

Research Impact of Open Access Research Contributions across Disciplines

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Abstract

The study is based on 4,413 papers identified from Elsevier's Scopus for various fields from 2000 to 2004 to assess the research impact of OA journal articles, from DOAJ based journals, using sampling techniques following 'R' software. It focuses to test the hypothesis "OA articles in hard, urban and convergent fields receive more citations (hence higher research impact) than those in soft, rural and divergent subjects, besides a comparative study of research impact across disciplines, supported with experimental method and literature review.

Keywords: Research Impact, urban and rural disciplines, hard and soft disciplines, Open Access impact

1. Introduction

Many grounds demand universal open access to scholarly information. The rising cost of scholarly materials particularly journals; stable or declining budgets; declining numbers of society publishers providing reasonable pricing; mergers within the commercial publishing industry resulting in less competition and increased prices; and a shifting emphasis from communicating scientific information to generating profits for publishing company stakeholders, have left the scientists around the world inaccessible to the current literature in the field. These access barriers represent impact barriers for research and researchers where careers largely depend on visibility and eventually on citation counts (1,2,3)

Open access calls for the free availability of scholarly literature on the internet. The open access movement has gained significant momentum over the past several years. It maintains that all scientific and scholarly literature should be available to all for free via the internet. (4,5) More recently, research funders and research institutions in several countries have been proposing official policies to actively encourage or even require their fundees and employees to self-archive their research output in order to make it freely accessible online to all potential users, rather than leave them accessible only to those who can afford the journals in which they happen to publish (6) What makes OA so important is its potential effect on visibility, usage and impact of research. The careers and funding of researchers depend on the uptake of their findings- as does the progress of research itself. Academic institutions, federal agencies, publishers, editors, authors and librarians increasingly rely on citation analysis for promotion, tenure funding, and reviewer and evaluation and selection decisions (7). It is now established that research impact has increased by open access. It is in this context that the present paper endeavors to make a comparative study of research impact of OA articles across six disciplines through citation analysis.

2. Objectives

The following objectives are laid down for the study:

- i) To assess the research impact of OA journal articles across disciplines.
- ii) To compare the research impact of OA journal articles across disciplines.
- iii) To verify the hypothesis drawn for the purpose.

3. Scope

The scope of the study is limited to Open Access articles appearing in 24 English language 'OA' journals in the field of Physics, Chemical Engineering, Sociology, Psychology, Economics and Environmental Science.

4. Related Literature

Lawrence (2001)(8) analyzed 1, 19,924 conference articles in computer Science across 1990-2000 and found that OA articles are cited 4.5 times more than non-OA articles. Antelman (2004) (9) studied the research impact of OA vs. non-OA articles across four disciplines and found that OA articles have a greater research impact than non-OA articles in all the four disciplines. Further OA articles in Mathematics and Electrical & Electronics Engineering have a greater research impact than those in Political Science and Philosophy. Harnad & Brody (2004) (10) compared the citation counts of individual OA and non-OA articles appearing in the same (non-OA) journal which reveals the citation advantage for OA. (10) found that OA increases the impact of publicly funded research after studying the OA impact advantage across all the disciplines using a 12 year sample of 14 million articles. In another study by Hajjem, C., Harnad, S., & Gingras, Y. (2005) (11) covered ten disciplines across 12 years and found that OA articles have consistently more citations and it is unlikely that OA citation advantage is merely or mostly a self-selection bias (for making only one's better articles OA). Esysenbach (2006) (12) used web of science database to find the impact factor of prestigious journal "Proceedings of the National Academy of Sciences (PNAS)", publishing both OA and non-OA articles. It reveals that OA articles published side by side with non-OA articles are cited more quickly and twice compared to non-OA articles. Tonta, Unal & Al (2007)(13) studied the research impact of OA articles across nine disciplines and found that the research impact varies from discipline to discipline. The OA articles in Biology and Economics has the highest research impact, compared to OA articles in hard, urban and convergent disciplines (such as Physics, Mathematics and Chemical Engineering). Hajjem, et al (2005) (14) analyzed the citation impact of OA articles across four disciplines (Biology, Business, Psychology and Sociology) using ISI CD-ROM database from 1992-2003 and found a citation advantage of 25%-250% for OA articles. To examine the cause of OA research impact in the field of Astronomy Kurtz, et al. (2005) (15) analyzed OA (Open access), EA (early access) and SB (self-selection bias) postulates and found that there is a strong EA and SB effect for higher citations than OA effect

5. Methodology

5.1 Selection of Journals

The directory of OA journals (www.doaj.org) was used to select OA journals in six disciplines. Mono-lingual (English language) journals dealing with a single discipline and having back issue available since 2000 were selected. Since Elsevier's Scopus database is used for identification of citations, the journal titles not covered by Scopus were excluded.

5.2 Selection of articles

The 'O A' articles selected for the study belong to period of 2000, 2002, & 2004 in the disciplines of Physics, Chemical Engineering, Economics and Environmental Science, while papers published between 2000-2004 in the field of Psychology and Sociology as the frequency of these articles being low in the journals. The articles of each journal after arranging them in chronological order, a 10% sample was randomly selected using function "sample" of 'R' software. (R Development)(16). Scopus, as a tool for identification of citations, was used in view of the following revelations from the literature.

Jasco(2005) (17) compared WOS, Scopus and Google Scholar citation databases in terms of their major features and found that Google Scholar lacks competence and understanding of basic issues of citation indexing. Meho & Yang (2006)(18) found that use of Scopus and Google Scholar in addition to WOS significantly alters the ranking of scholars through citation counts. Burnham (2006)(19) found that Scopus and WOS complement each other as neither resource is all inclusive. WOS has advantage over Scopus in the depth of coverage, with the full WOS database going back to 1945 and Scopus going back to 1966. Baur & Bakkalbasi (2005) (20) found that WOS provided the largest citation counts for the articles published in 1958, whereas Google Scholar provided higher citation counts for the articles published in 2000 from the Journal of American Society for Information Science and Technology (JASIST). There is no difference in citation counts between WOS and Scopus for the articles published in 2000. Bakkalbasi, Bauer, Glover & Wang (2006) (21) found that WOS retrieved higher citation counts for articles published in Oncology and 'Condensed Matter Physics' journals in 1993 than Scopus and Google Scholar. Scopus showed higher citation counts for more current (2003) Oncology articles whereas Google scholar provided largest set of unique citations for current (2003) on Oncology articles. The Institute for Scientific Information (ISI) citation database is used for decades and often as the only tool for locating citations and conducting citation analysis. ISI databases (or web of science), however may no longer be adequate as the only or even the main sources of citation because new databases (like Scopus, Google Scholar, etc) and tools that allow citation searching are now available. (Meho and Yang, 2006) (22).

The 441 OA articles thus selected were searched for citations in Scopus database. The number of citations, self citations, date and other details were recorded for each article. (Table -1) The data is tabulated and analyzed in a systemic way to reveal findings in accordance with desired objectives. The standard statistical techniques were used to estimate various statistical tests.

| Subject | DOAJ journals | Sample journals | Total articles | Sample articles |
|---------------------------|---------------|-----------------|----------------|-----------------|
| Physics | 69 | 6 | 2738 | 274 (10.00)* |
| Chemical Engineering | 15 | 3 | 842 | 85(10.09) |
| Psychology | 79 | 4 | 188 | 19(10.10) |
| Sociology | 57 | 4 | 102 | 11(10.78) |
| Economics | 65 | 4 | 233 | 24 (10.30) |
| Environmenta l Science | 54 | 3 | 276 | 28(10.14) |
| Total | 339 | 24 | 4379 | 441(10.07) |

Table 1: Sampling Statistics
*Figures in parenthesis indicate percentage.

6. Hypothesis

Hypothesis formulated for the purpose of testing reads: "OA articles in hard, urban, and convergent disciplines have higher research impact than those in soft, rural and divergent disciplines"

The queue is taken from the study of Tonta, Unal and Al(2007)(23) who bases his study on previous

studies Whitley(2000)(24), Antelman(2006) (25), Becher & Trowler(2001) (26) and classifies the disciplines in hard/soft, urban/rural, convergent/ divergent fields. The Physics and Chemical Engineering represent hard/urban/convergent disciplines, as these are hard and Applied Sciences that are convergent for having close relationship with other discipline and urban in their social aspects. Sociology and Psychology represent soft/rural/divergent, as these are soft and concentrate on rural issues and divergent in nature. The disciplines Economics and Environmental science represent mixture of hard/soft, urban/rural, convergent/ divergent components.

7. Results and Discussion

The 441 OA articles received a total 1052 citations (Mean =2.38, S.D. =4.96). The average number of citations per OA articles varied from discipline to discipline and from journal to journal within various disciplines. The Economics received highest average citations (3.33) whereas the Sociology the lowest (0.27). *Demographic Research* received the highest average citations (5.12) whereas *IDEA: a journal of social issues, Journal of Memetics- evolutionary models of information transmission* the lowest (0.00) among the journals. The distributions of citations for all disciplines are Skewed (as the S.D. for all disciplines are higher than averages). The standard deviation within journals varied from 10.67 (*Brazilian journals of Physics*) to 0.00 (*Psyche: an interdisciplinary Jr. of research on consciousness*). (Tables 2-4.)

| S. No. | Name of the Journal | Total articles | Total citations | Self citations | Mean | Median | Mode | S. D. | Half life (in years) |
|--|---------------------------------------|----------------|-----------------|----------------|------|--------|------|-------|----------------------|
| 1 | Acta Physica Polonica B | 88 | 290 | 57 (19.65)* | 3.29 | 2 | 0 | 4.91 | 3 |
| 2 | Brazilian jr. of Physics | 55 | 167 | 56 (33.53) | 3.03 | 1 | 0 | 10.67 | 4 |
| 3 | Entropy | 6 | 19 | 7 (36.84) | 3.16 | 3 | 0 | 3.12 | 3 |
| 4 | New Journal. of Physics | 34 | 85 | 16 (18.82) | 2.5 | 1 | 0 | 3.07 | 3 |
| 5 | Pramana: Jr. of Physics | 73 | 80 | 22 (27.5) | 1.10 | 0 | 0 | 2.09 | 4 |
| 6 | Turkish Jr. of Physics | 18 | 13 | 3 (23.07) | 0.72 | 0 | 0 | 1.4 | 5 |
| Physics | | 274 | 654 | 161 (24.61) | 2.38 | 1 | 0 | 5.81 | 3 |
| 1 | Brazilian Jr. of Chemical Engineering | 22 | 40 | 13 (32.5) | 1.81 | 1 | 1 | 2.01 | 4 |
| 2 | Iranian Polymer Journal | 13 | 20 | 8 (40.0) | 1.53 | 1 | 0 | 1.85 | 3 |
| 3 | Jr. of Chemical Engg. Of Japan | 50 | 137 | 55 (40.14) | 2.74 | 1.5 | 1 | 3.32 | 4 |
| Chemical Engineering | | 85 | 197 | 76 (38.57) | 2.31 | 1 | 1 | 2.86 | 4 |
| Physics & Chemical Engineering. | | 359 | 851 | 237 (27.84) | 2.37 | 1 | 0 | 5.26 | 4 |

Table2: Citation Count of OA articles (n Physics and Chemical Engineering)
* Figures in parenthesis indicate percentage

Out of 24 journals two journals (*IDEA: a Journal of social issues & Journal of Memetics-evolutionary models of information transmission*) receives no citation. Four journals receive only one citation each. Out of 1052 citations 294 (27.94%) are self citations. The self citation rate differs from discipline to discipline and from journal to journal within disciplines. The Environmental Science gets the highest self citation rate (46.15%) whereas the Sociology received no self citation (0.0%). Out of 441 articles 164(37.18%) receives no citation, 100(22.67%) articles receive one citations each, 49(11.11%) articles receive two citations each and 38(8.16%) receive three citations each and 90(20.40%) articles more than three citations. The highest rate of citation is received by Sociology (72.72%) and the lowest by Economics

(16.66%). Out of 24 journals the top five research impact journals belong to Economics(2), Environmental Sciences(1) and Physics(2). The top ten research impact articles are from Physics(6), Chemical Engineering(2), Economics(1) and Environmental Science(1). The top ten research impact articles receive 236(22.43%) citations in aggregate. (Table 5)

| S. No | Journal | Total articles | Total citations | Self citations | Mean | Median | Mode | S. D. | Half life (in yrs) |
|-----------------------------------|---|----------------|-----------------|----------------|------|--------|------|-------|--------------------|
| 1 | Current Research in Social Psychology | 10 | 13 | 3 (23.07)* | 1.3 | 0.5 | 0 | 1.82 | 3 |
| 2 | Dynamical Psychology | 3 | 1 | - | 0.33 | 0 | 0 | 0.57 | - |
| 3 | Journal Of technology in counseling | 5 | 12 | 1 (8.33) | 2.4 | 2 | 1 | 1.67 | 3 |
| 4 | Psyche | 1 | 1 | - | 1 | 1 | 1 | 0.00 | 4 |
| Psychology | | 19 | 27 | 4 (14.81) | 1.42 | 1 | 0 | 1.67 | 3 |
| 1 | Jr. of Criminal justice & popular culture | 4 | 2 | - | 0.5 | 0.5 | - | 0.57 | 4 |
| 2 | IDEA: a Journal of social issues | 1 | 0 | - | 0.0 | 0 | 0 | 0.00 | - |
| 3 | Journal of Memetics | 2 | 0 | - | 0.0 | 0 | 0 | 0.00 | - |
| 4 | Theory & Science | 4 | 1 | - | 0.25 | 0 | 0 | 0.5 | 5 |
| Sociology | | 11 | 3 | - | 0.27 | 0 | 0 | 0.46 | 4 |
| Psychology & Sociology | | 30 | 30 | 4 (13.33) | 1.00 | 0.5 | 0 | 1.46 | 3 |

Table3: Citation Count of OA articles (Psychology and Sociology)
*Figures in parenthesis indicate percentage

| S.No | Name of the Journal | Total articles | Total citations | Self citations | Mean | Median | Mode | S. D. | Half life (in yrs) |
|--|-----------------------------------|----------------|-----------------|----------------|------|--------|------|-------|--------------------|
| 1 | Asian Development Review | 3 | 12 | - | 4.00 | 4 | - | 1.00 | 4 |
| 2 | IMF Staff papers | 9 | 21 | 2 (9.52) | 2.33 | 1 | 1 | 2.59 | 6 |
| 3 | Demographic Research | 8 | 41 | 9 (21.95) | 5.12 | 4.5 | 1 | 4.76 | 4 |
| 4 | Jr. of Regional analysis & Policy | 4 | 6 | - | 1.5 | 1.5 | - | 1.29 | 3 |
| Economics | | 24 | 80 | 11 (13.75) | 3.33 | 2.5 | 1 | 3.42 | 4 |
| 1 | Electronic green Journal | 3 | 1 | - | 0.33 | 0 | 0 | 0.57 | 4 |
| 2 | Park Science | 4 | 3 | 1 (33.33) | 0.75 | 0.5 | 0 | 0.95 | 1 |
| 3 | Water S. A. | 21 | 87 | 41 (47.12) | 4.14 | 2 | 0 | 5.09 | 4 |
| Environmental Science | | 28 | 91 | 42 (46.15) | 3.25 | 1 | 0 | 4.67 | 5 |
| Economics & Environmental Science | | 52 | 171 | 53 (30.99) | 3.28 | 2 | 0 | 4.10 | 5 |

Table4: Citation Count of OA articles(Economics and Environmental Science)
*Figures in parenthesis indicate percentage

Half life period (time taken to receive half of all citations) differs from discipline to discipline and from journal to journal within each discipline. The half life period estimated for Physics and Psychology is 3 years. It is 4 years for Chemical Engineering, Sociology and Economics whereas it is calculated 5 years for Environmental Science. However, the highest half life period amongst the journals is 6 years for *IMF Staff Papers*.

| S. No | Title/Author/Volume/Year of Publishing of the article . | Citation Count | Title of the Journal |
|-------|--|----------------|--|
| 1 | Paths to Self-Organized Criticality/ Ronald Dickman, Miguel A. Muñoz, Alessandro Vespignani, and Stefano Zapperi/ 30, 1/2000 | 78 | Brazilian Journal of Physics ** |
| 2 | Chiral Doubling of Heavy--Light Hadrons: BaBar 2317 MeV/c ² and CLEO 2460 MeV/c ² Discoveries /M.A. Nowak, M. Rho, I. Zahed /35,10/2004 | 34 | Acta Physica Polonica B**** |
| 3 | Soil-water utilisation and sustainability in a semi-arid grassland/ HA Snyman /26,3/2000 | 20 | Water SAP |
| 4 | The Hadronic τ Decay of a Heavy H^{bpm} in ATLAS /Ketevi Adikle Assamagan, Yann Coadou/33,2/2002 | 19 | Acta Physica Polonica B**** |
| 5 | The Ising Model and Real Magnetic Materials /W. P. Wolf /30,4/2000 | 16 | Brazilian Journal of Physics** |
| 6 | Removal and Recovery System of Hexavalent Chromium from Waste Water by Tannin Gel Particles /Yoshio Nakano, Michihito Tanaka, Yasuo Nakamura and Masayuki Konno / 33,5/2000 | 15 | Journal of Chemical Engineering of Japan** |
| 7 | Extraction Mechanism of Rare Metals with Microcapsules Containing Organophosphorus Compounds / Eiji Kamio, Michiaki Matsumoto and Kazuo Kondo/ 35,2/2002 | 15 | Journal of Chemical Engineering of Japan** |
| 8 | From Atomic Physics to Solid-State Physics: Magnetism and Electronic Structure of PrNi ₅ , ErNi ₅ , LaCoO ₃ and UPd ₂ Al ₃ /R.J. Radwanski, R. Michalski, Z. Ropka /31,10-11/2000 | 13 | Acta Physica Polonica B**** |
| 9 | TRIMU P --- a New Facility to Investigate Fundamental Interactions with Optically Trapped Radioactive Atoms /Klaus Jungmann/33,8/2002 | 13 | Acta Physica Polonica B**** |
| 10 | Tempo-Adjusted Period Parity Progression Measures: Assessing the Implications of Delayed Childbearing for Cohort Fertility in Sweden, the Netherlands and Spain / Hans-Peter Kohler, José Antonio Ortega / 6/2002 | 13 | Demographic Research* |

Table5: The Highest ten cited OA articles in the sample
Number of * mark(s) on the title of a journal indicates frequency of that particular journal in the list.

7.1 Testing the Hypothesis

The average citation rate for hard/urban/ convergent disciplines (Physics & Chemical Engineering) is 2.37 with Standard Deviation 5.26. Out of 851 citations received for 359 articles in this group 237 (27.84%) are self citations, 136 (37.88%) articles receiving no citation, 79 (22.00%) getting one citation each, 41 (11.42%) receiving two citations, 34 (9.47%) receive three citations and 69(19.22%) receive more than three citations. In this group the lowest citation rate was for *Turkish Journal of Physics* (0.72) and the highest for *Acta Physica Polonica B*(3.29). The highest S.D. was for *Brazilian Journal of Physics*, (10.67) while the lowest for *Turkish Journal of Physics* (1.40). The collective S.D. for Physics journals was 5.81 whereas it is 2.86 for Chemical Engineering journals. This means that distribution of citations for physics are more Skewed than those of Chemical Engineering. The half life period for this group is 4 years.

For soft/rural/divergent disciplines (Sociology and Psychology) the average citation rate is 1.00 with Standard Deviation of 1.46. There are only four self citations (13.33%) out of 30 citations for 30 OA articles. Out of 30 articles 15(50.00%) receive no citation, 9(30.00%) receives one citation, 2(6.66%) receive two citations, 1(3.33%) receive three citations and 3(10.00%) gets more than three citations. Out of the 8 journals in this group two journals receive no citation and three receive only one citation each. However the lower S.D. of this group suggests less skewed-ness in the distribution of citations. The half life period for this group stood at 3 years. In this group the highest citation rate is 2.4 for *Journal Of technology in counseling*.

The third group of Economics & Environmental Science (mixture of hard/ soft, urban/ rural, convergent/ divergent components) presents the average citation rate of 3.28 with Standard Deviation of 4.10. The

self citation rate varies significantly from 13.75% (Economics) to 46.15 % (Environmental Science). The overall self citation rate being 30.99% .Out of 171 citations received for 52 OA articles, 13(25.00%) receive no citation, 12(23.07%) receive one citation each, 6(11.53%) receive two citations 3(5.76%) receive three citations, and 18(34.61%) receive more than three citations. Out of 7 journals in this group no journal receives zero citations and one journal receives one citation. The half life period for the articles in this group is 5 years. The lowest citation rate in this group is for *Electronic Green Journal* (0.33).

Thus the hypothesis that “OA articles in hard/urban/convergent disciplines have higher research impact (receive higher citations) than those in soft, rural and divergent disciplines” is accepted. However the disciplines Economics & Environmental Science (mixture of hard/ soft, urban/rural, convergent/divergent components) receive highest citations than either of the two groups. Even if we exclude the self citations from all the disciplines, the hypothesis is still acceptable and Economics and Environmental Science still show the highest citation rate.

8. Conclusion

Research impact of OA articles varies from discipline to discipline and from journal to journal within disciplines. The hard, urban and convergent disciplines have higher research impact than those of soft, rural and divergent disciplines, but less than mixed hard/ soft, urban/ rural, convergent/ divergent disciplines. The results are some what similar to Tonta, Unal, & Al (2007).(27) However further studies need to be undertaken on a wider research canvas to ascertain the cause of varying degree of acceptance of OA by the researchers in these disciplines.

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