selected. Specifically, cited references of journals in KSCD and its citation index information were examined with KJCR indicators.

This research dealt with (1) statistical numeric information of journals in KSCD, (2) analysis of document types cited, (3) ratio of domestic to international documents cited and ratio of citing different disciplines, (4) analysis on immediacy index, peak time, and half-life of cited documents, and (5) analysis on impact of journals based on KJCR citation indicators.

2. Previous studies

Citation analysis is a research method of bibliometrics, which investigates the relationship between cited and citing documents. Citation analysis was first used by Gross and Gross and has been a research area because of its usefulness of the methodology and result (Gross and Gross 1927). There have been many applications of citation analysis such as user studies, history of science studies, communication patterns of scientists, evaluation of scientific influence and productivity, information retrieval, collection development, studies of document types or use in a field, studies of research trends, and distribution of information resources (Choi 1996). Using cited references of journal articles to examine a relationship among documents is reliable because authors of journals cite articles that were evaluated and were really used in their work. Cited references to journal articles are also proper for applying bibliometric methods, so that it can provide the big picture of information resource usage (Ko 2005). This enables us to figure out the environment of information use and citing behaviors of researchers without interviewing or surveying user groups.

A typical example of citation analysis is *Journal Citation Reports* (JCR), a publication of Thomson Reuters. JCR ranks journals quantitatively and qualitatively based on the analysis of the relationships among journals with some citation indicators. Although citation analysis of JCR relies on citation counts (i.e., numeric values), it is assumed that the number of citations represents the intellectual influence and quality of a given cited work (Wade 1975). Further, JCR supplements the limitations derived from evaluating research performance by the simple total number of citations. An objective evaluation could be hindered by simply relying on the total citations because a journal will be cited more frequently if it has many articles and articles that were published a long time ago. JCR, however, has a weak-

ness in that it treats all citations the same. In other words, JCR cannot evaluate the citation counts qualitatively. Despite this limitation, JCR has been widely used in the process of collection development by librarians and information professionals. Citation analysis has been applied to many disciplines (e.g., economics, education, law, science, technology) internationally, just as Gross & Gross firstly applied it to the discipline of chemistry (Seong-Soon Ko 2005).

Related research in and outside of the country since 2005 is organized in <Table 1> and <Table 2> below. Overall, it turned out that many researchers have performed their research not only for information retrieval or evaluative purposes but also for finding any patterns in citation such as preference of information type, information life cycle, collaborations among researchers, and demands for current information by academic fields or researchers. In particular, research using citation analysis such as networks among researchers, integration among academic fields, developmental process of academic fields or research trends, and knowledge maps have been productively performed recently (Cho 2010).

〈Table 1〉 Previous Domestic Studies

Year of Publication	Field	Purpose	Sample	Result	Conclusion
Hyun-Yang Cho, 2005	Mechanical, Architectural, Electrical and Electronic area	Analysis of citing behavior of researchers by field	29,610 cited documents of 2,333 articles in 1999, 2001, 2003	• Researchers in electronics are likely to cite conference proceedings at a relatively high percentage (16.54%) • Dependency on English (89%) is the highest in electronics • The citation half-life of mechanical engineering and electronics are 8 years and 6 years each	• Researchers in engineering are more likely to cite articles, followed by books, proceedings, reports, dissertations, web resources, and others. • Researchers in engineering rely on current resources.
Seong-Soon Ko, Sang-Ki Choi, 2005	Engineering, Natural science, Social Science, Humanities, Arts and Physical Education	To figure out the use behavior of professors for international journals based on cited references	Among 4,749 foreign articles cited by Korean 258 articles published in Korean journals from 2002 to 2003, 1,030 (engineering), 741 (natural science), 2,286 (social science), 636 (humane studies), and 56 (arts and physical education) articles were selected	• Journal articles were more likely to be cited in engineering, natural science, and social science • 68.2% of cited references was SCI listed • Journals published in recent 6 to 10 years were frequently cited	It is necessary to select journals that meet users needs and the goal of library by using the result of citation analysis
Jong-Yup Han, 2007	Marine Science	To examine the current condition of OSJ and to set an achievable plan	23,096 cited documents of 679 articles from 4 SCI journals in OSJ and JCR published from 2005 to 2007	• OSJ takes 184.8 days in average (faster than JCR) • OSJ has 7 more references than SCI in average • Cited SCI journals from OSJ has 0.683 bigger impact factor in average than those from JCR	• The number of researchers of an article in four journals has high percentage of co-authorship • OSJ includes relatively more authors from Asia • OSJ includes relatively more authors who work in research institutes and universities

Year of Publication	Field	Purpose	Sample	Result	Conclusion
So-Young Yu, Jae-Yun Lee, 2008	Life Sciences	A structural analysis of citation network within an institution in order to find the effect of the citation network on citation patterns of the institution and in deciding the importance of journals in the institution	122 articles published from 2006 to 2007 by professors in biotechnology	• Biochemical research including cytology in Y university has high productivity • Citation count for Journal of Biological Chemistry that belongs to biochemical field is 69, the highest citation frequency in the institution	• Analysis of citation network of the institution provides useful information for research trends and journal citation in the institution that might not be acquired by simple citation counts
Seung-Won Lee, 2008	Chemistry	To examine information use behaviors of users	The total number of doctoral dissertations from 2000 to 2008: 3,258	• "Journal of American Chemical Society" had been the most highly cited (232 times, 7.64%) • Researchers prefer to cite journal articles	• The most highly cited document type is journal articles (90%) • The number of necessary journals satisfying 50% of user needs is 27 types of journals • 50% of cited documents was 7.6 years old • Researchers in chemistry prefer to use journals, and they tend to rely on documents written in English
Jun-Min Chung, 2010	Library and Information science	To analyze cited documents with objective and various indicators and to use them in evaluting science and technology documents	2,086 documents		• Document lifetime for un-cited documents was processed with grace period. • A database consisting of documents having high impact factors could be a solution for revitalizing the market and financial problem of libraries
Douho Im, Young-Mee Chung, 2010	Science and Technology	To find out the way of managing journals in interdisciplinary fields by analyzing journal citation and interdisciplinarity based on citation patterns of Korean researchers	56,293 SCIE articles from 2006 to 2007	• Materials Science and Multidisciplinary fields have high citation rates (0.163) in Materials Science and Characterization & Testing • Biochemistry & Molecular Biology has the highest citation rates (0.184) in • Multidisciplinary Sciences in Biology · Meficine, General & Internal has 0.029 citation rates (ranked in 23rd) • Statistics & Probability has the highest citation rates (0.215) in Medical informatics • Pharmacology & Pharmacy has the highest citation rates (0.219) in Integrative & Complementary Medicine	Using the analysis of interdisciplinarity by citation rates with citation frequency is proven to be useful for managing journals in interdisciplinary fields

〈Table 2〉 Previous Foreign Studies

Author/ Year	Area	Purpose	Target	Result	Conclusion
JASON C. DEWLAND (2010)	Business, Finance	The study was undertaken to gain the better understanding of the local faculty researchers' needs, to examine how the library supports their needs, and to compare the local results with the metaresearch focused on specific subject or journals	253 publications of the faculty of the University of Mississippi's School of Business	The total number of citations were 10,542, of which 2,409 (22%) were non- journal citations	Solely relying on published rankings of journals in the disciplines would not be an effective means of supporting faculty research
D. Gnana Bharathi (2011)	Scientometrics	The criteria for the evaluation of scientific journals have changed from characteristics of its contents to citations of articles.	CA-A Cancer Journal for Clinician and 19 other journals	The calculated values are consistent with time and can be used to back-track the status of a journal in its past and for continued evaluation.	The new Index ensures neutrality, qualitative and quantitative hierarchy and consistency in the estimation of journal ranking.
Juan Miguel Campanario (2011)	Scientometrics	It studied the effect on journal impact factors(JIF) of citations from documents labeled as articles and reviews versus citations coming form other documents.	It selected a set of 700 journals indexed in the SCI section of JCR that receive a low number of citations.	The author found that most journals obtained citations that contribute to the impact factor from documents labeled as articles and reviews.	He did not find evidence that citations that contributed to the impact factor were dependant on non-peer reviewed documents or only a few citing records.
Thomas V. Perneger (2009)	Clinical Epidemiology	To examine whether the prestige of a journal, measured by its impact factor, influences the numbers of citations obtained by published articles, independently of their scientific merit.	Citation counts were retrieved for articles describing consensus statements that were published in multiple journals	For consensus statements were published in multiple copies: UOROM was published in three journals, CONSORT in eight journals, STARD in 14 journals, STROBE in eight journals.	The prominence of the journal where an article is published, measured by its impact factor, influences the number of citations that the article will gather over time.

Although citation research has been performed in science and technology in order to figure out the citing behavior of researchers, there is little citation research that analyzes core journals covering the every field of science and technology. In response to this, the research analyzing a vast amount of citations from all the existing fields of science and technology has the potential to grant us an understanding Korean scientists' citing behaviors in Korean journals.

3. Analysis of Result

3.1 Basic statistics of KSCD citation data

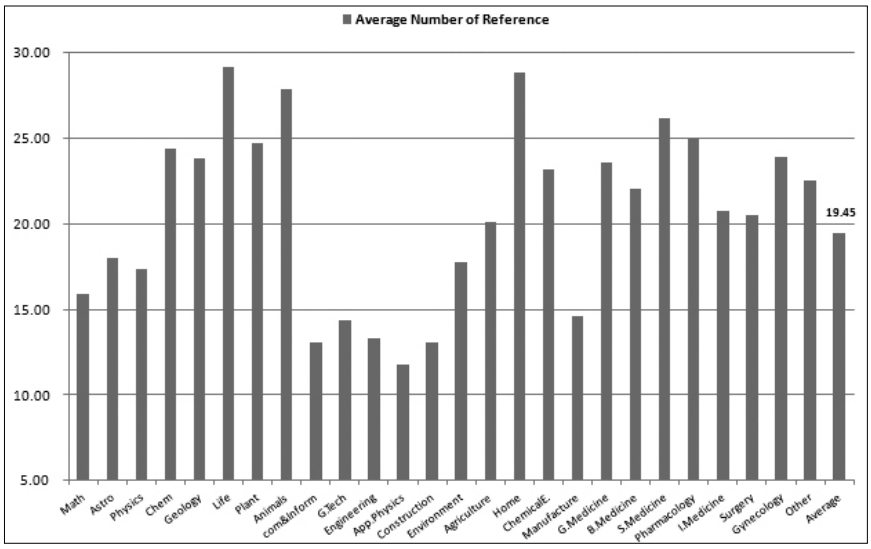
The statistics from KSCD citation data for this research is shown in <Table 3> below. The KSCD has over one million scientific journal articles and six million references to those articles. This research analyzed citation data of journal articles published between 2005 and 2009 because using recent five years of data is reliable for statistical analysis in terms of currency and accuracy. Specifically, this

research analyzed 459 types of Korean journals in science and technology fields, which are the foundations for KJCR and KSCI services of KISTI. This study uses the tables and graphs below to show various aspects of the results. In particular, citation analysis was done with broad and narrow classifications of subjects. Since KSCD also has some journal data from the humanities, social studies, and the arts and physical education, this study regarded these fields as "others" in subject classification.

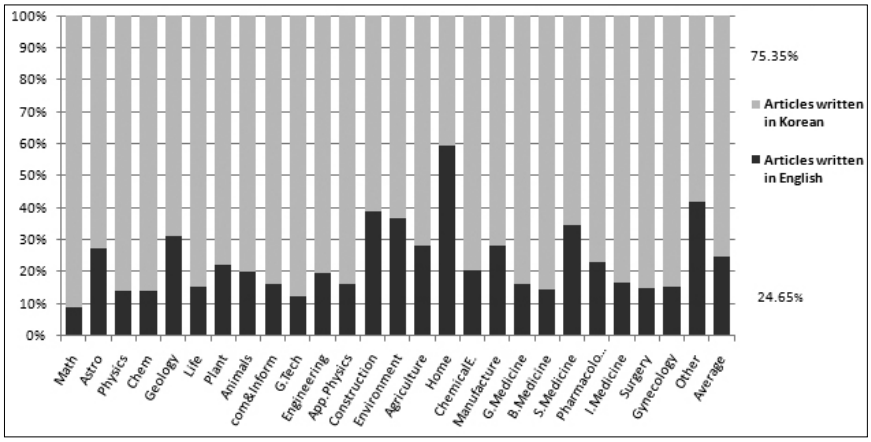
With the simple statistical calculation from KSCD data, some characteristics of Korean journals in the science and technology were revealed. <Figure 1> shows the differences in the average number of references by subject. The average number of documents cited by an article in science and technology was (19.45). An article in natural science had the highest average number of references (23.1), followed by medicine & pharmacy (22.3) and applied science (16.3). Also, the average number of authors increased

〈Table 3〉 Basic Statistics of KSCD Citation Data (2005-2009)

Broad Classification	Subject	Abbr.	Number of Journal Type	Number of Journal	Number of Article	Number of Reference
Natural Science	Mathematics	Math	5	153	2,475	39,369
	Astronomy	Astro	6	127	1,165	20,939
	Physics	Physics	10	301	7,155	124,280
	Chemistry	Chem	8	227	4,478	109,022
	Ethnography, Geology	Geology	13	278	2,688	64,070
	Life Science	Life	22	484	6,569	191,589
	Plant	Plant	6	135	1,720	42,454
	Animals	Animals	7	170	2,855	79,425
Applied Science	Computer Information	com&Inform	18	645	7,852	102,425
	General Technology and Science	G.Tech	3	54	646	9,250
	General Engineering	Engineering	29	973	11,856	158,083
	Applied Physics	App.Physics	47	1,535	18,925	223,266
	Construction, Architecture and Civil Engineering	Construction	27	936	12,001	156,889
	Urban and Environment	Environment	8	189	2,376	42,226
	Agriculture	Agriculture	42	818	10,720	215,191
	Home Economics	Home	12	428	5,448	156,950
	Chemical Engineering	ChemicalE.	24	613	11,222	259,947
	Manufacturing	Manufacture	15	381	3,765	55,012
Medicine & Pharmacy	General Medicine	G.Medicine	15	356	4,512	106,217
	Basic Medical	B.Medicine	8	187	3,101	68,367
	Social Medicine	S.Medicine	16	335	4,833	126,293
	Pharmacology & Therapeutics	Pharmacology	12	312	4,993	124,441
	Internal Medicine	I.Medicine	30	898	12,793	265,009
	Surgery	Surgery	21	652	10,332	211,887
	Obstetrics and Gynecology	Gynecology	4	116	1,973	47,189
Other	Other	Other	51	1,127	14,032	315,634
Total			459	12,430	170,485	3,315,424



〈Figure 1〉 The Average Number of References (by Subject)



〈Figure 2〉 The Ratio of Domestic to Foreign Cited Articles (by Subject)

from 3.85 persons in 2005 to 3.96 persons in 2009 (2.8% rise). And the portion of articles written in English was increasing, given that the ratio of Korean to English articles was 74% : 26% in 2005 and became 67% : 33% in 2009. Natural science had the highest percentage of English articles, followed by applied science and medicine and pharmacy. The ratio of Korean to English articles was shown in <Figure 2> below.

3.2 The analysis of document types cited

The types of references cited by journal articles

are diverse such as journal, book, conference proceeding, thesis, instruction, patent, standard, report and web resource. <Table 4> presents the result of analyzing the document types cited. As several previous studies already proved, journal article were the most highly cited. In particular, journals were frequently cited in medicine & pharmacy (89.9%), natural science (84.3%), and applied science (64.8%). In the applied science, proceedings were highly cited (14.7%) compared to other fields. For example, the ratio of proceedings being cited was 23% in the area of computer and information.

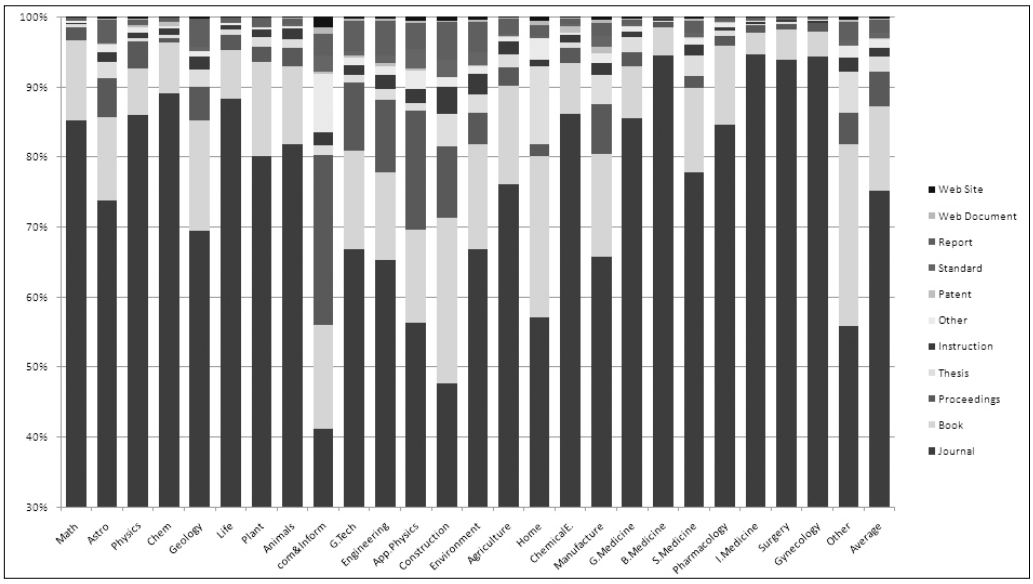
〈Table 4〉 Analysis of Document Types Cited (by Subject)

Broad Classification	Narrow Classification	Journal	Book	Proceedings	Thesis	Instruction	Other	Patent	Standard	Report	Web Document	Web Site
Natural Science	Mathematics	33,538	4,494	755	165	92	128		9	171	13	4
	Astronomy	15,455	2,489	1,172	482	280	241	12	47	687	35	39
	Physics	106,796	8,447	4,803	561	803	1,036	360	271	792	149	262
	Chemistry	97,081	7,987	746	498	916	316	666	221	445	57	89
	Ethnography, Geology	44,524	10,113	3,080	1,594	1,147	448	11	385	2,587	67	114
	Life Science	169,225	13,272	4,278	1,344	1,360	452	150	237	1,099	75	97
	Plant	34,047	5,656	952	557	465	127	33	60	516	23	18
	Animals	65,040	8,829	2,107	926	1,201	257	78	158	616	128	85
Applied Science	Computer Information	42,205	15,075	24,902	1,481	1,845	8,644	267	2,361	3,198	930	1,517
	G.Tech	6,186	1,300	899	97	127	99	31	61	396	30	24
	General Engineering	103,228	19,778	16,299	2,455	3,329	1,887	636	1,685	7,997	300	489
	Applied Physics	125,568	29,830	37,867	2,556	4,508	5,671	972	6,234	8,196	631	1,233
	Construction, Architecture and Civil Engineering	74,851	36,965	16,190	7,175	5,992	2,177	149	3,702	8,506	211	971
	Urban and Environment	28,186	6,366	1,904	1,071	1,298	456	66	747	1,845	121	166
	Agriculture	163,914	29,973	5,773	4,185	3,842	1,310	217	912	4,422	352	291
	Home Economics	89,543	36,235	2,555	17,582	1,481	4,780	90	493	2,371	975	845
	Chemical Engineering	223,977	18,749	5,710	1,891	2,947	933	2,181	1,134	1,957	222	246
	Manufacturing	36,192	8,085	3,857	2,364	885	775	548	811	1,026	237	232
Medicine & Pharmacy	General Medicine	90,932	7,773	2,091	2,348	856	825	28	221	663	281	199
	Basic Medicine	64,587	2,741	614	63	173	33	1	42	89	18	6
	Social Medicine	98,323	15,208	2,132	3,687	1,946	1,260	100	795	2,217	386	239
	Pharmacology & Therapeutics	105,237	14,172	1,670	901	726	583	208	329	481	44	90
	Internal Medicine	250,813	8,308	2,876	199	1,107	386	9	108	879	223	101
	Surgery	199,003	9,179	1,622	592	543	219	19	101	496	70	43
	Obstetrics and Gynecology	44,518	1,658	577	31	124	71		3	167	29	11
Other	Other	173,710	81,352	13,886	18,199	6,234	5,206	311	2,050	8,441	688	1,404
Average		75.1%	12.2%	4.8%	2.2%	1.3%	1.2%	0.2%	0.7%	1.8%	0.2%	0.3%

<Figure 3> is the diagram of <Table 4>. This tells that there is a significant difference in the rate of document types cited, especially journals, depending on subject area. For example, while almost 95% of total citation counts came from journal articles in general medicine, ratio of citing journal articles in computer and information was only about 40% of total citation counts. Rather, researchers in computer and information cited relatively many proceedings compared to other researchers in different disciplines.

3.3 The ratio of domestic to foreign citations and the ratio of citing different disciplines

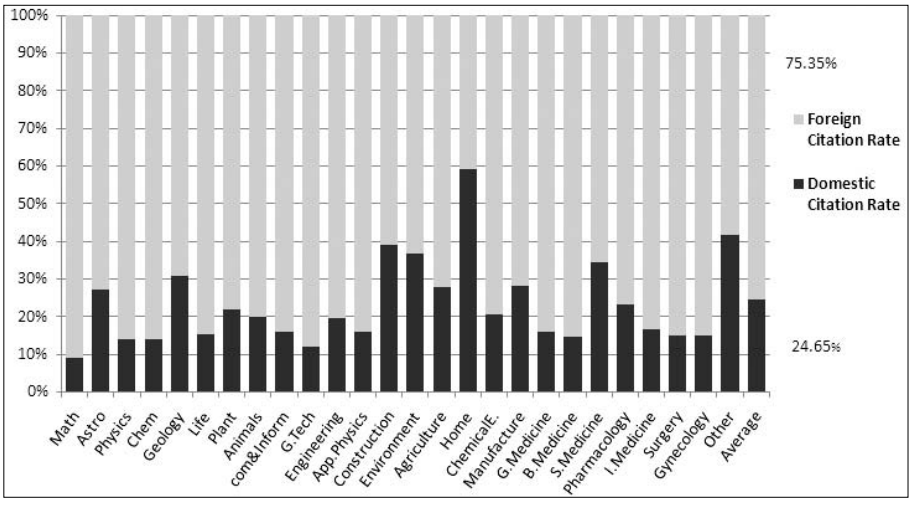
It is possible to see the ratio of domestic to foreign citations through citation analysis. This informs the level of dependence on foreign resources depending on subject field. The results of the analysis is shown below in <Table 5>. Natural science has the highest dependence on foreign resources (83%), followed by medicine & pharmacy (81%) and applied science (72%). Overall, Korean scientists cited foreign documents 72.35% of the time, compared to domestic documents which were cited 24.65% of the time. Although the change in the ratio of domestic to foreign citation was examined from 2005 to 2009, there was no meaningful statistical trend during this time. <Figure 4>, displayed with graphs, shows the level of dependence on foreign documents by topic in an easy manner. In the case of citing journals, 76.76% of the time foreign journals were cited while 21.47% of the time domestic journals were cited. In the following chapters, citation analysis only focused on domestic citations.



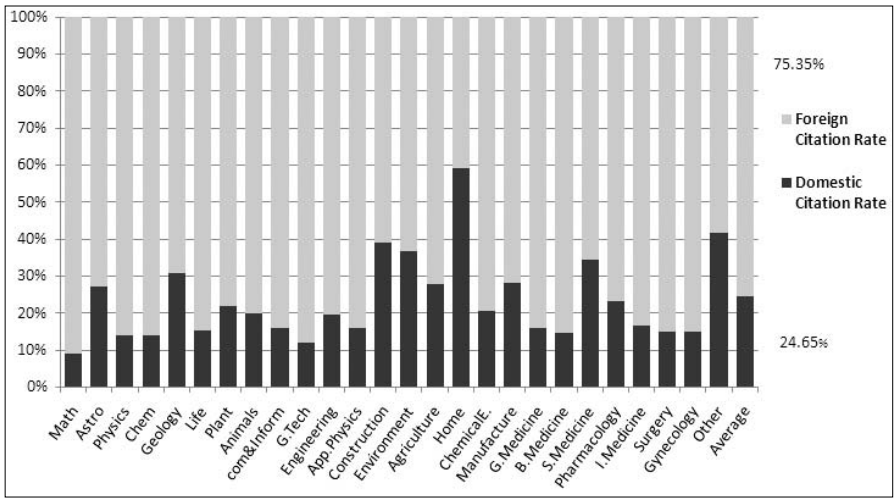
〈Figure 3〉 Analysis of Document Types Cited (by Subject)

〈Table 5〉 The Ratio of Citing Domestic and Foreign Documents (by Topic)

Broad Classification	Narrow Classification	Citing Domestic Documents	Citing Foreign Documents	Domestic Citation Rate	Foreign Citation Rate
Natural Science	Mathematics	3,282	33,594	8.90%	91.10%
	Astronomy	5,712	15,227	27.28%	72.72%
	Physics	17,250	105,802	14.02%	85.98%
	Chemistry	15,265	93,757	14.00%	86.00%
	Ethnography, Geology	19,787	44,283	30.88%	69.12%
	Life Science	29,356	161,480	15.38%	84.62%
	Plant	9,332	33,122	21.98%	78.02%
	Animals	15,817	63,608	19.91%	80.09%
Applied Science	Computer Information	13,811	72,714	15.96%	84.04%
	General Technology and Science	1,112	8,138	12.02%	87.98%
	General Engineering	29,210	119,890	19.59%	80.41%
	Applied Physics	31,926	166,565	16.08%	83.92%
	Construction, Architecture and Civil Engineering	60,236	94,530	38.92%	61.08%
	Urban and Environment	15,502	26,724	36.71%	63.29%
	Agriculture	60,130	155,005	27.95%	72.05%
	Home Economics	93,071	63,879	59.30%	40.70%
	Chemical Engineering	53,357	206,030	20.57%	79.43%
	Manufacturing	15,294	39,182	28.07%	71.93%
Medicine & Pharmacy	General Medicine	17,054	89,163	16.06%	83.94%
	Basic Medical	9,944	58,423	14.55%	85.45%
	Social Medicine	41,387	78,284	34.58%	65.42%
	Pharmacology & Therapeutics	28,314	93,999	23.15%	76.85%
	Internal Medicine	43,868	221,141	16.55%	83.45%
	Surgery	31,776	180,111	15.00%	85.00%
	Obstetrics and Gynecology	7,089	40,100	15.02%	84.98%
Other	Other	131,998	183,636	41.82%	58.18%
Total and Average		800,880	2,448,387	24.65%	75.35%



〈Figure 4〉 The Ratio of Domestic and Foreign Citations (by Topic)



〈Figure 5〉 The Ratio of Citation from Researchers' Own Disciplines to Citation from Disciplines Outside of Researchers' Disciplines

On the one hand, the analysis showed that almost 70% of researcher's citations referred to articles taken from their own discipline, while only about 30% of citations were taken from fields outside of the researchers primary field of study. This fact is shown in <Figure 5>. Further, <Figure 5> implies that citing behavior of researchers could be vary among different disciplines. While the ratio of citing self-discipline to other disciplines is about 9:1 in mathematics, some disciplines such as plant, animals or social medicine cited more than 50% of articles taken from other disciplines. This might be attributed to the characteristics of scientific communities and disciplines.

3.4 Immediacy, peak time and half-life of cited documents in Korean journals

The age (=year) of cited document indicates the elapsed time since that document was published. In other words, the age of cited document can be analyzed to determine the time required for a document to become cited once it has been published. In this research, citation ages (i.e., immediacy, peak-time, and half-time of citation) were analyzed as illustrated in <Table 6>. The immediacy rate of citation measures the percentage of citing documents published in a given year, and the peak time of citation refers to the most frequently cited year. Also, citation half-life, which calculates the life cycle of documents, indicates the year that accounts for 50% of current citation counts.

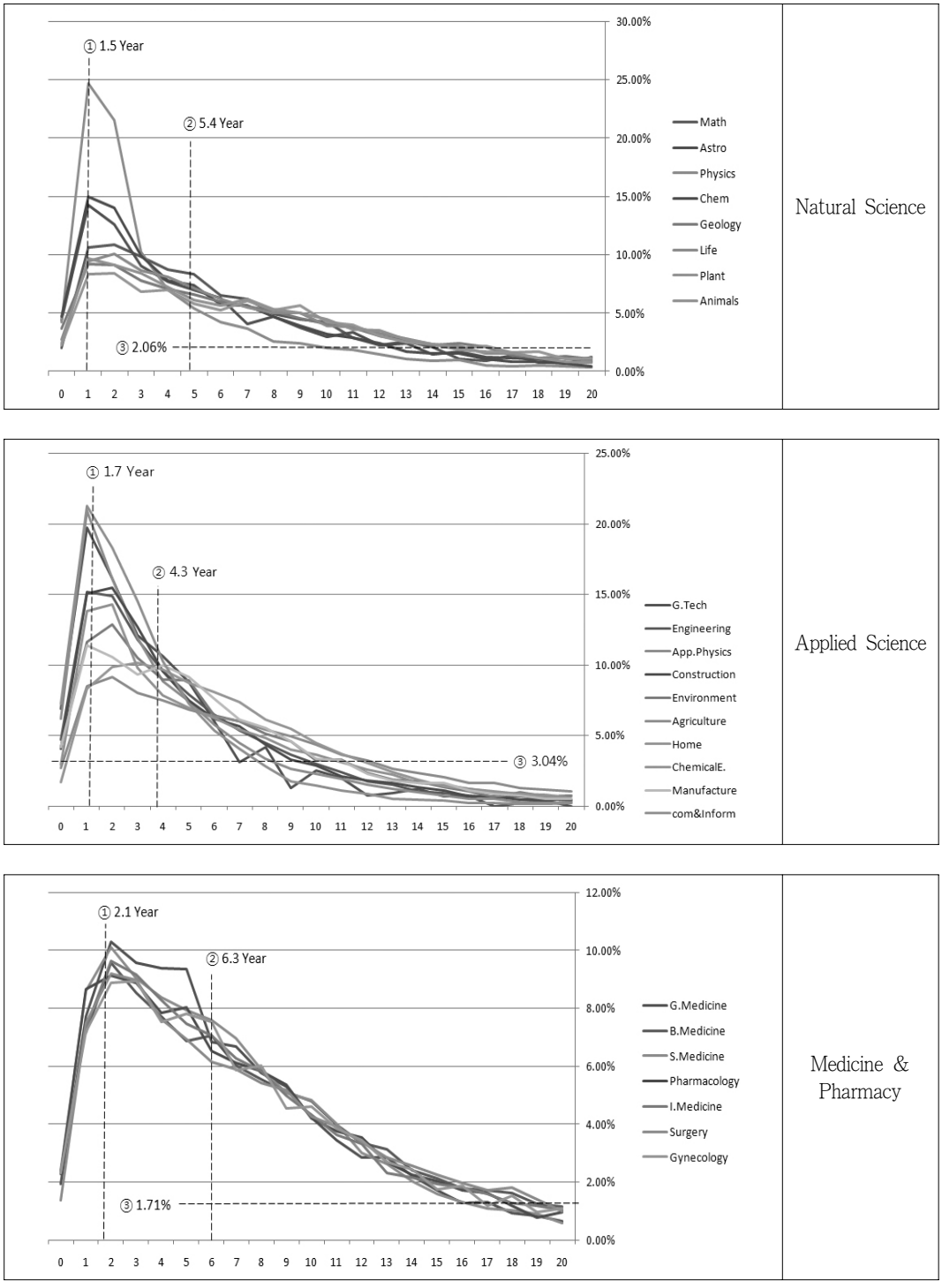
The analysis of citation age is an effort to measure the changing speed of knowledge. In particular, knowing the speed of knowledge transfer and degradation plays a critical role in understanding modern knowledge-based society. It helps in understanding characteristics of academic disciplines and managing

〈Table 6〉 Analysis of Citation Ages for Cited Documents in Korean Journals

Broad Classification	Narrow Classification	Average Half life	Average Citation Immediacy	Peak Time
Natural Science	Mathematics	5.3	0.96%	2
	Astronomy	4.7	3.85%	1
	Physics	2.3	1.74%	1
	Chemistry	4.3	2.32%	1
	Ethnography, Geology	6.7	2.51%	2
	Life Science	6.0	2.01%	2
	Plant	7.3	1.76%	2
	Animals	6.7	1.34%	1
Average (Natural Science)		5.4	2.06%	1.5
Applied Science	General Technology and Science	3.0	4.27%	1
	General Engineering	4.0	2.89%	1
	Applied Physics	3.0	3.52%	1
	Construction, Architecture and Civil Engineering	3.7	3.08%	2
	Urban and Environment	4.7	3.48%	2
	Agriculture	6.7	1.98%	2
	Home Economics	6.0	2.28%	3
	Chemical Engineering	4.7	1.82%	2
	Manufacturing	5.0	2.95%	1
	Computer Information	2.3	4.17%	2
Average (Applied Science)		4.3	3.04%	1.7
Medicine & Pharmacy	General Medicine	5.3	1.69%	2
	Basic Medical	6.7	1.10%	2
	Social Medicine	6.0	2.33%	2
	Pharmacology & Therapeutics	6.3	2.13%	2
	Internal Medicine	6.3	2.13%	2
	Surgery	7.0	0.89%	2
	Obstetrics and Gynecology	6.7	1.72%	3
Average (Medicine & Pharmacy)		6.3	1.71%	2.1
Average (Total)		5.2	2.36%	1.7

information effectively, in addition to evaluating researchers or journals. For instance, a journal article citing recent documents is not always rated high because the tempos of knowledge transfer and degradation are significantly different depending on nature of disciplines. However, the fact is that knowledge is going to be degraded from the peak-time of citation. That is, reaching the half-life of citation means that the lifetime of document is halved, so that the value of specific document being analyzed is decreasing. (Lee 1996).

<Figure 6, 7 and 8> are graphs of <Table 6>. From these figures, it was possible to compare the trends of citation ages according to various disciplines. When it comes the rate of citation immediacy, the average rate was 2.36%. The percentage of citation immediacy was relatively high in applied science rather than in natural science and medicine & pharmacy. With respect to the peak time of citation, the average year was 1.7 years, and natural science



〈Figure 6, 7 ,8〉 Citation Ages by Discipline (Immediacy Index, Peak Time, Half time)

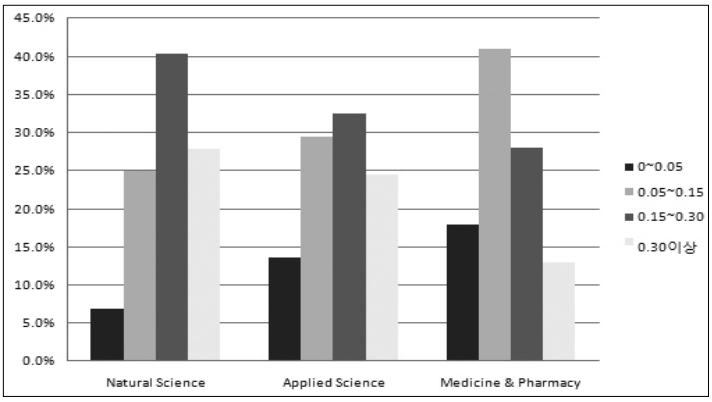
had the fastest peak time, followed by applied science and medicine & pharmacy. For the half-life of citation, the average was 5.2 years. In this case, natural science had a shorter half-life than applied science and medicine & pharmacy. From this result, it turned out that documents published in a given year were not cited frequently because of limitation in distribution. Also, Korean scientists prefer to cite documents published recently (e.g. those that are 2 to 6.5 years old). Although mentioned in previous studies, this research has a value in that it produced reliable numeric indicators for citation data by analyzing journal articles published between 2005 and 2009 from every field of science and technology.

3.5 Impact analysis of journals by using KJCR indicators

This research performed not only simple analyses such as finding citing patterns, calculating citation age, but also the specialized analysis by using the impact factor of JCR-level rated Korean journals in science and technology. This could have been done thanks to *Korea Journal Citation Reports* (KJCR) supported by KSCD. The impact factor of 2009 was shown in <Table 7> and <Figure 9>. The average of total impact factors was 0.214, which means that 20% of articles published in the two preceding years were cited. Applied science has the highest impact factor, followed by medicine & pharmacy and natural science.

〈Table 7〉 Analysis of Impact Factor for Science and Technology Journals in Korea

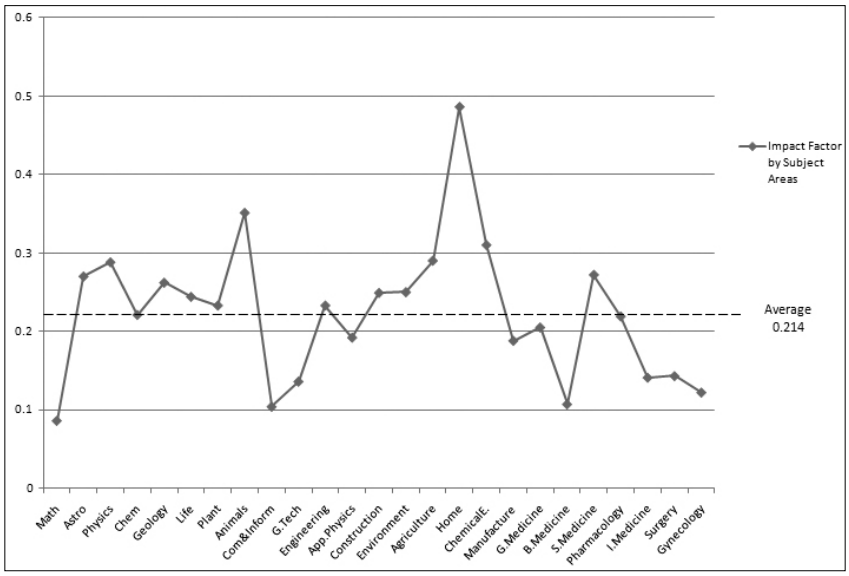
Subject Area	Sample	Average	2009 IF			
			0~0.05	0.05~0.15	0.15~0.30	Over 0.30
Natural Science	72 Types	0.167	6.9%	25.0%	40.3%	27.8%
Applied Science	228 Types	0.248	13.6%	29.4%	32.5%	24.6%
Medicine and Pharmacy	100 Types	0.228	18.0%	41.0%	28.0%	13.0%
Total	400 Types	0.208	13.4%	33.8%	32.2%	20.6%



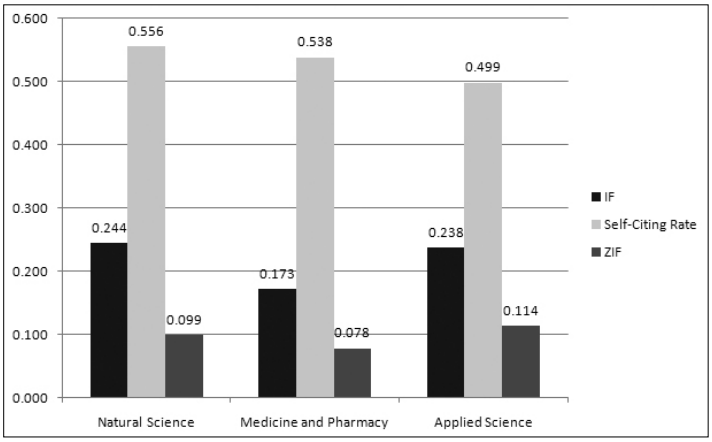
〈Figure 9〉 Distribution of Impact Factors

<Figure 9> shows the distribution of impact factors analyzed comprehensively. <Figure 10> presents the distribution of impact factors depending on subject.

<Figure 11> illustrated the ZIF (Z Impact Factor) by disciplines, which is the impact factor accounting for the removal of instances of self-citation. The result showed that the average journal self-citation rate was the highest in natural science, medicine & pharmacy and applied science in that order. And the ZIF was the highest as follows: natural science, applied science, and medicine & pharmacy.



〈Figure 10〉 Analysis of Impact Factors (by Subject)



〈Figure 11〉 Impact Factor, Self-Citation Rate, ZIF

Lastly, in order to get reliable impact factor, the impact factor of 2009 from KJCR were calculated periods of 2, 3, and 5 years. And it was found that the impact factor decreases as we increase the year used to calculate the impact factor. The calculated impact factors of 2009 using these periods were 0.214 (2 years), 0.194 (3 years), and 0.172 (5 years). Overall, the impact factor was the highest in natural science, followed by applied science and medicine & pharmacy.

4. Conclusion

To understand citing behavior of Korean scientists on Korean journals, this paper analyzed cited references and citation index databases from 2005 to 2009 available from KSCD. In addition, the impact factors of 2009 (2 years, 3years, and 5 years) for science and technology fields in Korea were calculated by using KJCR of KISTI in order to measure the influences of those journals.

The following is a summary of the results of this research. First, there were differences in the number of citations depending on subject in science and technology. Also, the number of authors was increasing as well as the number of articles written in English. Second, the results showed that the most highly cited document type was journal articles, and it also showed that the percentage of document types cited was different by subject area. Third, on average, 72.35% of documents cited by Korean journals in science and technology fields were foreign articles, and 30% of cited documents belonged to a field that was not researchers primary field of study. Fourth, the immediacy citation rate (average 2.36%), peak-time (average 1.7 years), and half-life (average 5.2 years) of cited journals were revealed through the analysis of citation age for science and technology journals in Korea. Finally, the impact factor for science and technology journals in Korea was measured by using KJCR indicators. As a result, the average impact factor was determined to be 0.214, and the average journal self-citation rates was more than 50% in every field. The result also indicated that the impact factor decreases as the period for calculating the impact factor increases (i.e., 2 years, 3 years, and 5 years).

From this research, citing behavior of Korean scientists was synthetically analyzed. And the reliable statistical information regarding citation of science journals in Korea was acquired. This accurate information for citation can provide future implications to researchers in science and technology and in scientific information service. In future research, the scope of this research will be broken down and the scope of KSCD is going to be widened by linking to supplementary databases for a more accurate and reliable analysis.

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