K-Means clustering for impact factors normalization: Effective method to compare journal performance

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Abstract—***Impact factor is a widely used method to compare journals .But this Impact factor value is totally subject category or research field dependant. The people, Employers, universities, government agencies, and accreditation agencies use the impact factor values of journals to compare research work of a person/persons published in it with research work published by other persons in other subject category's journal. This is not a fair way of comparison of journals across subject categories. Our proposed method gives in-brief comparison for comparing journals from different research areas, which helps administrators, who is not aware of different research fields, to take decide the research works quality and librarians to manage and purchase journals from different research categories. This method does not use maximal impact factor or first few impact factors for normalization. This method is also not depends on number of journals available in particular subject category. We used internationally accepted impact factor and not proposed any new or normalized impact factor.***

Keywords— ***K-Means,*** *Clustering, Journal evaluation, Bibliometrics, impact-factor, Journal Citation Reports phrases*

I. INTRODUCTION

The idea of impact factor was first introduced by Eugene Garfield in science in 1995 as a simple way to count influence of a journal. [1] But now-a-days, the impact factor of journal, where the article is published in, is used as measurement of the quality of the article by different universities for tenure and promotions researches, and also to evaluate their research scholars. This is also used by different government agencies for grants and for funding different research projects and to evaluate the quality of research held in different organizations. In this paper, we first explained the fact about why Impact factor of journals should not be used to compare two or more journals from different subject categories. The proposed method is compared with normalized impact factors and rank-normalized impact factors for comparing journals across different categories. Then we stated our proposed algorithm which explains how to use a machine learning technique called clustering. This helps different universities, government agencies to compare journals across research categories. We have also explained flow of our proposed algorithm with the help of a simple example.

II. NEED OF JOURNALS CLUSTERING

Impact factor is based on citation analysis. Citation analysis has its own International Society of Scientometrics and Informetrics. Main advantage of Impact factor is simplicity.[2] In many countries, including India, the impact factor is not only used as bibliometric indicator to measure quality of journal but also to measure research articles, the researchers who wrote those papers, the university where researcher works. It is even used to measure quality of institute where these researches work in. [3] A journal's impact factor is calculated using two factors. First is the number of citations in the current year to articles, research papers and review papers published by the journal in the last two years and second is the number of articles, research papers and review papers published by journal in the last two years. IF for Journal j in current year is given by

$$IF(j) = A/B \quad (1)$$

Where

A = Citations in all journal papers during year to papers published in j during previous two years

B = No. of articles published in j during previous two years

An impact factor could also be calculated using more number of years of references and articles, but according to Garfield E. this impact value would be little correct. [4] But as we mentioned in abstract of this paper, this impact factor is highly research are dependant. It should not be used to compare journals across different subject categories due to following reasons. It may be possible that top journals in one subject are may have impact factor higher than that of bottom journals in other area. .[3] The average number of references included in the research paper is comparatively lower in some subject categories. E.g. the citation density is very low for mathematics journals than other subject journals.[5] The number of retrospective years required to find 50% of the cited references (The half life) is longer for physiology journals than that for physics journals. [6] The Fundamental and pure subject areas may have higher average impact factors than specialized or applied ones.[3].In social sciences, there are average two authors per paper while in fundamental life sciences, there are four authors per papers. There is a strong and significant correlation between the average number of authors per paper and the average impact factor for a subject area. [3]. There may be less number of journals available in small research subject category. Dynamic research fields with high activity and short publication lags, such as biochemistry and molecular biology, have a correspondingly high proportion of citations to recent publications–and hence higher journal impact factors–than, for example, ecology and mathematics.[7][8][9][10] the speed of discovery is different subject categories[11] is also cause of different impact factors.[12][16][21]These are various reasons stating why two journals from different category should not be compared using impact factors.

III. RELATED WORK AND COMPARISION

The normalization of impact factor is the method proposed by Sen, B.K for the comparison of journals across subject categories[13][14] The equation for the normalization is given by

$$\mathrm{NIF}(j) = \frac{IF(j)}{\text{Highest IF}_S} \qquad (2)$$

Where

NIF(j) = Normalized Impact Factor of a journal j

IF(j) = Impact Factor of a journal j

Highest IF_S = Highest IF in the Subject Category s.

But the main problem with this method is that it uses maximal impact factor of the subject category (Highest IF_s). This maximal value or few maximal values [14] cannot always be feature of most of journals present in the subject category. [15] As alternative way, we can use Rank normalization method proposed by Pudovkin AI and Garfield E. The Formula for rNIF(j) is given by the equation 3

$$\mathrm{rNIF(j)} = \frac{N_s - Rank(j) + 1}{N_s} \qquad (3)$$

Where

rNIF(j) is rank normalized IF of journal j.

N_s is number of journals in the subject category S

Rank (j) is the rank of journal in the category S

rNIF is based on number of journals in the category .It should be noted that Some subject categories may have more journals compare to other categories.

Our proposed approach does use maximal IF or few maximal impact factors. It is also not depends on number of journals in the subject area. It gives more summarized comparison to the administrators to take decision about the grands, fundings etc. E.g. suppose there are 3 clusters, cluster I low, Cluster II medium and cluster III of the high quality journals from different subject categories. The research work published in the journals from category III will be preferred for the funding. University May consider researcher whose papers published in journals from category III for promotions, tenures. The research scholars can select journals from category III for interdisciplinary publications.

IV. DISCUSSION ON PROPOSED CROSS CATEGORY JOURNALS COMPARISON SCHEME

We proposed category wise clustering of the impact journals based on their impact factor values. The clustering is an unsupervised learning technique which groups patterns or object according to its properties and behaviors. In the scheme, we have proposed the use of k-means clustering technique for the clustering of the journals. There are total M subject categories. For each of the category, we have to apply clustering technique. We will then get k clusters per subject categories. These clusters should be arranged in the descending order of the means. Equal level clusters, one from each group, will be merged to form total k super clusters. The proposed algorithm is given as follows.

M = No. of subject categories

For all subject categories S $(S_1$ *to* $S_M)$
 Samples $X = \{x_{js}\}$*, all journals j from categorys S*
 Initialize means $m_i, i = 1, \dots\dots, k,$ *to k random* x_{js}
 Repeat
 assign each item x_{js} *to the cluster which has the closest mean;*
 calculate new mean for each cluster;
 until convergence criteria is met;
 Arrange all k clusters in the descending order of mean values as $C_{S1}, C_{S2}, C_{S3} \dots C_{Sk}$
END For
For i = 1 to K
 $Ci = C_{1i} + C_{2i} + \cdots \dots + C_{Mi}$
END For

V. EXAMPLE AND RESULT

For the example purpose, we have considered there are only three categories. Suppose Category one is having 64 journals, category two is with 29 journals and category three is having 27 journals. Table 1, Table 2 and 3 show the 64 journals from category I, 29 journals from category II and the 27 journals from category III with their Impact factors respectively. We have hidden actual names of journals and categories in this paper. Because, this is only proposed method and we do not want to defame any journal.

For Category I minimum value 0.021, maximum value 18.203, mean 1.86 and std. deviation 2.687.For Category II minimum value 0.011, maximum value 49.926, mean 2.571and std. deviation 9.132.For Category III minimum value 0.235, maximum value 19.632, mean 2.381and std. deviation 3.892.

A. Result

Clustering criterion: Determinant (W)

Stop conditions: Iterations = 500 / Convergence = 0.00001

Number of classes: 10

Initial partition: Random

Repetitions: 10

Table IV, V shows Category wise result by class and category wise result by journals. Here sum of wts.: sum of weights, WCV: Within-class variance Min.D.(C): Minimum distance to centroid, Avg.D.(c): Average distance to centroid, Max.D.(C): Maximum distance to centroid. [17][18][19][20]The evolution graph for subject category I, II and III are given in the figure I, II and III respectively. Total iterations required are 4,3 and 3 from subject category I,II and III respectively. The subject category wise statistics for each iteration are given in the table VI. We will have total 10 clusters per subject category. As shown in table VI, for each subject category, clusters are arranged in the descending order of means. Top clusters (with highest means) one from each subject category are merged to form super cluster 1, similarly clusters those are at same level in its subject category are merged to form super clusters.

TABLE I
65 JOURNALS IN THE SUBJECT CATEGORY I WITH IFS

Journal	IF	Journal	IF
Cat I A	0.75	Cat I AG	0.7
Cat I B	1.448	Cat I AH	0.144
Cat I C	3.54	Cat I AI	1.46
Cat I D	1.19	Cat I AJ	5.368
Cat I E	0.293	Cat I AK	0.572
Cat I F	1.791	Cat I AL	3.25
Cat I G	0.391	Cat IAM	2.145
Cat I H	2.221	Cat I AN	0.097
Cat I I	2.478	Cat I AO	0.637
Cat I J	2.338	Cat I AP	5.108
Cat I K	2.092	Cat I AQ	7.493
Cat I L	18.203	Cat I AR	0.392
Cat I M	0.76	Cat I AS	0.459
Cat I N	0.896	Cat I AT	0.393
Cat I O	0.874	Cat I AU	0.46
Cat I P	7.667	Cat I AV	0.505
Cat I Q	0.758	Cat I AW	2.26
Cat I R	0.28	Cat I AX	0.523
Cat I S	1.447	Cat I AY	0.508
Cat I T	0.595	Cat I AZ	0.508
Cat I U	1.588	Cat I BA	2.471
Cat I V	2.65	Cat I BB	1.482
Cat I W	2.822	Cat I BC	1.262
Cat I X	2.276	Cat I BD	0.021
Cat I Y	0.32	Cat I BE	0.571
Cat I Z	1.065	Cat I BF	0.551
Cat I AA	1.314	Cat I BG	3.975
Cat I AB	1.926	Cat I BH	1.394
Cat I AC	6.523	Cat I BI	0.064
Cat I AD	1.31	Cat I BJ	0.229
Cat I AE	0.634	Cat I BK	0.604
Cat I AF	0.742	Cat I BL	0.253

TABLE IIIII
29 JOURNALS IN THE SUBJECT CATEGORY II WITH IFS

Journal	IF	Journal	IF
Cat II A	0.59	Cat II P	0.551
Cat II B	0.751	Cat II Q	0.69
Cat II C	0.841	Cat II R	3.007
Cat II D	0.424	Cat II S	0.461
Cat II E	1.628	Cat II T	1.549
Cat II F	1	Cat II U	0.011
Cat II G	0.676	Cat II V	0.123
Cat II H	0.479	Cat II W	1.234
Cat II I	1.194	Cat II X	1.01
Cat II J	0.188	Cat II Y	0.288
Cat II K	49.926	Cat II Z	0.275
Cat II L	1.801	Cat II AA	0.714
Cat II M	0.782	Cat II AB	0.54
Cat II N	2.257	Cat II AC	1.172
Cat II O	0.411		

Thus, Super cluster 10 contains bottom clusters (with lowest means) one from each subject category. Final 10 clusters are shown in the table VII. Journals those are in cluster 1 are high quality journals while journals in the cluster 10 are low quality journal.

TABLE IVVVI
27 JOURNALS IN THE SUBJECT CATEGORY III WITH IFS

Journal	IF	Journal	IF
Cat II A	0.882	Cat III O	0.775
Cat III B	0.235	Cat III P	3.733
Cat III C	1.069	Cat III Q	1.27
Cat III D	1.234	Cat III R	0.726
Cat III E	1.675	Cat III S	0.739
Cat III F	0.923	Cat III T	1.414
Cat III G	3.76	Cat III U	7.154
Cat III H	0.315	Cat III V	6.231
Cat III I	0.522	Cat III W	19.632
Cat III J	0.75	Cat III X	2
Cat III K	1.232	Cat III Y	1.542
Cat III L	0.333	Cat III Z	4.6
Cat III M	0.347	Cat III AA	0.769
Cat III N	0.437		

TABLE IV
SUBJECT CATEGORY WISE RESULT BY CLASS

Subject	I	II	III	I	II	III
Class	1	1	1	2	2	2
Objects	9	3	2	9	6	6
Sum of wts	9	3	2	9	6	6
WCV	0.005	0.001	0.001	0.010	0.004	0.010
Min.d.(C)	0.013	0.009	0.020	0.018	0.009	0.018
Avg.D.(C)	0.061	0.020	0.021	0.081	0.049	0.076
Max.D.(C)	0.092	0.030	0.021	0.176	0.099	0.157
Class	3	3	3	4	4	4
Objects	3	4	4	4	3	2
Sum of wts	3	4	4	4	3	2
WCV	0.133	0.001	0.008	0.022	0.017	0.053
Min.d.(C)	0.048	0.017	0.031	0.059	0.031	0.163
Avg.D.(C)	0.258	0.026	0.066	0.121	0.094	0.163
Max.D.(C)	0.387	0.035	0.132	0.184	0.142	0.163
Class	5	5	5	6	6	6
Objects	9	2	2	4	3	5
Sum of wts	9	2	2	4	3	5
WCV	0.012	0.000	0.000	0.026	0.001	0.000
Min.d.(C)	0.040	0.005	0.013	0.063	0.006	0.002
Avg.D.(C)	0.096	0.005	0.013	0.130	0.023	0.016
Max.D.(C)	0.168	0.005	0.014	0.198	0.034	0.026
Class	7	7	7	8	8	8
Objects	12	3	2	8	1	2
Sum of wts	12	3	2	8	1	2
WCV	0.004	0.008	0.008	0.044	0.000	0.426
Min.d.(C)	0.019	0.016	0.064	0.032	0.000	0.462
Avg.D.(C)	0.056	0.064	0.064	0.166	0.000	0.462
Max.D.(C)	0.095	0.096	0.064	0.383	0.000	0.462
Class	9	9	9	10	10	10
Objects	1	2	1	5	2	1
Sum of wts	1	2	1	5	2	1
WCV	0.000	0.281	0.000	1.386	0.000	0.000
Min.d.(C)	0.000	0.375	0.000	0.091	0.006	0.000
Avg.D.(C)	0.000	0.375	0.000	0.955	0.006	0.000
Max.D.(C)	0.000	0.375	0.000	1.324	0.007	0.000

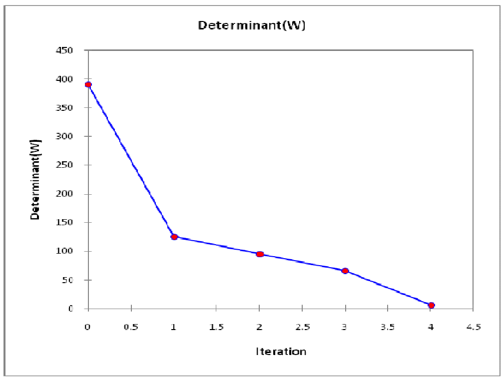

Fig. 1.Evolution chart for subject category I

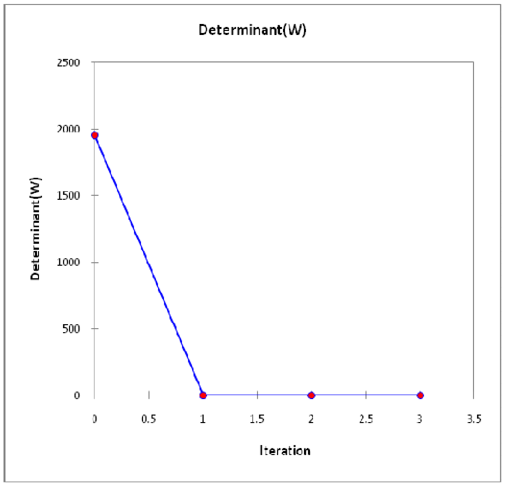

Fig. 2 Evolution chart Subject for category II

VI. APPLICATIONS

Following are advantages of the algorithm

- This technique is very useful to compare universities from different domain based on research work. We can compare quality of research work at Technological Universities with medical universities and agricultural universities.
- The administrator who is not having knowledge of the reach work can compare different research articles.
- This technique can be used by librarians to purchase different level journals from different fields.
- This technique can be used by governments to compare different research works from different research areas for grants and funding.
- Using this technique, a university can recommend the set of journals for publication of research work to their research scholars. This technique can be used by accreditation agencies like (e.g in india NBA or NAAC) to decide quality of research work done at particular university /Institute.

TABLE V

SUBJECT CATEGORY WISE RESULT BY JOURNALS

Subject I				Subject II		Subject III	
Journal	C	Journal	C	Journal	C	Journal	C
Cat.I.1	1	Cat.I.33	1	Cat.II.1	1	Cat.III.1	1
Cat.I.2	2	Cat.I.34	5	Cat.II.2	2	Cat.III.2	2
Cat.I.3	3	Cat.I.35	2	Cat.II.3	2	Cat.III.3	3
Cat.I.4	4	Cat.I.36	10	Cat.II.4	3	Cat.III.4	3
Cat.I.5	5	Cat.I.37	7	Cat.II.5	4	Cat.III.5	4
Cat.I.6	6	Cat.I.38	3	Cat.II.6	5	Cat.III.6	1
Cat.I.7	7	Cat.I.39	6	Cat.II.7	2	Cat.III.7	5
Cat.I.8	8	Cat.I.40	5	Cat.II.8	3	Cat.III.8	2
Cat.I.9	8	Cat.I.41	1	Cat.II.9	6	Cat.III.9	2
Cat.I.10	8	Cat.I.42	10	Cat.II.10	7	Cat.III.10	6
Cat.I.11	6	Cat.I.43	10	Cat.II.11	8	Cat.III.11	3
Cat.I.12	9	Cat.I.44	7	Cat.II.12	4	Cat.III.12	2
Cat.I.13	1	Cat.I.45	7	Cat.II.13	2	Cat.III.13	2
Cat.I.14	4	Cat.I.46	7	Cat.II.14	9	Cat.III.14	2
Cat.I.15	4	Cat.I.47	7	Cat.II.15	3	Cat.III.15	6
Cat.I.16	10	Cat.I.48	7	Cat.II.16	1	Cat.III.16	5
Cat.I.17	1	Cat.I.49	8	Cat.II.17	2	Cat.III.17	3
Cat.I.18	5	Cat.I.50	7	Cat.II.18	9	Cat.III.18	6
Cat.I.19	2	Cat.I.51	7	Cat.II.19	3	Cat.III.19	6
Cat.I.20	1	Cat.I.52	7	Cat.II.20	4	Cat.III.20	7
Cat.I.21	2	Cat.I.53	8	Cat.II.21	7	Cat.III.21	8
Cat.I.22	8	Cat.I.54	2	Cat.II.22	7	Cat.III.22	8
Cat.I.23	8	Cat.I.55	2	Cat.II.23	6	Cat.III.23	9
Cat.I.24	8	Cat.I.56	5	Cat.II.24	5	Cat.III.24	4
Cat.I.25	5	Cat.I.57	7	Cat.II.25	10	Cat.III.25	7
Cat.I.26	4	Cat.I.58	7	Cat.II.26	10	Cat.III.26	10
Cat.I.27	2	Cat.I.59	3	Cat.II.27	2	Cat.III.27	6
Cat.I.28	6	Cat.I.60	2	Cat.II.28	1		
Cat.I.29	10	Cat.I.61	5	Cat.II.29	6		
Cat.I.30	2	Cat.I.62	5				
Cat.I.31	1	Cat.I.63	1				
Cat.I.32	1	Cat.I.64	5				

TABLE V

CLASSES IN DESCENDING ORDER OF MEANS AND FINAL CLUSTERS

Subject I		Subject II		Subject III		Final C
Class	IF	Class	IF	Class	IF	
9	18.203	8	49.926	9	19.632	1
10	6.523	9	3.007	8	7.154	2
3	3.540	4	1.628	10	4.600	3
8	2.471	6	1.194	5	3.760	4
6	1.926	5	1.000	4	2.000	5
2	1.394	2	0.751	7	1.542	6
4	1.065	1	0.551	3	1.232	7
1	0.700	3	0.461	1	0.882	8
7	0.505	10	0.275	6	0.750	9
5	0.229	7	0.123	2	0.347	10

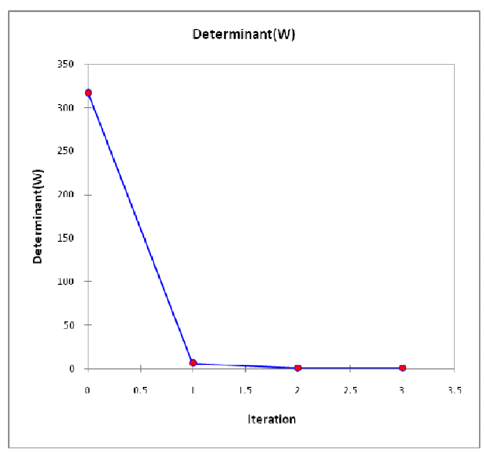

Fig.3 Evolution chart Subject category III

TABLE VI

FINAL LEVELS OF THE JOURNALS

VII. CONCLUSIONS

Impact factor is a widely used method to compare journals .But this Impact factor value is totally subject category or research field dependant. The people, Employers, universities, government agencies, and accreditation agencies use the impact factor values of journals to compare research work of a person/persons published in it with research work published by other persons in other subject category's journal. This is not a fair way of comparison of journals across subject categories. Our proposed method gives in-brief comparison for comparing journals from different research areas, which helps administrators, who is not aware of different research fields, to take decide the research works quality and librarians to manage and purchase journals from different research categories. This method does not use maximal impact factor or first few impact factors for normalization. This method is also not depends on number of journals available in particular subject category. We used internationally accepted impact factor and not proposed any new or normalized impact factor.

Journal	C	Journal	C	Journal	C	Journal	C
Cat I.1	1	Cat III.20	2	Cat II.21	5	Cat III.10	7
Cat I.13	1	Cat III.25	2	Cat II.22	5	Cat III.15	7
Cat I.17	1	Cat I.3	3	Cat III.2	5	Cat III.18	7
Cat I.20	1	Cat I.38	3	Cat III.8	5	Cat III.19	7
Cat I.31	1	Cat I.59	3	Cat III.9	5	Cat III.27	7
Cat I.32	1	Cat II.5	3	Cat III.12	5	Cat I.8	8
Cat I.33	1	Cat II.12	3	Cat III.13	5	Cat I.9	8
Cat I.41	1	Cat II.20	3	Cat III.14	5	Cat I.10	8
Cat I.63	1	Cat III.26	3	Cat I.6	6	Cat I.22	8
Cat II.4	1	Cat I.4	4	Cat I.11	6	Cat I.23	8
Cat II.8	1	Cat I.14	4	Cat I.28	6	Cat I.24	8
Cat II.15	1	Cat I.15	4	Cat I.39	6	Cat I.49	8
Cat II.19	1	Cat I.26	4	Cat II.6	6	Cat I.53	8
Cat III.1	1	Cat II.1	4	Cat II.24	6	Cat II.9	8
Cat III.6	1	Cat II.16	4	Cat III.5	6	Cat II.23	8
Cat I.2	2	Cat II.28	4	Cat III.24	6	Cat II.29	8
Cat I.19	2	Cat III.3	4	Cat I.7	7	Cat III.7	8
Cat I.21	2	Cat III.4	4	Cat I.37	7	Cat III.16	8
Cat I.27	2	Cat III.11	4	Cat I.44	7	Cat I.12	9
Cat I.30	2	Cat III.17	4	Cat I.45	7	Cat II.11	9
Cat I.35	2	Cat I.5	5	Cat I.46	7	Cat III.23	9
Cat I.54	2	Cat I.18	5	Cat I.47	7	Cat I.16	10
Cat I.55	2	Cat I.25	5	Cat I.48	7	Cat I.29	10
Cat I.60	2	Cat I.34	5	Cat I.50	7	Cat I.36	10
Cat II.2	2	Cat I.40	5	Cat I.51	7	Cat I.42	10
Cat II.3	2	Cat I.56	5	Cat I.52	7	Cat I.43	10
Cat II.7	2	Cat I.61	5	Cat I.57	7	Cat II.14	10
Cat II.13	2	Cat I.62	5	Cat I.58	7	Cat II.18	10
Cat II.17	2	Cat I.64	5	Cat II.25	7	Cat III.21	10
Cat II.27	2	Cat II.10	5	Cat II.26	7	Cat III.22	10

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