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Assessment of Scientific Productivity by India and South Korea

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ABSTRACT

The purpose of this study is to make a quantitative analysis and to compare scientific productivity between the countries of India and South Korea: both countries offer scholarships and fellowships for various programs and disciplines. The data are collected from SCOPUS through the open access portal www.scimagojr.com and mainly focus on rank and number of publications, global publication share and growth of publications, international collaboration pattern, quality of publications, and open access pattern. Various bibliometric indicators have been used along with simple percentage. Further, a new relative indicator Relative Open Access Index (ROAI) is proposed to compare the number of documents in an open access platform with its overall scientific production. Among the most productive countries, India is ranked at fifth and South Korea at thirteenth in the year 2018. India improved by eight positions while South Korea did by three from 1998 to 2018 at the global level. South Korea has a higher proportion of publications with international collaboration as compared to India. Both countries maintain better positions in a few disciplines such as chemical engineering and materials science.

Keywords: Bibliometrics; Scientometrics; Scientific output; Productivity; Rank; India; South Korea

1. INTRODUCTION

Every country shows its power not only in natural resources but also in the scientific output which is used as the benchmark for measuring the quality and quantity of research carried out. Both countries (India at 3 and South Korea at 9) were ranked among the top ten most productive countries in the science and engineering articles[1]. According to Bloomberg's Innovation Index 2019, South Korea tops while India stands at 54th. Both countries offer scholarships and fellowships for various programs and disciplines to their counterparts[2].

Even though both countries have tried to offer support and help to research and development, the scientific productivity behavior of these countries is seldom studied. Among a few of them, Gupta[3] compared the overall science and technology publication output of India, China, and South Korea based on the SCOPUS database. Magnone, Surwase and Kademani[4] studied Indo-Korean co-publications for the period 1994-2013. Pattanashetty and Harinarayana[5] examined the mechanical research output from India, Japan, and South Korea on different parameters including growth, collaboration indices, and activity index. Srivastav et al.[6] conducted a bibliometric evaluation on scientific research production of India and China in the field environmental chemistry. There is some articles[7-8] focusing on the research productivity at the national level also. From the above studies, it is clearly evidenced that there has been no comparative study on research productivity between India and South Korea.

The purpose of this study is to make a quantitative analysis and compare the scientific productivity between the countries of India and South Korea. More specifically, changes in global rank and share of the publications are discussed.

2. DATA AND METHODS

SJR database (http://www.scimagojr.com) is used to collect bibliometric information for the chosen countries. Nowadays, the SCImago database is also being used to analyse scientific productivity[9-12]. The present study covers the scientific productivity of these countries for a period of 21 years, 1998-2018. All the document types and sources are considered for this study. Data pertaining to number of documents and rank, documents not cited, share of international collaborative papers and proportion of documents in open access platform was imported into MS-Excel for further analysis. The database was accessed during September 2019. In order to analyse and compare the scientific productivity of both countries, the following indicators were used: Compound Annual Growth Rate (CAGR)[13], Activity Index, Relative Growth Index (RGI)[14] and Relative Citation Impact (RCI)[15]. Further, a new relative indicator called Relative Open Access Index (ROAI) is proposed in this study.

2.1 Relative Open Access Index

To the best of our knowledge, there has been no indicator

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to compare the share of open access articles of a country with the global[16-17]. To substitute for this, a new relative indicator *Relative Open Access Index* (ROAI) is proposed. This index is in line with CAI[18].

$$ROAI = \frac{OA_{ij} / OA_{io}}{OA_{oj} / OA_{oo}}$$

Where,

OA_{ij} = Number of open access articles for a country

OA_{io} = Total output of a country

OA_{oj} = Number of open access articles for all the countries

OA_{oo} = Total output of all the countries

ROAI=1 indicates that a country's open access publications correspond to the world average, ROAI > 1 reflects higher than the world average, and ROAI < 1 is lower than the world average.

In this study, ROAI is used to compare the proportion of documents in open access platform of India or South Korea in a specific discipline with that of country.

3. RESULTS

3.1 General Characteristics

Table 1 provides the information about number of documents and ranks in documents, population and GDP along with income classification. In terms of number of documents, Indian authors outnumbered the South Korean authors by a factor of 2 in the year 2018. In terms of rankings, India ranked higher than South Korea in the three indicators (documents, population, and GDP) In terms of income, India belongs to lower middle income group where as South Korea belongs to high income.

Table 1. General characteristics

Indicators	India	South Korea
No. of Documents (2018)	171,356	85,725
Documents Rank (2018)	5	13
Population Rank – 2018	2	28
GDP Rank - 2018	7	10
Classification by income	LMI	HI

Statistics on population: https://en.wikipedia.org/wiki/List_of_countries_by_population_(United_Nations)
GDP: https://databank.worldbank.org/data/download/GDP.pdf
Classification of country (2019):www.worldbank.org (HI – High Income, UMI – Upper Middle Income, LMI – Lower Middle Income)

3.2 Global Publication Share, Rank and Growth

Table 2 provides the global publication share, rank changes and growth of India and South Korea in a ten-year interval, 1998, 2008 and 2018. Both the countries improved their ranks from 1998 to 2018: their global publication shares have also been increased. India improved by 8 positions from 13 in 1998 to 5 in 2018. Similarly, South Korea improved by 3 positions from 16 in 1998 to 13 in 2018 with a fluctuation in 2008. Similarly, both the countries maintained an annual growth of 10 per cent during the period 1998-2018. However, there is a dip of 50 per cent in terms of publication growth for South Korea from 1998-2008 to 2008-2018. This result is consistent with Science and Engineering Indicators[1].

3.3 International Collaboration Pattern

Table 3 shows the highest percentage of international collaborative publications is registered by South Korea with almost 30 per cent in the year 2018, and lowest by India with 16.74 per cent in the year 1998. There were a little bit fluctuation trends for South Korea, whereas there was a gradual increase for India.

Table 3. International collaboration trend of India and South Korea

Country	Share of ICP		
	1998	2008	2018
India	16.74	17.42	17.84
South Korea	24.18	23.92	29.27

3.4 Rank Changes of Publications in Various Disciplines

Table 4 presents the global ranking of India and South Korea in 27 broad disciplines in a ten year interval period (1998, 2008, and 2018). In almost all areas, the rankings of both counties have become higher during the periods. In 2018, both countries ranked within the twenty in almost all areas except nursing and psychology for India and arts and humanities for South Korea.

A ranking matrix (Annexure 1) shows that South Korea's rank in most of the broad disciplines falls between 5 and 15, whereas many of India's ranks are above 5. Pearson correlation analysis shows that publications of India and those of Korea in those disciplines have a significant relationship of 0.547 at level

Table 2. Global publication shares, related ranks and growth of India and South Korea

Country	Global Publication Share			Global Publication Rank			CAGR		
	1998	2008	2018	1998	2008	2018	1998-2018	1998-2008	2008-2018
India	1.88	2.73	5.52	13	10	5	10.55	10.13	10.96
South Korea	1.16	2.32	2.76	16	12	13	9.41	13.75	5.23

Table 4. Rank changes in various disciplines

Subject	1998		2008		2018	
	India	SK	India	SK	India	SK
Agricultural & Biolog. Sciences (ABS)	9	32	10	14	6	13
Arts & Humanities (AAH)	17	30	23	28	19	25
Bioch., Genetics & Mol. Biology (BGM)	15	17	10	11	6	10
Business, Manag. & Accounting (BMA)	9	16	8	16	6	14
Chemical Engineering (CHE)	9	12	6	8	3	5
Chemistry (CHM)	9	13	5	10	3	9
Computer Science (CSC)	15	11	13	9	3	10
Decision Sciences (DES)	8	15	12	13	3	13
Dentistry (DEN)	23	26	8	16	3	12
Earth & Planetary Sciences (EPS)	13	32	12	19	12	19
Economics, Econometrics & Finance (EEF)	13	19	10	19	10	13
Energy (ENE)	9	13	7	9	3	9
Engineering (ENG)	12	10	11	7	3	8
Environmental Science (ENV)	12	26	6	14	3	14
Health Professions (HEP)	31	20	20	15	18	13
Immunology & Microbiology (IAM)	17	15	11	10	9	11
Materials Science (MAT)	9	11	8	7	3	7
Mathematics (MTH)	13	15	12	11	3	14
Medicine (MED)	15	26	12	15	10	13
Neuroscience (NEU)	22	24	17	14	15	14
Nursing (NUR)	18	25	24	11	22	10
Pharmacol.,Toxicol. &Pharmaceut. (PTP)	7	15	4	10	3	11
Physics & Astronomy (PHA)	10	12	10	9	5	10
Psychology (PSY)	25	35	34	28	21	18
Social Sciences (SOS)	12	30	13	25	13	16
Veterinary (VET)	4	43	4	19	5	17
Multidisciplinary (MUL)	5	28	5	28	6	10

of 0.01. This verifies that publications of India are consistently higher than those of Korea in most of the disciplines listed.

3.5 Activity Profile

Accordingly, activity index for India and South Korea in various disciplines in a ten year interval period (1998, 2008, and 2018) is calculated and presented in Table 5. Both countries give the equal effort in the areas of chemistry, chemical engineering, energy, materials science, pharmacology, and physics & astronomy. However, both countries differ in some disciplines. For example, India concentrates in computer science, decision sciences, dentistry, engineering and mathematics, while South Korea in dentistry, health professionals, medicine and nursing.

3.6 Growth in Various Disciplines

The analysis of growth patterns based on CAGR and RGI reveals that there is no common pattern among the countries (Table 6). There is a decrease in growth rate from 1998-2008 to 2008-2018 for both countries in some disciplines: agricultural

Table 5. Activity index of India and South Korea in various disciplines

Subject	India			SK		
	1998	2008	2018	1998	2008	2018
ABS	1.85	1.55	0.88	0.47	0.85	0.96
AAH	0.28	0.18	0.17	0.20	0.19	0.29
BGM	0.92	1.11	0.97	1.08	1.17	1.29
BMA	0.55	0.68	0.84	0.52	0.38	0.78
CHE	1.53	1.61	1.64	1.78	1.78	1.59
CHM	1.94	2.03	1.16	1.70	1.54	1.33
CSC	0.84	0.88	1.82	1.70	1.34	1.04
DES	1.60	0.96	1.56	1.58	0.68	0.87
DEN	0.30	1.04	1.49	0.33	0.72	1.07
EPS	1.18	1.05	0.63	0.50	0.53	0.62
EEF	0.61	0.78	0.65	0.62	0.42	0.74
ENE	1.49	1.19	1.31	1.28	1.31	1.20
ENG	0.95	0.95	1.45	1.76	1.51	1.26
ENV	1.27	1.68	1.13	0.62	0.76	0.96
HEP	0.13	0.37	0.31	0.42	0.61	1.01
IAM	0.80	1.29	0.70	1.46	1.57	1.30
MAT	1.40	1.40	1.37	1.96	1.88	1.54
MTH	0.98	0.87	1.34	1.48	1.06	0.83
MED	0.65	0.80	0.69	0.53	0.75	1.05
NEU	0.39	0.48	0.41	0.47	0.84	0.93
NUR	0.20	0.21	0.20	0.19	0.68	1.16
PTP	1.84	2.40	1.53	1.36	1.22	1.07
PHA	1.44	1.31	1.35	2.00	1.68	1.19
PSY	0.12	0.11	0.20	0.12	0.19	0.42
SOS	0.49	0.45	0.42	0.22	0.28	0.54
VET	3.81	2.60	0.96	0.19	0.77	0.69
MUL	1.80	1.74	0.95	0.20	0.22	1.30

and biological sciences, chemistry, dentistry, environmental science, and immunology & microbiology. However, there is a contradictory growth in terms of CAGR. For example, there was a decrease in decision sciences for India, whereas there was an increase for South Korea from 1998-2008 to 2008-2018. The highest and lowest growth is achieved by South Korea in nursing and veterinary science, respectively. However, India's highest growth has been observed in dentistry, while the lowest was similar with South Korea. There is a contradictory growth in both countries. For example, India's growth in computer science is 20.7 per cent during 2008-2018, whereas it is 3.79 per cent for South Korea. More or less, the same growth of publications is achieved in immunology for both countries.

3.7 Pattern of Open Access

Even though, the term Open Access was coined in the 1990s, getting familiar in the 2000s and majority of journals charge open access fee. Moreover, publishing in open access platform is based on the country's policy decision. For example, the use of PubMed Central repository is mandatory for researches supported by US National Institutes of Health. The analysis of open access pattern reveals that there is no common pattern among the countries (Table 7). For almost one third of the broad disciplines there is no interest in publishing in open access platforms throughout the reference period: business, chemistry, computer science, decision sciences, economics, energy, engineering, materials science, and physics. However, both countries show their interests in the recent period (2018) in a few disciplines: agriculture, biochemistry, dentistry, environmental science, neuroscience, and multidisciplinary.

3.8 Quality of Publications

To compare the quality of publications, the value of citations per paper (CPP) has been collected and relative citation impact has been calculated (Table 8). Range of CPP is from 3.65 to 15.04 for India, while from 6.96 to 30.6 for South Korea. The highest CPP has been achieved in chemical engineering by India, while multidisciplinary and chemistry by South Korea. Lowest CPP has been achieved in veterinary by India, while South Korea in mathematics. Chemistry, Physics and Medicine related subjects have gained higher impact for both countries. Similar trend has been observed in relative citation impact (RCI).

The highest h-index value has been achieved in medicine by both countries, which clearly states that they produce world class quality publications in this field (Fig. 2). South Korea's highest h-index is also in chemistry. However, India recorded the second highest h-index value in chemistry, whereas South Korea's is in biochemistry. Very interestingly, Pearson correlation analysis shows that h-indexes of India and those of Korea in those subjects have a significant relationship of 0.94 at level of 0.01, as Fig. 2 shows the general picture. This verifies that h-indexes of Korea are consistently higher than those of India in most of the subjects listed.

4. CONCLUSIONS

The results of this study reveal publication and collaboration trends of India and South Korea which are useful

Table 6. Growth of publications in various disciplines

Subject	CAGR 1998-2008		CAGR 2008-2018		CAGR 1998-2018		RGI 1998-2008		RGI 2008-2018		RGI 1998-2018	
	India	**SK**	**India**	**SK**	**India**	**SK**	India	SK	India	SK	India	SK
ABS	8.08	20.65	5.96	7.69	7.01	13.99	0.80	1.50	0.54	1.47	0.66	1.49
AAH	8.31	16.20	12.00	11.39	10.14	13.77	0.82	1.18	1.09	2.18	0.96	1.46
BGM	9.35	11.79	9.80	6.54	9.57	9.13	0.92	0.86	0.89	1.25	0.91	0.97
BMA	15.66	13.09	13.06	13.08	14.35	13.08	1.55	0.95	1.19	2.50	1.36	1.39
CHE	11.40	14.45	13.66	6.36	12.53	10.33	1.13	1.05	1.25	1.22	1.19	1.10
CHM	9.58	11.55	5.21	3.93	7.37	7.67	0.95	0.84	0.48	0.75	0.70	0.82
CSC	18.23	18.56	20.70	3.79	19.46	10.93	1.80	1.35	1.89	0.72	1.84	1.16
DES	10.10	9.96	23.35	14.24	16.54	12.08	1.00	0.72	2.13	2.72	1.57	1.28
DEN	24.33	22.94	14.77	9.17	19.45	15.85	2.40	1.67	1.35	1.75	1.84	1.68
EPS	8.47	15.23	6.72	8.13	7.59	11.62	0.84	1.11	0.61	1.55	0.72	1.24
EEF	17.54	13.84	10.13	12.57	13.78	13.20	1.73	1.01	0.92	2.40	1.31	1.40
ENE	12.74	19.31	17.90	9.68	15.29	14.39	1.26	1.40	1.63	1.85	1.45	1.53
ENG	12.39	14.26	15.98	3.58	14.17	8.79	1.22	1.04	1.46	0.68	1.34	0.93
ENV	13.53	16.23	11.12	12.27	12.32	14.23	1.34	1.18	1.01	2.35	1.17	1.51
HEP	21.18	17.31	9.62	11.28	15.25	14.26	2.09	1.26	0.88	2.16	1.45	1.52
IAM	12.76	11.79	4.17	3.12	8.38	7.37	1.26	0.86	0.38	0.60	0.79	0.78
MAT	9.43	12.52	11.76	4.21	10.59	8.29	0.93	0.91	1.07	0.80	1.00	0.88
MTH	10.02	11.23	18.26	4.77	14.07	7.95	0.99	0.82	1.67	0.91	1.33	0.85
MED	10.13	15.25	8.86	8.51	9.50	11.83	1.00	1.11	0.81	1.63	0.90	1.26
NEU	9.94	17.84	9.90	7.07	9.92	12.33	0.98	1.30	0.90	1.35	0.94	1.31
NUR	11.57	31.01	8.98	9.53	10.27	19.79	1.14	2.26	0.82	1.82	0.97	2.10
PTP	10.90	10.30	6.15	3.85	8.50	7.02	1.08	0.75	0.56	0.73	0.81	0.75
PHA	8.33	10.99	10.65	1.08	9.48	5.92	0.82	0.80	0.97	0.21	0.90	0.63
PSY	8.67	18.78	20.73	16.62	14.54	17.69	0.86	1.37	1.89	3.18	1.38	1.88
SOS	11.55	18.70	13.13	17.97	12.34	18.33	1.14	1.36	1.20	3.43	1.17	1.95
VET	1.60	30.24	-1.57	2.05	1.94	15.28	0.16	2.20	-0.14	0.39	0.18	1.62
MUL	7.35	12.56	7.81	29.43	7.58	20.70	0.73	0.91	0.71	5.62	0.72	2.20

Table 7. Relative open access index for India and South Korea in various disciplines

Subject	1998		2008		2018	
	India	SK	India	SK	India	SK
ABS	0.44	1.25	0.83	1.45	1.07	1.24
AAH	0.33	1.47	1.07	0.99	0.87	0.50
BGM	1.50	0.86	1.31	1.45	1.88	1.42
BMA	0.55	0.11	0.32	0.50	0.34	0.50
CHE	0.97	0.15	0.75	0.42	1.68	0.91
CHM	0.24	1.11	0.71	0.88	0.70	0.97
CSC	0.61	0.30	0.45	0.38	0.59	0.74
DES	0.73	0.24	0.56	0.39	0.18	0.24
DEN	0.52	0.32	2.79	1.58	2.49	1.25
EPS	0.80	1.70	0.99	1.78	1.04	1.05
EEF	0.20	0.19	0.24	0.55	0.58	0.89
ENE	0.06	0.27	0.45	0.60	0.35	0.87
ENG	0.65	0.30	0.31	0.27	0.66	0.64
ENV	0.83	0.51	0.75	0.54	1.70	1.06
HEP	0.15	0.66	2.14	0.90	0.97	0.78
IAM	0.72	1.34	1.19	1.39	1.12	1.10
MAT	0.49	0.31	0.67	0.39	0.48	0.61
MTH	0.69	0.77	1.07	0.99	0.39	0.80
MED	1.81	2.15	1.71	1.89	1.77	1.46
NEU	2.71	0.60	2.12	2.02	1.96	1.45
NUR	1.85	1.34	0.90	1.76	0.82	1.00
PTP	1.49	0.47	1.73	1.42	2.06	1.09
PHA	0.77	0.65	0.99	0.75	0.72	0.98
PSY	0.13	0.00	0.68	0.43	1.24	0.45
SOS	0.19	0.24	0.54	0.40	0.64	1.03
VET	0.11	2.98	0.63	3.61	0.77	1.65
MUL	2.05	4.30	0.98	3.71	2.74	3.16

Table 8. CPP and RCI of India and South Korea in broad disciplines

Subject	CPP		RCI	
	India	SK	India	SK
ABS	9.07	12.69	1.01	0.98
AAH	8.53	16.84	0.95	1.30
BGM	13.43	19.85	1.49	1.53
BMA	5.51	14.67	0.61	1.13
CHE	15.04	18.52	1.67	1.43
CHM	14.53	19.94	1.61	1.54
CSC	4.71	6.99	0.52	0.54
DES	6.39	12.52	0.71	0.97
DEN	5.37	12.89	0.60	1.00
EPS	10.01	13.5	1.11	1.04
EEF	5.18	10.47	0.58	0.81
ENE	11.16	13.03	1.24	1.01
ENG	6.94	9.82	0.77	0.76
ENV	11.39	15.17	1.27	1.17
HEP	7.9	11.05	0.88	0.85
IAM	14.79	16.05	1.64	1.24
MAT	12.12	14.48	1.35	1.12
MTH	6.02	6.96	0.67	0.54
MED	10.38	14.7	1.15	1.14
NEU	12.08	17.81	1.34	1.38
NUR	14.34	9.48	1.59	0.73
PTP	10.34	17.21	1.15	1.33
PHA	11.22	13.8	1.25	1.07
PSY	9.16	14.53	1.02	1.12
SOS	4.61	7.56	0.51	0.58
VET	3.65	7.91	0.41	0.61
MUL	9.98	30.6	1.11	2.36

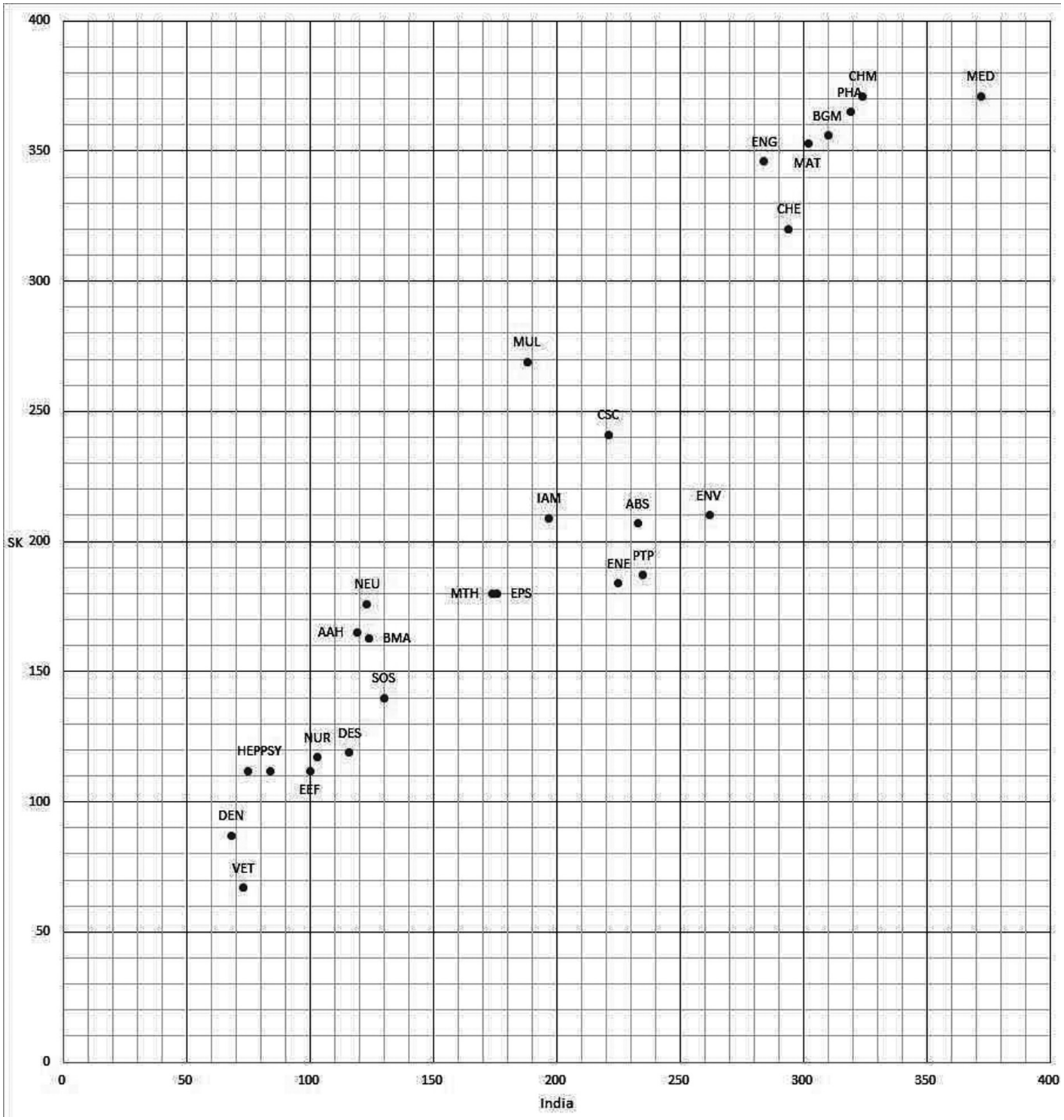

Figure 2. Ranking of h-index matrix of India and South Korea in broad disciplines (2018).

for the academic as well as research community, and for policy makers and those who support research and development; each country can learn and get mutual benefits from the other country through future cooperation in various areas using different approaches. For example, in the top areas in both countries, they can pursue world-class excellence through cooperation, and in other areas where one country is superior to another, that country can lead cooperation to support and cooperate with another in various ways. In this regard, this article recommends the six subject areas of biochemistry, genetics & molecular biology; chemical engineering; chemistry; materials sciences; physics & astronomy; and medicine as candidate areas to make more productive cooperation between the two countries.

This article has some limitations in that it has not investigated the reasons why productivities in these countries have increased during these years[7]. Therefore, further studies to investigate the reasons and/or relationships between productivities and some kinds of national investments into

research and development maybe very interesting and useful, not only for both countries but also for other nations in similar situations.

This study dealt with macro level (e.g. country as a whole) analysis, and did not cover the meso (e.g. source journals, author affiliations) and micro (e.g. individual authors, research teams) levels. These might be of interest for future research on relationship between these countries.

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Annexure I

Ranking of publications matrix of India and South Korea in broad disciplines (2018)