JSCIRES RESEARCH ARTICLE

Indo-Korean Co-Publications: An Analysis Using Asymmetric (α) Index

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ABSTRACT

This paper concerns about the development and use of an asymmetric index (α) for the computation of the co-publications between two countries in a scientometric perspective. Korea and India are selected as assessing cases for illustrating the application of the 'α' index on co-publication analysis against several parameters such as growth in a number of the scholarly communications, document types, subject areas, and sources for the period 1994 to 2013. A total of 8823 co-publications were published by Indo-Korean researchers during the aforementioned period of time. The asymmetric index of Indo-Korean co-publications of India with Korea ($\alpha^{India\text{-}Korea}$) and vice versa ($\alpha^{Korea\text{-}India}$) were obtained and the values were 0.099 and 0.114, respectively. The results suggest that the overall efforts of Korean researchers have more effective co-operation with Indian researchers. In addition, a comparison with the best-known Salton's (cosine) measures is provided and the results show that its value (0.11) is independent of the relative size of the collaborative systems.

Keywords: Co-publications, Korea, India, Asymmetric index, Indicator, Scientometrics, International collaboration.

INTRODUCTION

Many scientometrics studies have been appeared in the literature dealing with the different aspects of scholarly communications[1-7]. Kademani *et al.*[1] studied the growth and development of world literature on Bhabha Scattering by using three different databases 'International Nuclear Information System' (INIS), Science Citation Index, and INSPEC and found that a total of 1305 papers were published by the scientists in the field Bhabha Scattering during 1969-2008; and there were 47 countries involved in the research in this field where Germany was the top producing country with 421 papers followed by the USA with 420 papers, Italy with 293 papers, and Switzerland with 263 papers. Magnone[4] studied R&D capability of environment friendly technologies in China, Japan, and Korea and found that a total of 788 papers were published during 1990–2011 in the field of water-gas shift 'WGS' technologies by scientists in China, Japan and Korea; where China was the top producing country with 394 papers (50%) followed by Japan with 250 papers (32%), and Korea with 144 papers (18%). Prakasan *et al.*[6] analysed India's strengths and weaknesses in international collaborative research at the macro and micro levels of collaborative fields. Surwase *et al.*[7] illustrated principles, techniques and applications of co-citation analysis introducing co-citation analysis softwares viz. SciVal Spotlight and CiteSpace; and also stated that by applying single-link clustering and multidimensional scaling, the co-citation analysis technique can literally map the structure and development of science. In particular, it is well known that the number of co-publications is typically employed as an indicator of collaboration in a wide range of subjects at every level. It is quite clear that many studies have appeared in the academic literature with their attention focused on the national trend of co-publication productivity on the most varied subjects[8-14]. Ali-Khan *et al.*[8] provided a scientometric analysis of the China–Canada collaboration in stem cell research publications indexed in Scopus database and examined collaboration levels, collaboration preferences, scientific impact, the

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Access this article online

Official Publication of

PhcogNet
Bringing Medicinal Plants Researchers Together

Website: www.jscires.org

DOI: 10.5530/jscires.5.3.4

collaborating institutions in China and Canada, areas of mutual interest, and funding sources and found that China–Canada collaboration is rising steadily; enhanced the impact of collaborated publications as compared to papers authored solely. Egghe and Leydesdorff[15] revealed the relation between Pearson's correlation coefficient and Salton's cosine measure based on the different possible values of the division of the -norm and the -norm of a vector; where they analysed author co-citations among 24 informetricians and constructed two matrices: the asymmetric occurrence matrix and the symmetric co-citation matrix; and got a threshold value for the cosine of which none of the corresponding Pearson correlations would be negative. Leydesdorff[21] argued that in the web environment, the approach of retrieving original citation data is often not feasible and in that case, one should use the Jaccard index. Unlike Salton's cosine and the Pearson correlation, the Jaccard index abstracts from the shape of the distributions and focuses only on the intersection and the sum of the two sets. Since the correlations in the co-occurrence matrix may partially be spurious, this property of the Jaccard index can be considered as an advantage in this case. Ahlgren, Jarneving & Rousseau[22, 23] questioned the use of Pearson's correlation coefficient as a similarity measure in Author Co-citation Analysis (ACA) on the grounds that this measure is sensitive to zeros. Analytically, the addition of zeros to two variables should add to their similarity, but these authors demonstrated with empirical examples that this addition can depress the correlation coefficient between variables and argued that one should consider using Salton's cosine instead of the Pearson correlation coefficient as a similarity measure in author co-citation analysis. In this paper, we extend these previous work in investigating the collaborative relationship performance of symmetrical to asymmetrical systems by considering variability at the quantity level.

The purpose of this paper is to study the collaboration relationship between India (officially the Republic of India but hereinafter known as 'India') and South Korea (officially the Republic of Korea but hereinafter known as 'Korea') by looking at Indo-Korean co-publications as a degree of collaborative interaction between these two countries. Consequently, the aim of this study is to attempt to answer the following questions: Is it possible, in general, to analyse the scientific collaboration relationships between two different collaborative systems quantitatively different in publication performances through the counts of the co-publications? Which index (intrinsic coefficient or relative indicator) do we need to effectively measure and quantify the Indo-Korean collaborative 'efforts' in a relative sense from the Korean or Indian point of view? Are there any quantitative differences between a symmetrical (Salton's measure)[11, 15] and an asymmetrical index that also includes the relative volume of overall national publications? More specifically, in this paper the researcher's idea has been driven by two key questions: How do the relative overall efforts of Korean- and Indian-researchers affect the number of Indo-Korean co-publications? And, if it is the case, how can we precisely measure the intrinsic value of a co-publications between two countries in a relative way?

Taking the above observations in the account, the aim of the present study was to quantitatively determine and analyse the Indo-Korean co-publications from 1994 to 2013. To take stock of the situation of the Indo-Korean co-publications, the change in the Indo-Korean co-publication pattern of co-affiliated publications was analysed from different points of view, including document types and subject areas, as well as Indo-Korean co-publications with other countries.

To this aim we introduce a new asymmetric index (α) as a scientometric indicator of asymmetry of two systems (*i.e.*, continents, countries, institutes, universities, departments, groups, authors, and so on), which is itself an important relative indicator of collaboration between two different systems with different contexts and sizes, as well as different number of publications, performance of R&D activities, economic factors (*i.e.*, gross domestic expenditure on R&D), and so on. Namely, general $\alpha^{A\text{-}B}$ index is the relative measure of the co-authorship strength of first system (called 'A') with the second one (called 'B'), and at the same time $\alpha^{A\text{-}B}$ value is different than $\alpha^{B\text{-}A}$ because 'A' and 'B' are two different collaborative systems. Specifically, this index is fully normalised to take into account of the relative publishing efforts (as the number of publications) and the effective number of co-publications between two subjects. The indicator is constructed as an index and takes on values between 0 and 1, where 0 means that there are no co-publications between selected systems. However, the main difference between the classical Salton and McGill's measure[16] and the presented one is the fact that the Salton (cosine) measure - as symmetrical strength of co-authorship links - "is calculated for a pair of countries as the number of joint papers divided by the geometric mean (square root of the product) of the two countries' totals"[11].

Although the proposed asymmetric index is applicable for all asymmetric systems (across countries, fields, institutions, universities, groups, etc.), Korea and India are selected for an in-depth case study analysis of Indo-Korean

co-publications between 1994 and 2013. In particular, as a case study of the application of the asymmetric index (α) for the co-publications between two countries we consider India and Korea because they have different contexts and sizes, as well as the different number of publications, the performance of R&D activities, and the (macro) economic factors. Table 1 shows some selected macroeconomic and educational indicators as well as R&D intensity of these two countries. The majority of economic data presented in this table are derived from the Organization for Economic Co-operation and Development (OECD) for India and Korea[17] as well as from the United Nations Educational, Scientific, and Cultural Organization[18]. In details, the big difference between these two countries is the income level, R&D expenditure (% of GDP) and its distribution by type of activity (Experimental develop, Applied research and Basic research), researchers in full-time equivalent or per 1 million inhabitants. Here it can be noted that the annual growth rate of Indo and Korean publications are 10.3% and 9.1%, respectively. In particular, these two countries show an increasing trend in terms of gross domestic expenditure on R&D in the period considered and, at the same time, they are different in several ways. In order to explain this point further, Figure 1 shows the comparative performance in science between India and Korea with a normalised index of performance relative to the median values in the Organisation for Economic Co-operation and Development (OECD) area[17]. As it can be noted, in India Government R&D expenditures

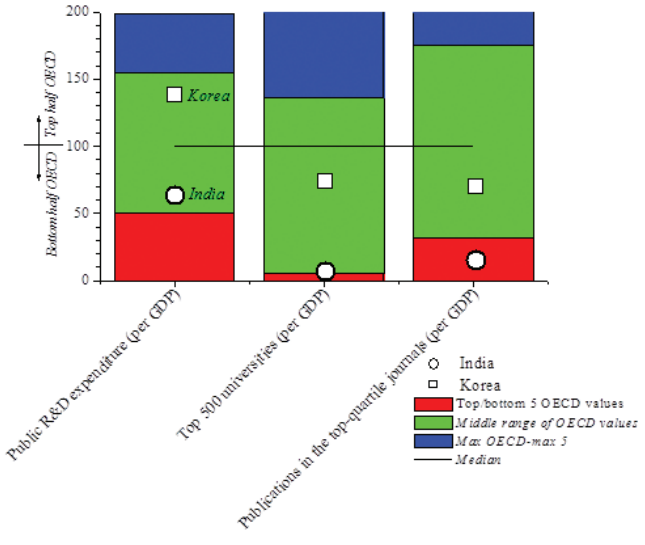

Figure 1: Comparative performance of national science with a normalised index of performance relative to the median values in the Organisation for Economic Co-operation and Development (OECD) area (Index median=100)[17].

accounted at a normalized index with OECD area of 60.27 (Index median = 100) in 2007. This country has about 2.25 world-class university and a weak publication record in top academic journals in the range of bottom 5 OECD values. By comparison, for instance, although Korea has relatively high public-sector expenditures on R&D with a normalized index of 136.33, its universities (Top 500 Universities=70.77) and research publication outputs rank comparatively low (about 66.34) by international standards (Index median in OECD area = 100). All these characteristics make the co-publication between selected countries a potential candidate to study further in the area. This was one of the motivations for the present work.

Experimental section

Collection of data

Scopus database was used for both countries to retrieve the publications during 1994-2013 (20 years). A total of 899569 publications for 'India', 674156 publications for 'Korea' and 8823 co-publications for 'India-Korea' were downloaded.

The evaluation of the cumulated data from 1994 to 2013 was performed with accurate collection of the Indo-Korean co-publications including the time distribution of Indo-Korean document types and subject areas, as well as Indo-Korean co-publication with third countries. Each of these analysis steps is discussed in the 'Result and Discussion' sections.

Basic concept of the asymmetric index (α)

The asymmetric $\alpha^{A\text{-}B}$ and $\alpha^{B\text{-}A}$ indexes are here defined as the (principal) square root of the ratio between the number of co-publications (i.e., n^{AB}) between two 'A' and 'B' collaborative systems in general (*i.e.*, continents, countries, institutes, universities, departments, groups, authors, and so on) and the overall number of publications of the first system (i.e., n^{A}) and the overall number of publications of second system (i.e., n^{B}), respectively. In particular, these asymmetric $\alpha^{A\text{-}B}$ and $\alpha^{B\text{-}A}$ indexes are defined as following:

$$\alpha^{A\text{-}B} = (n^{AB} / n^{A})^{1/2} \quad \text{(eq. 1)}$$

$$\alpha^{B\text{-}A} = (n^{AB} / n^{B})^{1/2} \quad \text{(eq. 2)}$$

where n^{A} and n^{B} are the publications associated with the generic system 'A' and with the generic system 'B', respectively, and where n^{AB} represents the relative co-publication activity on the basis of co-publications published between selected systems.

Table 1: Macroeconomic indicators and R&D intensity for India and Korea

	India	Korea
Population	1,267,401,849	50,424,000
Surface Area (Km^2)	3,287,260	100,150
GDP per capita ($)	1,617	28,101
Income level[3]	Lower middle income	High income
Total public expenditure on education as a % of GDP	3.2	5.0
R&D expenditure as a % of GDP	0.81	4.03
Distribution of R&D expenditure by type of activity	22% Experimental dev. 25% Applied research 18% Basic research 35% Not specified	62% Experimental dev. 20% Applied research 18% Basic research
Number of universities in top world university rankings[2] – Top 500	ARWU=1 QS-WUR=7	ARWU=10 QS-WUR=13
Academic Ranking of World Universities–Top one[3]	Indian Institute of Science (301-400)	Seoul National University (101-150)
Compound annual growth rate of publications (%)	10.3	9.1
Researchers in full-time equivalent	192,819	288,901
Researchers per 1 million inhabitants	160	5,804
Researchers in full-time equivalents by sector of employment (%)	Business= 38.7 Higher education= 11.5 Government= 45.6 Private non-profit= 4.2	Business= 77.4 Higher education= 14.1 Government= 7.3 Private non-profit=1.2
Female researchers in Higher education sector as % of the total number of researchers	13	26.6

1. *According to the World Bank's economic data release of September 2013*
2. *ARWU= Academic Ranking of World Universities, QS-WUR= QS World Universities Rankings*
1. *www.shanghairanking.com/*

If the two selected collaborative systems (i.e., 'A' and 'B') are asymmetric in nature (i.e., across countries, institutions, groups, researchers, fields of study, areas, etc.) $\alpha^{A\text{-}B}$ can be defined as 'the effort' of 'A' system to have a collaborative interaction with 'B' system. Consistently $\alpha^{B\text{-}A}$ can be defined as 'the effort' of 'B' system to publish in a collaborative way with 'A' system. In this vein, it is important to point out that the numerical value of a generic 'α' depends directly on relative production of co-publications between 'A' and 'B' systems, and then indirectly on the intellectual commons and distributed efforts behind the scenes to orchestrate the process of these collaborative interactions (i.e., co-publications between 'A' and 'B' systems).

As defined above 'α' index is an absolute (dimensionless) number and its value is between 0 and 1 ($0.0<\alpha<1.0$). In particular now we focus on some particular cases of $\alpha^{A\text{-}B}$ and $\alpha^{B\text{-}A}$. Three different cases may exist.

(a) $\alpha^{A\text{-}B} \rightarrow 0$ when $n^{AB} \rightarrow 0$ or $n^{A} \rightarrow \infty$ (eq. 3)
$\alpha^{B\text{-}A} \rightarrow 0$ when $n^{AB} \rightarrow 0$ or $n^{B} \rightarrow \infty$ (eq. 4)

(b) $\alpha^{A\text{-}B} \neq \alpha^{B\text{-}A} \neq 0$ when $n^{A} \neq n^{B}$ and $n^{AB} \neq 0$ (eq. 5)
$\alpha^{A\text{-}B} = \alpha^{B\text{-}A} \neq 0$ when $n^{A} = n^{B}$ and $n^{AB} \neq 0$ (eq. 6)

(c) $\alpha^{A\text{-}B} \rightarrow 1$ when $n^{A} \rightarrow n^{AB}$ (eq. 7)
$\alpha^{B\text{-}A} \rightarrow 1$ when $n^{B} \rightarrow n^{AB}$ (eq. 8)

An interesting point is that a quite common case of two systems - when taken individually - can produce different output from a publishing point of view so that $\alpha^{A\text{-}B}$ and $\alpha^{B\text{-}A}$ values are different from zero.

For the sake of completeness, we also mention that the general concept of Salton's (cosine) measure (r^{AB}) quantifies collaborations strength between two countries ('A' and 'B') as:

$$r^{AB} = r^{BA} = p^{AB} / (p^{A} \times p^{B})^{1/2} \quad \text{(eq. 9)}$$

where p^{AB} is collaborated publications between 'A' and 'B', p^{A} and p^{B} are the number of publications of 'A' and 'B'; so that in this case r^{AB} (or r^{BA}) is the symmetrical mutual collaboration strength - with geometric mean - between 'A' and 'B' (or 'B' and 'A')[11-12].

There are several ways of plotting the asymmetric index (α) between two different collaborative systems (i.e., 'A' and 'B') in a 2D graph. Figures 2 (a), (b) and (c) are schematic

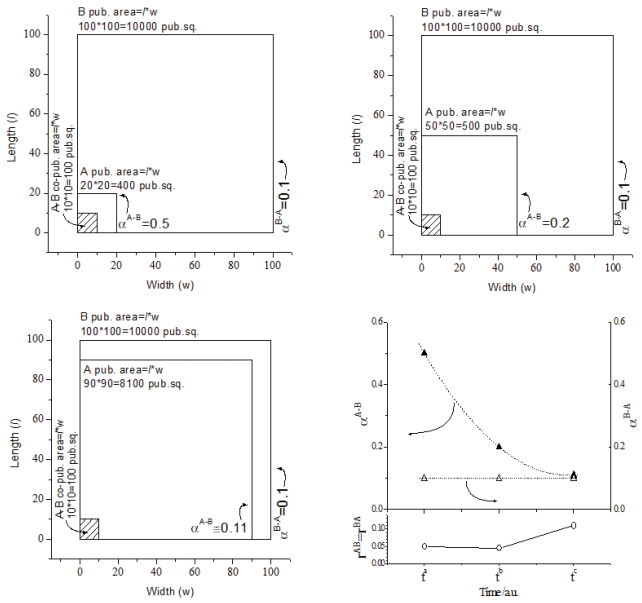

Figure 2: Suitable graphical representation of mathematical relationships (Eqs. 1-8) between two asymmetrical systems when (d) $\alpha^{A-B} = 0.5$, (e) $\alpha^{A-B} = 0.2$ and (f) $\alpha^{A-B} = 0.11$, and α^{B-A} is imposed as a constant. (d) An example of the time evolution of the dual system properties of α^{A-B} and α^{B-A} on the time (t^a, t^b, and t^c). The Salton indexes ($r^{AB}=r^{BA}$) are presented as reference values for comparison purposes

representations of the overlapping values associated with asymmetric co-publication activities between a generic system 'A' and another system called 'B'. In particular, in order to have an intuitively clearer representation with a mathematical meaning (see, Eqs. [1-8]), the authors proposed to use the graphical metric based on the 'square surface areas' which represents subsurface structural boundary for the documents published by 'A' or 'B' systems, and the co-publication produced together.

In this type of representation, the horizontal axis is called the 'Width' (w) while the vertical axis is called the 'Length' (l). The lengths of the two axes are visually balanced in a square shape with a corner at (0, 0). As a result, the drawn surface proportional in shape to the number of publications published by system 'A', 'B' publications and 'A-B' co-publications is used for a graphical representation of distribution of publications from 'A' system, 'B' system, and the co-publications that 'A' and 'B' systems produced together as co-publications between two systems 'A' and 'B'.

To understand this point, the schemas in Figure 1 (a, b, and c) are three representative examples of the correlation between two hypothetical systems ('A' and 'B') where an independent variable (i.e., publications) at every level of analysis (i.e. continents, countries, institutions, groups, researchers, etc.) can be combined with other types of analysis (time evolutions, citation analysis, etc.) to get a coupled scientometric analysis. These three schemas are differentiated only by the total number of publications associated with the system 'A'. In fact, it can be observed that the size of the total number of publications published by the 'B' system and 'A-B' co-publication values are constant over the system structure or over the time.

The asymmetric index (α) is very versatile and easily updated with the introduction of new data or metrics; for example in the measurements of the 'strength' of collaborations between 'A' and 'B' systems on a particular subject area (i.e., Chemistry, Chemical Engineering, etc.), the asymmetric index (α) is based on the relative number of co-publications between 'A' and 'B' systems (co-affiliated by 'A' and 'B' systems) and the absolute number of publications published by 'A' and 'B' systems in the given area of study.

As an example, let us consider the schema in Figure 2 (a). While the relative size of the originated figure is obviously dependent upon a number of factors, the size of the small square surface is more likely to be correlated with the relative efforts of both systems to the end of co-publications. If this is true, then the ratio between the length (l) of obtained 'A-B' co-publications figure and the 'width' (w) of the side of total 'A' publications in the same interval of time is the measure of co-authorship strength of 'A' system versus 'B' system to produce the 'A-B' co-publications (α^{A-B}). By the same token, the ratio between the 'A-B' length of the figure that represents a schematic drawing of the 'A-B' co-publications and the width of the side of all 'B' publications is the measure of co-authorship strength (α) of 'B' with 'A' to produce the 'A-B' co-publications (α^{B-A}).

To quantize this model, in a hypothetical case where, for example, the subject 'A' publishes at least 100% of co-publications with subject 'B', but in the same range of period 'A' don't have any co-publications with another subject (for example called 'C'), the measure of co-authorship strength gives $\alpha^{A-B}=1$ because the two sides of 'A' and 'A-B' squares overlap each other. In the second case, when 'A' and 'C' subjects don't have any co-publications together, the straight α^{A-C} is zero.

A more colloquial, but perhaps more intuitive, example is probably obtained in the case of two hypothetical scientists; for a young inexpert researcher at the start of his/her career in a group maybe he/she have only inter-group collaboration with the team leader of his/her group.

In this case the first one have an asymmetric index equals to the unit with team leader, and for increasing his/her cooperation out of the group – and new co-publications with other groups or team leaders – the index becomes less than the unit and closer to zero (i.e., progressive increasing of the independence).

In addition, Figure 2 (a, b, and c) can be conceptually interpreted in another way. This way is that it is an example of a temporal snapshot image of the co-publication situation between different systems (uniform in nature) at a given moment, an overall time range, or in an evolution phase on the basis of which collecting of data can be performed. In this case Figure 2 (a, b, and c) is the evolution of the time of co-publications between the same two systems from time "a" (t^a) to time "c" (t^c), where t^c is the time of, for example, Figure 2 (c). Consequently, the time evolution of selected dual system is determined by a single function of three variables ('A' and 'B' publications, and 'A-B' co-publications) at the time, and a graphical representation of 'α' versus time (t^a, t^b, and t^c) gives us some dynamical information respecting the co-publication history (α^{A-B}=0.5, 0.2 and 0.11; α^{B-A}=0.1=constant) in a given range of time from t^a to t^c. Figure 1 (d) shows an example of a time evolution of the properties of α^{A-B} and α^{B-A}. The symmetrical strength of collaboration between A and B, calculated through the Salton index, is also shown in Figure 1 (d) at the generic time t^a, t^b and t^c, without any information regarding the relative cooperative efforts.

In the light of these considerations, the asymmetric index (α) effectively represents the 'strength' of collaborations (as co-publications), and, at the same time, it is a quantitative and simple graphical method for the development of comparative analysis between two cooperative systems or sub-systems in the field of scientometric analysis of co-publications. Preliminary results of this work and some notes on proposed asymmetric index (α) are described in the next section of this study.

RESULTS AND DISCUSSIONS

Asymmetric index

This section provides a thorough analysis of all Indo-Korean co-publications for the selected period (1994–2013). India and Korea published 899569 publications and 674156 publications respectively. India and Korea continued the great legacy of bilateral collaboration in scientific research, and as a result of it, published 8823 co-publications during the study period. The asymmetric

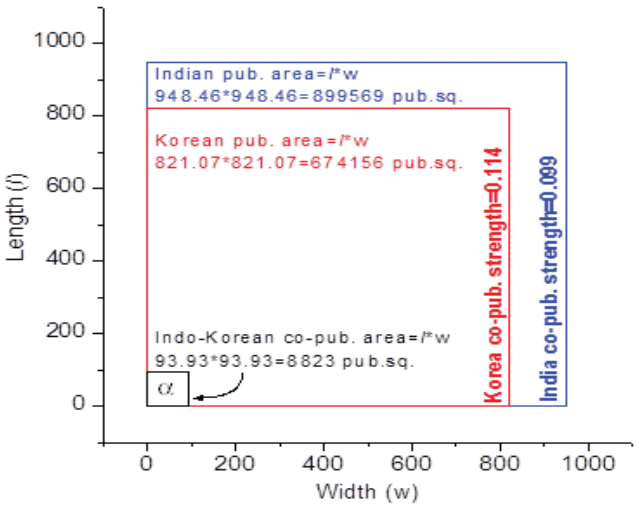

Figure 3: Asymmetric index ($\alpha^{India-Korea}$ and $\alpha^{Korea-India}$) and Indo-Korean co-publications strength

index $\alpha^{India-Korea}$ = 0.099 and $\alpha^{Korea-India}$ = 0.114 indicate the co-publication strengths of both the countries in relation to each other. As it can be noted in Figure 3 the $\alpha^{Korea-India}$ is bigger than the $\alpha^{India-Korea}$ index. This means that in a prospective of overall national effort, the relative efforts of Korea to co-operate with India are more intense (as a number of results and then academic publications) than India with Korea. In comparison, the symmetrical value calculated by classical Salton's (cosine) measure gives us an average value of 0.11.

Chronological growth of publications

Figure 4 shows the chronological growth of publication by India and Korea, as well as Indo-Korean co-publications. Figure 3 clearly indicates the almost steady and parallel growth of scientific publications of India and Korea. The same national trend is also observed for co-publication except 1999, 2000 and 2001 where a number of co-publications have come down. In a first approximation, this result can be related to the increasing of the government's contributions in the development of diplomatic relationships between these two countries in the period immediately before and after 1996. In particular, it can be remembered here that the "India-Korea Joint Commission for bilateral co-operation" was established in February 1996 and this happened just in time for the increase the amount of co-publications (1996-2008). Table 2 reveals that the minimum difference between India and Korea as an absolute number of publications occurred during the years 2004 and 2005.

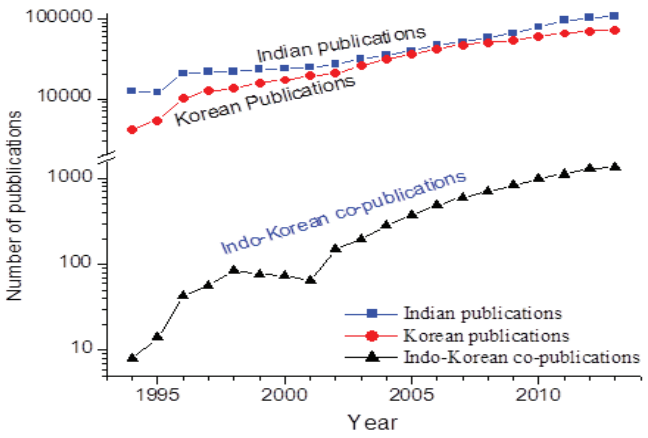

Figure 4: Year-wise distribution of Indian, Korean and Indo-Korean co-publications

Table 2: Year-wise distribution of Indian, Korean and Indo-Korean co-publications

Year	Number of publications			
	India	Korea	Difference	Indo-Korean
2013	107325	71831	35494	1357
2012	103435	70460	32975	1310
2011	95345	65672	29673	1119
2010	78329	59843	18486	983
2009	66198	53602	12596	830
2008	58290	50328	7962	704
2007	51311	46843	4468	603
2006	46100	42497	3603	487
2005	39890	36770	3120	378
2004	34631	31439	3192	284
2003	31339	25924	5415	197
2002	26864	20834	6030	149
2001	24773	19403	5370	65
2000	23779	17215	6564	73
1999	23281	15732	7549	78
1998	22012	13459	8553	84
1997	21569	12672	8897	57
1996	20632	10110	10522	43
1995	11994	5379	6615	14
1994	12472	4143	8329	8
Total	899569	674156	225413	8823

Collaborative Countries in Indian, Korean and Indo-Korean co-publications

The analysis of affiliating countries in Indian (899569) and Korean (674156) and Indo-Korean (8823) publications was carried to enlist the top-20 affiliating countries. Table 3 indicates the number and percentage of co-publications of top-20 countries appeared as the collaborative country in Indian and Korean publications respectively. India's collaborations are foremost with the United States (5.89%), followed by Germany (1.90%) and the United Kingdom (1.84%). These results are in good accord with the report entitled "Higher Education in Asia: Expanding Out, Expanding. Up The rise of graduate education and university research" by UNESCO[18]. Meantime, Korea seems to have a regional dimension and a geographical proximity in the world collaboration with Japan (4.01%) and China (2.71%). This result confirms earlier research findings of Korea that show limited research collaboration, compared with their high productivity and more in general that collaboration affinity is greatly shaped by geographic proximity[4, 5, 19].

The 8823 co-publications of India and Korea were analysed and the top-20 countries affiliated in these co-publications were found and depicted in Figure 5. It can be noted that at national level both India and Korea separately has few co-publications with Russia (0.41% and 0.89%, respectively) but, at the same time, it shows some kind of glue effects between India and Korea with 1724 co-publications and climbed to the third position of top-20 countries affiliated in Indo-Korean co-publications.

Asymmetric index ($\alpha^{India\text{-}Korea}$ and $\alpha^{Korea\text{-}India}$) for Indo-Korean co-publications

Figure 6 indicates the year-wise values of the asymmetric index ($\alpha^{India\text{-}Korea}$ and $\alpha^{Korea\text{-}India}$) for Indo-Korean co-publications. It is clearly evident from the figure that the Korea favour more collaboration with India, compared to the relative collaboration of India with Korea. The values of the asymmetric index for $\alpha^{Korea\text{-}India}$ are superior to $\alpha^{India\text{-}Korea}$ throughout the period. The difference between indexes is maximum during 2011-2013 and minimum during 2004-2006.

Document Type

In this section, the various document types of Indian, Korean and Indo-Korean co-publications have been analysed. As usual, the journal articles are the most favourite type of document types preferred by both the countries (Table 4). In addition, co-publication focus also in Conference paper and Review with 835 and 234 co-publications, respectively. As well as the asymmetric index ($\alpha^{India\text{-}Korea}$, $\alpha^{Korea\text{-}India}$) for Indo-Korean co-publications as per document type of co-publications was calculated which is depicted in Figure 7. From this figure, it is also clear that,

Table 3: Top-20 countries affiliated in Indian and Korean publications

SN	Country Collab. with India	#Co-Pub.	%Co-Pub.	Country Collab. with Korea	#Co-Pub.	%Co-Pub.
1	United States	53,021	5.89	United States	89,480	13.27
2	Germany	17,089	1.90	Japan	27,054	4.01
3	United Kingdom	16,535	1.84	China	18,296	2.71
4	Japan	11,633	1.29	Germany	10,718	1.59
5	France	10,720	1.19	United Kingdom	10,401	1.54
6	South Korea	8,823	0.98	India	8,823	1.31
7	Canada	8,476	0.94	Canada	8,589	1.27
8	Australia	6,953	0.77	France	6,912	1.03
9	Italy	6,650	0.74	Russia	5,972	0.89
10	China	5,936	0.66	Australia	5,570	0.83
11	Switzerland	4,567	0.51	Italy	4,751	0.70
12	Spain	4,464	0.50	Taiwan	4,439	0.66
13	Malaysia	4,199	0.47	Switzerland	4,122	0.61
14	Netherlands	4,173	0.46	Spain	3,558	0.53
15	Taiwan	4,171	0.46	Netherlands	3,007	0.45
16	Russia	3,720	0.41	Poland	2,635	0.39
17	Brazil	3,288	0.37	Singapore	2,356	0.35
18	Sweden	3,286	0.37	Sweden	2,225	0.33
19	Singapore	3,137	0.35	Brazil	1,901	0.28
20	Poland	2,895	0.32	Belgium	1,875	0.28

Table 4: Distribution of Indian, Korean and Indo-Korean co-publications as per document type of co-publications

Document Type	Number of publications		
	India	Korea	Indo-Korean
Article	700270	490169	7552
Article in Press	2520	1136	22
Book	516	169	2
Book Chapter	4913	1860	40
Conf. Paper	117361	154827	835
Editorial	5870	2509	50
Erratum	1796	1781	37
Letter	22890	5841	27
Note	6020	2096	16
Review	34464	12750	234
Short Survey	2904	879	8
Others	45	139	0

as we expected, Erratum documents has the same indexes for both countries because usually, these types of documents include the name of every author and then, in this case, both affiliations.

Subject areas

The subject areas of publications as appeared in Scopus database have been analysed and presented in Table 5.

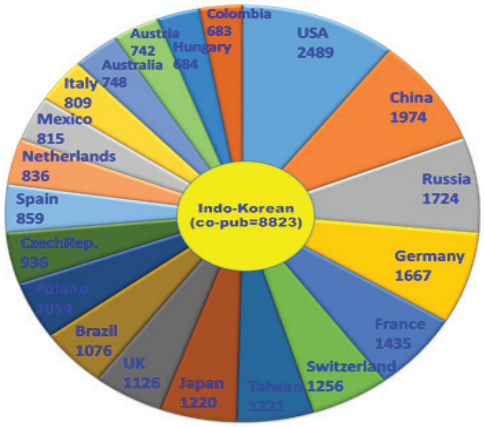

Figure 5: Top-20 countries affiliated in Indo-Korean co-publications

The highest number of Indo-Korean co-publications falls in 'Physics and Astronomy' (3694, 41.9%) followed by 'Materials Science' (2163, 24.5%), 'Engineering' (1624, 18.4%) and 'Chemistry' (1614, 18.3%). Figure 8 provides the asymmetric index ($\alpha^{India\text{-}Korea}$, $\alpha^{Korea\text{-}India}$) for Indo-Korean co-publications as per subject area of co-publications. For example, it can be noted that "big science" projects in the Astronomy subject are inevitably also large-scale engineering projects and then the co-publications are co-affiliated by both countries at the same

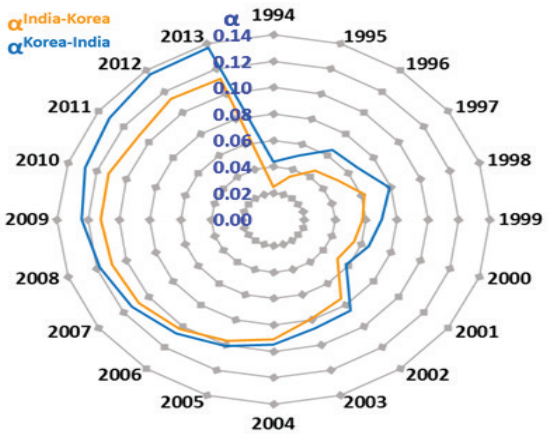

Figure 6: Year-wise asymmetric index ($\alpha^{\text{India-Korea}}$ and $\alpha^{\text{Korea-India}}$) for Indo-Korean co-publications

level ($\alpha^{\text{Korea-India}}$ =0.17). Another point to note here is that Korea has a strong tradition in the field of environmental science ($\alpha^{\text{Korea-India}}$=0.15 in comparison with $\alpha^{\text{India-Korea}}$ =0.09) and has already prioritised green innovation at the highest level by a low-carbon green growth policy. This national priority is reflected also in the so called "557" initiative, which has earmarked US$2.4 billion to invest in green technology[17].

Journals Preferred by Indo-Korean Scientists for Publication

The top-20 journals preferred by Indo-Korean scientists for their co-publications are listed in Table 6. SCImago Journal Rank (SJR) indicator is a measure of the scientific

Table 5: Subject areas of Indian, Korean publications and Indo-Korean co-publications

Sr#	Subject Area	Number of publications		
		India	Korea	Indo-Korean
1	Agricult. & Biol. Sciences	99893	36682	569
2	Arts and Humanities	3895	3062	12
3	Biochem., Gen. & Molec. Biology	112168	95526	873
4	Business, Manag. & Accoun.	15787	6541	42
5	Chemical Engineering	53216	47789	822
6	Chemistry	134649	78442	1615
7	Computer Science	81967	87957	524
8	Decision Sciences	6429	5473	50
9	Dentistry	5896	3105	8
10	Earth and Planetary Sciences	40330	16153	327
11	Economics, Econometrics &Fin.	6372	4549	14
12	Energy	24667	17745	249
13	Engineering	148937	183221	1623
14	Environmental Science	56536	21306	462
15	Health Professions	4511	7376	26
16	Immunology and Microbiology	29998	28215	359
17	Materials Science	111141	113321	2166
18	Mathematics	46762	43537	662
19	Medicine	174229	118119	631
20	Multidisciplinary	15658	2348	53
21	Neuroscience	10256	13282	21
22	Nursing	2469	6707	15
23	Pharmac, Toxicol & Pharmaceut.	74805	26867	268
24	Physics and Astronomy	128765	127748	3694
25	Psychology	2767	3378	21
26	Social Sciences	25484	14167	63
27	Veterinary	18567	3830	38
28	Undefined	124	22	0

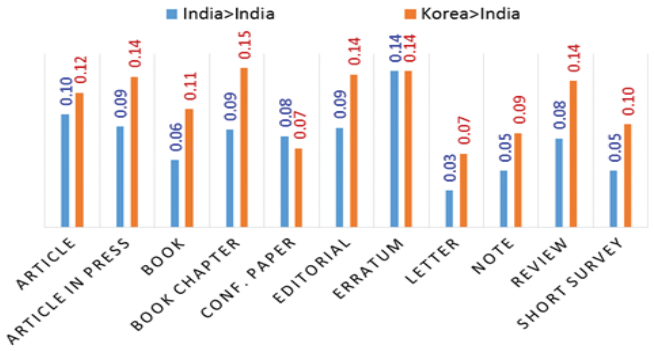

Figure 7: Asymmetric index ($\alpha^{India-Korea}$, $\alpha^{Korea-India}$) for Indo-Korean co-publications as per document type of co-publications

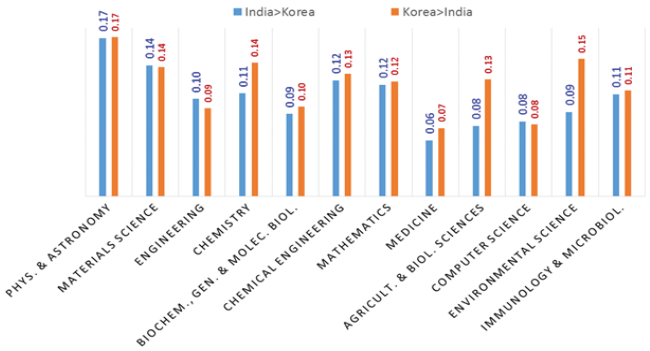

Figure 8: Asymmetric index ($\alpha^{India-Korea}$, $\alpha^{Korea-India}$) for Indo-Korean co-publications as per subject area of co-publications

Table 6: Top-20 journals publishing Indo-Korean co-publications

Sr#	Journal	#Pub.	SJR (2012)
1	Phys. Rev. Lett.	510	4.54
2	Phys. Lett. B	414	3.06
3	Phys. Rev. D	352	2.05
4	J. High Energ. Phys.	118	0.93
5	J. Alloys Compd.	104	1.16
6	Phys. Rev. C	100	1.97
7	Appl. Surf. Sci.	66	0.84
8	Acta Crystallogr E	63	0.23
9	Bull. Korean Chem. Soc.	63	0.33
10	Eur. Phys. J. C	61	2.75
11	J. Korean Phys. Soc.	59	0.26
12	Mater. Chem. Phys.	58	0.84
13	J. Appl. Phys.	55	0.99
14	J. Appl. Polym. Sci.	53	0.60
15	J. Nanosci. Nanotechnol.	48	0.38
16	Mater. Lett.	48	0.85
17	Curr. Appl Phys.	42	0.70
18	Comm. Com. Inf. Sc.	41	0.14
19	Appl. Phys. Lett.	40	1.94
20	Sens. Actuators B	39	1.25

influence of scholarly journals that accounts for both the number of citations received by a journal and the importance or prestige of the journals where such citations come from. It is a size-independent indicator and its values order journals by their "average prestige per article" and can be used for journal comparisons in science evaluation processes. The table provides the top-20 journals with a total number of Indo-Korean articles published in it and the SJR-2012 value for the journal. It can be pointed out here that collaboration between India and Korea tend to publish in International journals with high rank. In fact, as it can be noted there is a clear relationship between SJR and number of co-publications between India and Korea, and this can mean that in general the international collaboration help to meet national challenges in science and co-publications in high-rank journals.

CONCLUSIONS

Due to the advent of technology and multidisciplinary nature of research, it is being increasingly trans-national, enabling the efficient use of expertise and resources available. Traditional Salton's (cosine) measure (r) is a good symmetrical indicator of the strength of mutual collaboration between two collaborative systems (i.e., two countries). The asymmetric index is relative in nature and it can give a clear picture in point–of–view of a system studied. Thus has an advantage over traditional Salton's Cosine measure as the Asymmetric index may vary due to variable size of systems, but the Salton's Cosine measure do not vary due to the different sizes of the two systems studied.

The asymmetric index is useful, as it normalises for bias in the number of papers published by a system because of its size. This study proposed a new asymmetrical index (α) and its representation in a graphic sense. From this point of view, this study provides the extent and characteristics of Indo-Korean co-publications as a case study.

As illustrated in the present study, the proposed asymmetric index (α) can have broad implications and practical applications not only in analysis of number of Indo-Korean co-publications, but also for other countries or for different level purposes in other asymmetric systems.

REFERENCES

1. Kademani B.S., Surwase G., Mohan L., Kumar V. (2009). Bhabha scattering: a scientometric view. DESIDOC Journal of Library and Information Technology, 29(4) 3-11.

2. Kademani B.S., Sagar A., Surwase G., Bhanumurthy K. (2012). Publication trends in materials science: a global perspective. Scientometrics, Vol. 94(3). 1275-1295.
3. Kademani B.S., Surwase G., Sagar A., Lalit M., Bhanumurthy K. (2013). Research Trends in Radioactive Waste Management: A Global Perspective. International Journal of Low Radiation, 9(1) 59-94.
4. Magnone E. (2012). A general overview of scientific production in China, Japan and Korea of the water-gas shift (WGS) process. Information, 3(4) 771-789.
5. Magnone E. (2014). An overview on the South Korean scientific production in the field of chemistry (1993-2012). Information, 5(2) 285-304.
6. Prakasan E.R., Mohan L., Girap P., Surwase G., Kademani B.S., Bhanumurthy K. (2014). Scientometric Facts on International Collaborative Indian Publications. Current Science, 106(2) 166-169.
7. Surwsae G., Kademani B.S., Bhanumurthy K. (2012). Mapping the structure and development of science using co-citation analysis. National Workshop on Using Different Metrics for Assessing Research Productivity, 16-17 Feb., 2012, Indian Statistical Institute, New Delhi (India), pp.164-174.
8. Ali-Khan S.E., Ray M., McMahon D.S., Thorsteinsdóttir H. (2013). Sino-Canadian collaboration in stem cell research: a scientometric analysis. PLOS one, 8(2) e57176. doi:10.1371/journal.pone.0057176.
9. Bettencourt L.M.A., Kaiser D.I., Kaur J. (2009). Scientific discovery and topological transitions in collaboration networks. Journal of Informetrics, 3(3) 210-221.
10. Dutt B., Nikam K. (2014). Scientometrics of collaboration pattern in solar cell research in India. Annals of Library and Information Studies, 61(1), 65-73.
11. Glänzel W., Schubert A., Czerwon H. J. (1999). A bibliometric analysis of international scientific cooperation of the European Union (1985–1995). Scientometrics, 45(2) 185-202.
12. Glänzel W., Schubert A. (2001). Double effort = Double impact? A critical view at international co-authorship in chemistry. Scientometrics, 50(2) 199-214.
13. Koen F., Sjoerd H., Jarno H. (2009). Spatial scientometrics: towards a cumulative research program. Journal of Informetrics, 3(3) 222-232.
14. Yunwei C., Katy B., Shu F. (2012). Evolving collaboration networks in Scientometrics in 1978-2010: a micro-macro analysis. Scientometrics, 95(3) 1051-1070.
15. Egghe L, Leydesdorff L. (2009). The relation between Pearson's correlation coefficient r and Salton's cosine measure. arXiv:0911.1318v1.
16. Salton G., McGill M.J. (1987). Introduction to Modern Information Retrieval. McGraw- Hill, New York, NY, USA.
17. OECD. (2012). Science Technology and Industry Outlook. URL: http://www.oecd.org/sti/sti-outlook-2012-korea.pdf, http://www.oecd.org/eco/surveys/Overview_Korea_2014.pdf, http://www.oecd.org/sti/sti-outlook-2012-india.pdf and http://www.oecd.org/eco/surveys/India-2014-Overview.pdf.
18. UNESCO (Institute for Statistics). (2014). Higher Education in Asia: Expanding Out, Expanding Up. The rise of graduate education and university research. Canada. ISBN: 978-92-9189-147-4 in http://www.uis.unesco.org/Library/Documents/higher-education-asia-graduate-university-research-2014-en.pdf
19. Yoon B., Jeong Y. (2015). Development of international cooperation maps for R&D policy: exploring national factors in South Korea. Science Technology Society, 20(2) 225-251.
20. Hamers L., Hemeryck Y., Herweyers G., Janssen M., Keters H., Rousseau R., Vanhoutte A. (1989). Similarity measures in scientometric research: the Jaccard index versus Salton's cosine formula. Information Processing and Management, 25(3) 315-318.
21. Leydesdorff L. (2008). On the normalization and visualization of author co-citation data: Salton's Cosine versus the Jaccard Index. Journal of the American Society of Information Science & Technology, 59(1) 77-85.
22. Ahlgren P., Jarneving B., Rousseau R. (2003). Requirement for a co-citation similarity measure, with special reference to Pearson's correlation coefficient. Journal of the American Society for Information Science and Technology, 54(6), 550-560.
23. Ahlgren P., Jarneving B., Rousseau R. (2004). Author co-citation and Pearson's r. Journal of the American Society for Information Science and Technology, 55(9), 843-843.

How to cite this article: Magnone E, Surwase G, Kademani BS. Indo-Korean Co-Publications: An Analysis Using Asymmetric (a) Index J Scientometric Res. 2016;5(3):209-219. Full text available at http://www.jscires.org/v5/i1