Bibliometrics, Reference Enhanced Databases and Research Evaluation

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ABSTRACT

This study presents the panoramic view of the described issues related to coverage, services and bibliometrics for Research Evaluation (RE) purposes by three reference enhanced databases. The researchers' viewpoint is based on the relevant literature and data accessed from most preferred citation sources: Web of Science, Scopus and Google Scholar. The study seeks the worldview challenges, highlights and theorizes the core issues for those regions and disciplines that have more challenges and fewer opportunities in getting publishing, citing and cited by. It discusses the new insights and directs the stakeholders to explore other possible sources, metrics and evaluation techniques for RE.

Keywords: Bibliometrics, Research Performance Evaluation, Web of Science, Scopus, Google Scholar.

I INTRODUCTION

Scientific progress is clearly based on scholarly communication through different channels and formats. To deal accountability and performance evaluation issues, the same pace is required to answer. There is consensus that bibliometrics are supporting and monitoring tool for research assessment. Bibliometric techniques and metrics have become more crucial due to shortcomings of peer review evaluation. Inclusion of subjective elements, halo effect and limited cognition view (Horrobin 1990; Moxham and Anderson 1992), dependence on few individual member, awareness level, conflict of opinions, and bias towards new comers and young staff (Van Raan 2003) are a few concerns regarding RE. Scholarly output represents the scientific activity (Merton, 1942) and "Bibliometric assessment of research performance is based on one central assumption: scientists who have to say something important do publish their findings vigorously in the open, international journal ('serial') literature" (Garfield, Cronin, & Atkins, 2000, p.304). The outputs can be accessed and gauged through reference enhanced databases by applying bibliometric techniques through standards procedures and statistical analysis. Such studies date back to 1940 started from USA to other regions (Zainab, 2000).

One of the most important objectives of online database providers is to offer research activity gauging services and metrics. Besides providing coverage, they offer different metrics, evaluation techniques and e-services for research performance evaluation. These references enhanced databases are managing the world's scholarly sources based on their set policies. Data collection from authoritative source is much crucial in evaluative bibliometrics. Researchers get secondary data from these references enhanced databases and then exploit to understand the existing situation to improve research performance, examine/introduce new development(s), and to explore productive and qualitative cores for RE exercise.

The major used reference enhanced databases have been a topic of great interest in bibliometric community. New trends in bibliometric research studies like comparative analysis of citation sources, discovery of new indices, and its application issues at different levels are now the hottest topics of this field. The better use of these database records, metrics and the issues of quantity and quality cores are getting critics' most attention. Literature depicts that these issues are being addressed in developed countries having rich publications and citation culture about most publications oriented disciplines. The situation becomes alarming in developing countries or regions. They have a different publications culture, citing & cited by and evaluation process. They have rather immature system of research evaluation based on quantitative metrics like publication and citation count and impact factors.

The present study describes the issues about coverage, services and metrics for research evaluation as described in relevant literature. It will also raise issues for policy makers and database providers for regional and disciplinary prospective.

II OBJECTIVES

A comparative analysis of the records, metrics, techniques, evaluations services and interface options of three popular reference enhanced databases (WOS, Scopus and Google Scholar) is presented. The aim is to illustrate a big picture for bibliometric community and policy makers about records, metrics and analytical aids. Furthermore, it attempts to theorize the described issues for the regions with fewer opportunities and more challenges to get publications at international level, to get more citations and to get evaluation by same metrics.

III METHODOLOGY

All related information (journals, conferences, patents, and other document types), indexing and abstracting services, metrics and interface searching options are extracted from the current sites of these databases. The data is presented in quite a comparable way (Table1) and comprise of two sections A, B. Section A, deals with the records of document types and, section B is about the analytical service. The second section is subdivided into metrics and evaluation services offered by databases. It is further subdivided into section B (a) with title interface and searching options. In case of ISI Web of Knowledge, information is added from its new site that has been launched in July, 2011. While, in case of Scopus and Google Scholar the recent web links are used to collect data. The literature related to concerned parameters is reviewed and presented in introduction, discussions and conclusions of the study.

IV LITERATURE REVIEW

Numbers of factors affect the choice and selection of citation databases to bibliometric studies for RE; policy (Bar-llan, 2008a), software characteristics (Jacso, 2008a), time span (Jacso, 2005a; 2005b), breadth and consistency (Jacso, 2008b), updateness (Jacso, 2010b), small field and document types (Harzing & Van Der Wal, 2008) and completeness of data (Moed, Burger, FrankFort, VaanRaan, 1985), language (Etxebarria & Uranga, 2010). Scopus offers 20% more citation coverage than WOS (Falagas, 2009). Some subjects have better coverage in Scopus than WOS (Jasaco, 2008c, Meho & Rogress, 2008). Scopus coverage is especially better in Engineering, Computer Science and Health Sciences disciplines. Jacso also viewed it as strongly S&T oriented database (2008). In Clinical Medicine, Biological Sciences, and Physical Sciences, WOS provides better coverage (Moed, 2009). WOS policies are based on Eugene Garfield's concept of measuring importance of journals through journal selection process, whereas, Scopus is less discriminative to impact of journals (Moed, 2009). The Scopus calculates significanlty high Hirsch's h-index (claims to measure quality and quantity with one index) as compare to WOS (Meho & Rogers (2008). Google's scholar's h-score for computer and mathematics is found higher than other databases (Bar-Illan, 2008a) and same is found true in case of library and information Science (Sandreson, 2008).

Scopus has better citing records as compared to WOS (Bakri, 2010; Meho and Sugimoto, 2009; Archambault, Campbell, Gingras, Lariviere, 2009), while Norris and Oppenheim seek Scopus as an alternative to the WOS to evaluate the research impact in Social Sciences (2007). Bar-Ilan, Levene, & Lin (2007) observed that both gave similar results in citation counting and ranking and in some cases it affected the middle order ranking (Meho & Young, 2007). Gavel & Iselid (2008) exposed the overlaping isuues of coverage in the subscription of sources. Eighty four percent titles of WOS and 54% titles of Scopus overlaped each other. Scopus carried 24.29% more articles than WOS when searched for Malaysian Computer scientists and overlapping in publications was 35% (Bakri, 2010). Scopus covered most of impact factor journals of WOS coverage (López-Illescas, de Moya- Anegón, & Moed, 2008; Gorraiz & Schloegel, 2008). Many studies empirically found that Scopus was superior in citing records indexed (Gavel & Iselib, 2008; Meho and Sugimoto, 2009; Archambault et al., 2009; Lopez-Iiilescas et al., 2009; Vieira and Gomes, 2009; Meho and Rogers, 2008). That is why the h-index generated by scopus is significanlty high (Meho & Rogers (2008).

The size, source base, and composition of a database of a specific subject records are well facilitated in Scopus and Web of science (WOS) than Google Scholar (GS) (Jacso, 2005a). GS can be used as a "possible alternative" (Meho & Rogres, 2008) and it is criticized due to its 'inconsistent accuracy' (Falagas, Pitsouni, Malietzis & Pappas, 2009). Pérez (2009) investigated the variations of h-index among WOS, PsycINFO and GS. The citation error in the psychology publication record from WOS was rare (only 3%) as compare to GS and PsycINFO. For publication productivity, GS outperformed the other consulted sources. Norris and Oppenheim rejected its use to measure scholarly activity (2007). For disciplinary perspective, Jacso mentioned the unlimited time span, publishers, journal's list and discipline specific records as three limitations of GS (2005b). Previously, this database was criticized due to less coverage to academic publications, rarely updated, secretive about publishers and coverage of disciplinary resources, treatment of structured and unstructured data, inconsistency in retrieving data (Jacso, 2005a), dysfunctional research option and its literary genealogy (Jacso, 2005b). Price (2004) disclosed its indexing limit by 100-120K only. Redundancy, stray and orphan references are more problematic in case of GS to handle (Jacso, 2005b). Jacso raised the pragmatic issues and pointed out that its citation matching algorithm was worse (2006) and its metadata was like a great mess (Jacso, 2010a). GS has positive advantages over other databases due to better coverage to other languages (Meho, 2007), conference proceedings (Mohe and Yang, 2007) and, indexing & abstracting services (Jacsó, 2005a; Bauer and Bakkalbasi, 2005). GS is a reliable citation database and can be used for bibliometrics analysis (Sanderson, 2008).) Rely on only one database is enough and in some subjects the comparative results showed significantly correlation (Meho and Rogress, 2008). Jacso regrets the use of GS for policy decision mainly due to inflated and dysfuctional search as the corroboration of its citation count is very cumbersome (2010). The error found as expected outcomes via GS was less as described by Jacso (Harzing and Wander Wall, 2008). Citation databases produce quantitatively and qualitatively different counts (Kulkarni, 2009). Jacso (2006) also pointed the issues regarding social science disciplinary coverage due to less self archiving and other web posting for commercial databases. In social sciences the prestigious Spanish researchers published significantly in local and less appeared in above mentioned three databases (Etxebarria, & Uranga, 2010). GS found to be more suitable for both scientific productivity and impact for humanities (Baneyx, 2008), wider coverage of non-journal documents by GS (Kousha & Thelwall 2008), can help to identify a significant number of unique citations (Meho & Yang, 2007).

V SECTION A

A Web of Science via ISI New Web of Knowledge

The ISI launched its updated website "New Web of knowledge" with slogan "The Discovery Starts Here". Their claim is "a first choice of about twenty thousand millions researchers of ninety countries to stay relevant and evaluating impact". The data tracked from (New Web of Knowledge, n. d.) showed the total records were about forty six million out of which pre-1996 coverage was about twenty six million and after 1996 was twenty million across all disciplines published by three thousands and three hundred publishers. Total subscribed journals were twenty three thousands out of which approximately eleven thousands (high impact) can be accessed through WOS. It is important that journals access from WOS is by default for all years. Proceeding indexes in Sciences and Social Science can be assessed via WOS. More than five million papers with one hundred and ten thousands proceedings since 1990 were available on the ISI Web of Knowledge (WOK) platform. Since 2008, two editions of Conference Proceedings Citations Index (CPCI) coverage on WOS interface have added (see Section A of table). It is also providing a large number of access to Patents via Derwent Innovations Index ^{SM} (back files to 1963). Patent citation index is available to 1973 and access via WOS is also possible. It claims about nearly hundred percent indexing of cited references from 1900 and access to nine thousands websites. Data is now indexed using common vocabulary. Moreover, few disciplines specific citation index like BIOSIS Citation Index, Biological Abstracts, Zoological Record, MEDLINE, Global Health, Food Science and Technology Abstracts with back files in the field of health, medicine biology and zoological sciences are available. For physics, INSPEC , and for agriculture sources CAB abstracts with back files to 1898 and 1910 are valuable sources for research, academic and bibliometric purposes (New Web of Knowledge, n.d.). WOS coverage to all disciplines with more focus on Sciences was 67% to journals records (Jasco, 2005b). During 2005 to 2008, the increase in total record was about 16% (40.5-35 millions) and from 2009 to 2011it was 14% (46-40.5 millions) (Table1).

B SciVerse Scopus

Another commercial database, Scopus was launched in 2004 from the platform of ELSEVIER. It claims for world scientific publications coverage of about seventy percent. It is providing full text, indexing and abstracting services of 44.4 million records with 70% of content from international sources. Out of which, twenty one millions records were pre 1996 -1823 and the remaining belonged to 1996-2011, published by five thousands publishers. Scopus offered titles were approximate eighteen thousands and five hundred with four hundred trade publications and three hundred book series. Three hundred and fifteen million scientific web pages were indexed via Scirus with archived of Elsevier, Nature, and the journal Sciences. Since 2005, there was about twenty two percent increase in journals availability and twenty five percent in publishers (SciVerse Scopus, n.d.). Scopus in 2005, had slightly better coverage of abstracts whereby, 1/3 of total record had citation (Jasco, 2005b). This feature serves as an important role in increasing the relevancy of information and has a positive edge (Jacso, 2010). The citation search was limited to 1996 nonetheless, a good number of citation record was also available to pre-1996 (Jacso, 2008a).

Subject distribution by Scopus and WOS shows (see Figure 1) the strong obeisance towards Science disciplines. Within Sciences the percentage coverage of Physical Science, Health Science and Life Science were 31%, 29% and 18% respectively. The Social Science had 31% of total records. WOS Journal distributions by citation indexes of SCIE, SSCI and A&HCI are 67%, 21% and 12% of its total coverage. The total journals records of Scopus and WOS were 24,600 and 12,086. It depicts about 51, 00 and 1,086 journals are inter/ multidisciplinary in nature. WOS deals Arts and Humanities separately but Scopus doesn't. Scopus modestly covered social science, arts and humanities (Jacso, 2008c). Scopus has more coverage in natural science and engineering (Archambault et al., 2009).

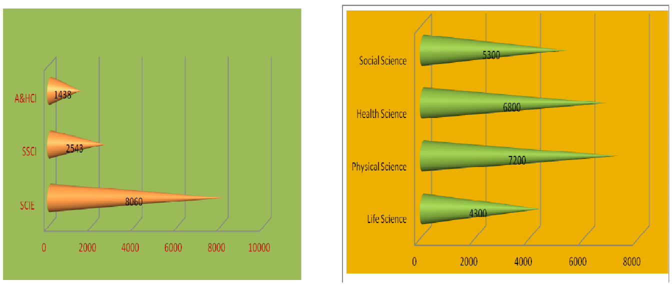

Figure 1. Subjects Distribution in WOS and Scopus

C GOOGLE SCHOLAR

GS, a free indexing source by the most popular platform of Google was also launched 2004. In line with the Google policy, it is providing full text, indexing and abstracting services to stakeholders with links to e-sources in various formats. Access to worldwide e-journals, links to open and subscribed access e-repositories, e-libraries, legal/court opinions and selected web pages have made it a potential challenge for research and evaluation purposes. Availability of full author written abstract or first page of restricted scholarly work is positive contribution for researchers and bibliometric community (Google Scholar, n. d.). This service is blessing for search and evaluation purposes throughout the world level and specifically for those regions that can not subscribe commercial databases due to financial constraints.

SECTION B

A Metrics and Evaluation Services

Previously, the bibliometricians and policy makers used publication count, citation analysis and Impact Factor (IF) to judge the quantity and quality of scholarly research at micro, meso and macro levels. After Harisch's h-index in 2005, a range of metrics has been introduced. Generally, the focus of the studies was to evaluate the subject(s) to determine the current patterns of writing and publishing, publications counts, prolific authors, citation analysis, impact factors of journals, individuals, institutions with the applications of traditional metrics or the new developments like h-index and its subsequent variances. These new developments got the considerable interest of this community. Eventually, the citation database providers included these indices (see Section B). For citation tracking WOS use the "Cited Reference Search" tab, while Scopus "View Citation Overview" and GS "Cited By" feature in the search results. Article influence, Eigenfactor, Impact Factor, Journal Analyzer, Journal Citation Reports, SJR, SNIP are used for journal evaluation (Guides to Resources, n. d.). After Harisch's h-index two other important metrics to gauge the quality and impact were introduced. The Normalized Impact per paper (SNIP) was introduced by Henk Moed. It "measures contextual citation impact by weighting citations based on the total number of citations in a subject field. The impact of a single citation is given higher value in subject areas where citations are less likely and vice versa". Another one is SCImago Journal Rank (SJR) by Félix de Moya. It is a "prestige metric based on the idea that 'all citations are not created equal'. With SJR, the subject field, quality and reputation of the journal has a direct effect on the value of a citation (SciVers Scopus, n.d.) (Table1).

B Interface Search Options

Interface design and options for searching purposes are most important features of the use and usability of e-databases. WOS claims "intuitive interface" for 'Search for' purpose. It offers thirteen searching key words. Six unique to others are; topic, editor, year published, document type, funding agency and grant number (Web of Science, n. d.). While, Scopus has simple one window interface design. It offers twenty one key words options for "Search in". The unique of them are; abstract, key words, source title, language, ISSN, DOI, CODIN, references, chemical name, and CAS number. Similarly, GS has one window interface with no such specific mentioned search options and works on page rank technology (Ttable1)

VI FINDINGS

The literature and the data of current web links provide insightful information. First two databases compete in favorable ways in terms of total data coverage, journal subscriptions evaluation metrics and services. Whereas, the GS with the slogan "stand on the shoulders of giants" have got the attentions of bibliometric community. Mainly, due to use of its page rank technology and 'cited by features' through access to unlimited sources in various formats. To retrieve and evaluate academic citations from GS becomes an easy and more reliable process with the availability of free Publish and Perish (POP) software (Harzing, 2011). POP's particular designed search features have improved the usability, efficiency and reliability of raw citation data for evaluation purposes using different metrics. The use of GS via POP gives more coverage to citation of humanities disciplines (Baneyx, 2008). Earlier, it was a very cumbersome and time consuming process to clean up GS data for evaluation process. Based on the data summary, some general findings can be inferred:

- There is a continuous increase in total records of commercial databases. The healthy competition among these citation sources pushes them to minimize the shortcomings.
- ISI web of knowledge provides more coverage and long history to pre-1996 scholarly literature. The strength of WOS falls in coverage, time span and journal selection policies. WOS was mostly criticized due to non access of conference data. During last three years two editions of CPCI in science (CPCI-S) and Social Science & Humanities (CPCI-SSH) has been added.
- Abstracting services are better in case of Scopus and GS.
- Scopus is being criticized due to its limited coverage and duration. However, it is empirically found by Jacso that its data coverage is underestimated. Inclusion of Citation Journal Reports (CJR) and abstracting services has increased its worth.
- Commercial databases are friendlier to Science, Technology, Engineering and Mathematics (STEM) disciplines than Humanities, Arts, Social and Physical Science (HASS). Scopus is more science oriented. Similarly, the metrics offered have more suitability to evaluate STEM than HASS disciplines for evaluation purposes.
- The use of WOS for research studies and evaluative purpose is more than Scopus or any other database.
- GS is more criticized because of its hidden aspects, messy data, providing more publication and citation counts. Due to coverage of unlimited sources and formats, it is more suitable to HASS disciplines.
- In few cases, significant overlapping of journals subscription is observed, so the subscribers must consider this point before approaching to both databases (WOS and Scopus)
- In rich publication and citation culture, their records, services and techniques are much helpful for bibliometrics analysis to understand the trends and patterns of productivity and impact. However, the application and use of these services are challenge for subjects having less coverage, poor publishing and citing practices.
- The policy regarding the inclusions of web links of commercial databases is not clear.

VII DISCUSSION AND CONCLUSIONS

Few other sources like Scirus, SiteSeer (a subject specific), Technological Innovation Database from China and BibTechMon, Illumina ACM digital library, IEEE explore, Arnetminer have also been used in bibliometric studies. These services are playing important role to understand trends in publications and citations. By applying new analyzing techniques, one can get the productivity and citation reports with limitations of data coverage and counting problems.

The current situation is more suitable to countries having well established publications and citations system. In this scenario, RE practices with metrics are found to be correlated. There are severe lack of studies particularly in developing countries context about the disciplinary coverage of citation sources, applicability and suitability of new metrics, objective vs. subjective issues (quantitative vs. qualitative core), use and usability of these databases and interface design. The most important of among these issues is the exploration and understanding of application of the metrics within disciplinary perspectives (STEM vs. HASS). These issues need to be considered from different stance in those regional perspectives where weak correlation observed. The governmental policies regarding research accountability issues are being revised. The quantity and quality indicators have become crucial concerns for stake holders and their need for RE cannot deny. Bibliometricians believe that citing and cited by is a complex process and there is no ideal monitoring mechanism that works in isolation and requires metrics to supplement or complement the process. Many questions about quantity regarding publication and quality like citation, IF and use of new metrics are emerged. The big challenge is either these services are meant for real contexts. Good amount of literature publish in open access repositories and is not indexed in WOS or Scopus. GS would be a good choice for such cases that have less coverage or no subscription in commercial databases.

The challenges for services providers and bibliometric community are to revisit their policies to more subject specific databases, attention to neglected disciplines and regions. Researcher's satisfaction level of being evaluated with these metrics, culture of citing and cited by and application of new evaluation techniques are needed to explore. Understanding of disciplinary perspectives, new epistemological views of stake holders about the limitations to record selection, metrics and evaluation techniques should be encouraged for future studies.

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Table 1. Comparative Analysis of Largest Citation Databases Coverage, Evaluation Metrics, Services and Interface Search Options

Attributes	New Web of Science (WOS)	SciVerse Scopus	Google Scholar via Google search engine
Type	Commercial	Commercial	Non commercial
Section A: Coverage journals, Subjects and Conferences proceedings	Total journals= 11,261 **Subject Coverage** • Science Citation Index Expanded -1945 to present • Journals= 8,060 Journals • Disciplines=173 to 1900 • Social Sciences Citation Index (SSCI) =6.4 million records-1956 to present • Journal = 2,543 • Disciplines= 55 to 1990 • Art & Humanities Science Index (A&HCI)= 3.7 million - 1975 to present • Journal= 1,483 • Chinese Science Citation Databases via WOS **Conference Proceedings** • Conference Proceeding Citation Index - Science (CPCI-S) -- 2004-present • Conference Proceedings Citation Index- Social Science & Humanities (CPCI-SSH) --2004-present Total records= 5.2 millions Proceedings= 110,000 VIA CPCI Subject categories=250	• Peer reviewed journals =17,500 **Subject Coverage** • Life Science(> 4,300 titles) • Physical Sciences (> 7,200 titles) • Health science (> 6,800 titles. • Social Sciences and Humanities (> 5,300 titles). **Conference papers**= 4.4 millions from proceedings and journals. Total records= about 44.4 million • Pre 1996 -1823= 21 millions • After 1996= 23 millions • Approximate titles= 18,500 • Publishers= 5,000 • Trade Publications= 400 • Book Series = 300	• Access to Worldwide online journals. **Subject coverage** • Life Science, and Environmental Science • Medicine, Pharmacology, and Veterinary Science • Business, Administration, Finance and Economics • Physics, Astronomy, and Planetary Science • Chemistry and Material Science • Social Science, Arts and Humanities • Engineering, Computer Science, and Mathematics. • **Include conferences and proceedings** • Links to open and subscribed access e-repositories • Links to e-libraries • Links to web pages
Patents	Records= 23 million to 1963 • Chemical Section (1997-present) • Electrical and Electronic Section (1997-present) • Engineering Section (1997-present) • Issuing Authorities= 40	Records= about 24.4 millions From 5 patents office	Include Patents
Section B Metrics Offered & Evaluation Services	• Publication count • Citation analysis • Journal Impact Factor via JCR • h-index • Citation Mapping • Citation Report • Author Finder • Researchers ID integration. • Eigenfactor *TM*	• Publication count • Citation analysis • Journal analyzer via CJR • h-index • h-graph • Citation tracker. • SJR • SNIP	**Via Publish and Perish (POP)** • Publication count & Citation analysis • Hirsch's h-index and related parameters • Egghe's g-index & Zhang's e-index • The contemporary h-index • The age-weighted citation rate • Two variations of individual h-indices • Number of authors per paper. • Individual h-index (original) • Individual h-index (POP variation) • Multi-authored h-index.
Section B (a) Interface and Searching Options	• Intuitive interface **Search options** • Search & Cited reference search • Advanced search • Search history • Marked list **Search for:** • Thirteen Options	• Simple, one window interface **Search Options** • Author search • Affiliation search • Advanced search **Search in:** • Twenty options	• Simple, one window interface **Search Options** • Simple search • Article • Include Patents • Legal Opinions and Journals • Advanced scholar search

Sources: (New web of Knowledge; n.d. ; Web of Science; n.d.; SciVerse Scopus, n.d.; Google Scholar, n.d., Harzing, 2011)