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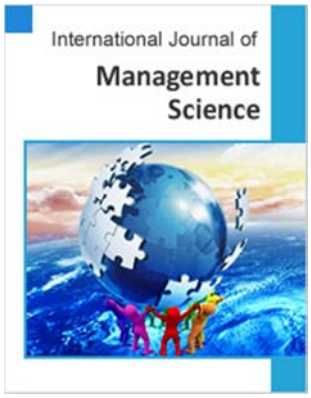

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Determining Key Opinion Leadership Status of Individual Researchers

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Abstract
This paper developed a new scheme for identifying research Key Opinion Leaders. The developed methodology is an approach for evaluating Average Percentile Rank of individual researcher by measuring their collaborative strength through their published works. The study considered and introduced new parameters useful in measuring collaboration, and Average Percentile Rank. With these parameters, a new relationship to quantify Percentile Rank was introduced and applied to evaluate the Research Key Opinion Leader status of individual research staffs of INGENIO, the joint research institute of the Spanish National Research Council (CSIC) and the Polytechnic University of Valencia (UPV), Spain. Overall, the result shows that, number of persons collaborating in a particular research, and the relative positions of the collaborators among their peers and within their organization are relevant and important in determining the KOL status of a researcher.

1. Introduction

One of the ways to remain innovative and successful in present day highly competitive and regulated work-life is connection to expertise from individuals commonly referred to as Key Opinion Leaders (KOLs) [1]. Rising stars are emerging KOLs that outshine their peers in many ways, showing great potential for the future [1, 2]. Therefore, one of the key management strategies to ensure organization success at present, and in the future is identification of KOLs and rising stars in the fields relevant to the business of the organization [3].

In academics, performances in research have been used as indicators of academic rising stars. Zhang et al., [2] studied and reported on how to identify academic rising stars. Specifically, the work of Zhang et al., [2] dwelled on how to effectively predict the top k% researchers who achieve the highest citation. While Zhang et al., [2] have reported that the methodology for their study is robust and outperforms all given benchmark methods, with over 8% average improvement, however, the weakness of this method is that it relies solely on citation impact. There are other methods that have equally been adjudged as adequate and useful for the purpose of identifying emerging KOLs. The other prominent methods of evaluating individual researchers include: g-Index [4]; h-Index [5]; i10 – Index [6]. Particularly, measuring collaboration is now considered an indicator of research performance. Many studies have been carried out to evaluate one or other aspects of research collaboration [7-10]. As a result, many services aimed at quantification of extent of collaboration are now available. The Weighted Fractional Count (WFC) of Nature Index is widely applied, and can be used to identify

the rising stars performers in the research world [11-14]. Although, the Nature Collaboration metric is already in use to evaluate scientific collaboration worldwide, however, the methodology of this metric is significantly flawed. It does not take cognizant of the total number of collaborators and the order of collaborator per publication. It is a fact, generally known in scientific publishing that the order of author listing is indicative of the extent of contribution/influence of the authors as per the published research.

In this present study, a measure of collaborative strength, used to determine percentile position ranking of scientists at INGENIO, the joint research institute of the Spanish National Research Council (CSIC) and UPV - the Polytechnic University of Valencia is presented. The approach in the new scheme introduces a new feature which considers the position of scientists in the author list of their published works. With this perspective, the study is original, and has great potentials. Herein, the justification for the study is identified.

2. Methodology

The co-authorship pattern of research staff at the INGENIO, Valencia in Spain was studied by measuring the collaborative strength of individual researcher at the institute. To determine the collaborative strength of individual researcher, the co-authorship of each publication as recorded against the researcher at the website of the following link: http://www.ingenio.upv.es/en/researchers#.WIXwZBJYvMw was obtained. The information used was as obtained at this link as at 23rd January, 2017. A simple count of the total number of authors listed on a particular publication was made, and recorded as n; the position of the researcher in the author list is recorded in ascending order as r; starting with the first author listed. A record of distribution of n and r was obtained for all the research staff of INGENIO who had publication records. The collaborative strength of individual researchers was determined using the relationship expressed as follows:

$$C_S = \sqrt[4]{\sum_{i=1}^{P}(n_i - r_i + 1)} \tag{1}$$

Where C_S is the collaborative strength, P is the total number of publications of the scientist and i is indicative of a particular publication of a scientist. The mean of the number of persons collaborating per paper (n_{mean}) and mean of the positions of a specific research staff (r_{mean}) were calculated using the following expressions

$$n_{mean} = \frac{\sum_{i=1}^{P} n_i}{P} \tag{2}$$

$$r_{mean} = \frac{\sum_{i=1}^{P} r_i}{P} \tag{3}$$

The percentile ranks of each researcher were also evaluated. The percentile ranks for each researcher within the organization (P_{Org}); and among research peers were determined (P_{Peer}). A schematic representation of P_{Org} and P_{Peer} is presented in Figure 1. P_{Org} is indicative of the rank of the researcher as measured by the collaborative strength relative to collaborative strength of other researchers within the organisation. P_{Peer} indicates the rank of the researcher relative to other researchers with which s/he has worked/collaborated This includes all research peers within and outside the organisation. The position of the researcher in the author list is indicative of the weight of the opinions of the researcher in the published work.

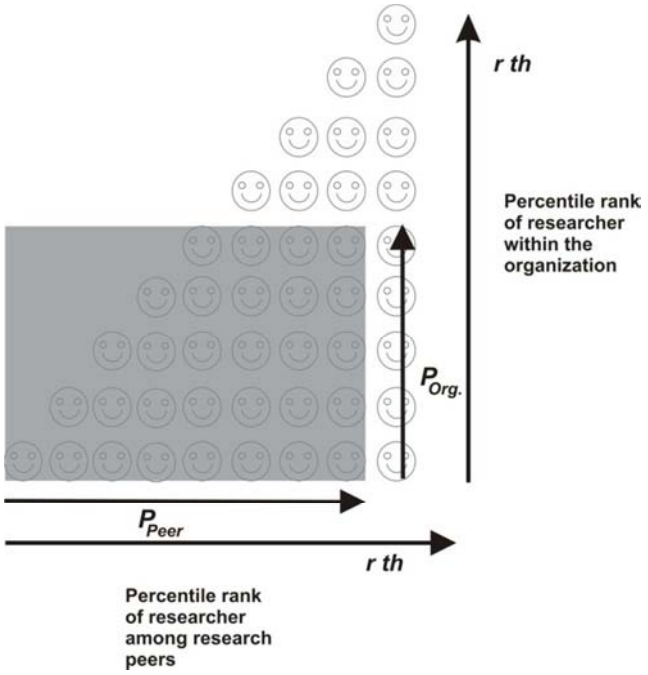

Figure 1. *A Schematic representation of relative positions of researchers within organization and among peers.*

The overall average percentile ($P_{Avg.}$) ranks was also determined. $P_{Org.}$ was determined by finding the relative position of the researcher when the measured collaborative strength of all researchers in the organisation was ordered in ascending order, i.e. from weakest collaborative strength to the strongest collaborative strength. P_{Peer} was determined as a function of the mean of the number of persons collaborating per paper (n_{mean}) and mean of the positions of a specific research staff (r_{mean}). The functional relationship used to determine P_{Peer} is expressed in equation (4) while equation (5) was used to determine as follows:

$$P_{Peer} = \frac{n_{mean} + 1 - r_{mean}}{n_{mean}} \tag{4}$$

$$P_{Avg} = \sqrt{P_{Org} . P_{Peer}} \quad (5)$$

The product of P_{Org} and P_{Peer}, as illustrated in Figure 1, indicates area of influence of opinion of researchers. It corresponds to area of rectangle with breath and length equal to P_{Org} and P_{Peer} respectively.

The adoption of co-authorship for measuring collaboration was informed from the premise laid by Katz and Martin, [7], which was similarly adopted by Gal et al., [8 ; Bozeman et al., [9]; and Voutilainen and Kangasniemi, [10]. Count of number of listed authors and total number of publications have also been used in Nature Index [11, 12]. Zhang et al., [2] equally indicated that percentile is a useful guidance to identify academic rising stars in the research community.

3. Results and Discussion

Information on the full names of the researchers at INGENIO, the initials corresponding to the full name of each researcher, the total number of publications of each researcher, the n_{mean}, r_{mean}, the collaborative strength (C_S) of each INGENIO researcher, the P_{Org}, P_{Peer}, and P_{Avg} is presented in Table 1. Figures 2 and 3 show the distributions of n and r respectively. They inform that INGENIO researchers collaborate mostly in groups ranging from 1 to about 5 persons in a group; and these researchers are mostly listed between the first and fourth authors.

Table 1. *Full names of CSIC-UPV (INGENIO) Scientists Investigated.*

S/N	Names	Initials	Number of Papers	n_{mean}	r_{mean}	C_s	P_{org}	P_{peers}	P_{Avg}
1.	Rafael Aleixandre Benarent	RAB	28	4.25	2.79	2.88	65th	58th	61st
2.	Joaquin Maria Azagra Caro	JMAC	96	2.70	1.28	3.90	94th	90th	92nd
3.	Sergio Belda Miquel	SBM	28	3.18	1.39	2.93	68th	88th	77th
4.	Alejandra Boni Aristizabal	ABA	60	3.13	1.82	3.43	82nd	74th	78th
5.	Elena Castro Martinez	ECM	129	3.15	2.06	4.09	97th	66th	80th
6.	Teresa de la Fuente Espinosa	TFE	1	4.00	3.00	1.19	6th	50th	17th
7.	Teresa Escrich Gallardo	TEG	6	2.17	1.33	1.82	29th	85th	50th
8.	Adela Garcia Aracil	AGA	122	2.18	1.41	3.82	91st	81st	86th
9.	Antonio Gutierrez Gracia	AGG	82	3.48	2.63	3.51	85th	53rd	67th
10.	J. Felix Lozano Aguilar	JFLA	9	2.22	1.56	1.97	32nd	75th	49th
11.	Monique Leivas Vargas	MLV	2	4.5	2.5	1.57	15th	67th	32nd
12.	Francisca Javier Ortega Colomer	FJOC	16	1.88	1.50	2.19	38th	73rd	53rd
13.	Victoria Pellicer Sifres	VPS	5	2.80	2.00	1.73	26th	64th	41st
14.	Francois Perruchas	FP	9	3.78	2.44	2.14	35th	62nd	47th
15.	Ismael Rafols	IR	30	3.33	2.23	2.82	62nd	63rd	62nd
16.	Nicolas Robinson-Garcia	NRG	4	2.75	1.75	1.68	18th	73rd	36th
17.	Enrique Tortajada Esparza	ETE	14	2.93	1.86	2.32	47th	71st	58th
18.	Richard Woolley	RW	20	3.20	2.50	2.41	50th	53rd	51st
19.	Jose David Barbera Tomas	JDBT	39	2.64	1.41	3.04	71st	84th	77th
20.	Carlos Benito Amat	CBA	15	2.53	2.00	2.19	41st	60th	50th
21.	Carolina Canibano Sanchez	CCS	17	2.59	1.47	2.45	53rd	82nd	66th
22.	Davide Consoli	DC	70	2.39	1.69	3.30	74th	71st	72nd
23.	Pablo D'Este	PDE	86	2.97	1.74	3.79	88th	75th	81st
24.	Ignacio Fernandez de Lucio	IFL	166	3.04	2.19	4.19	100th	61st	78th
25.	Monica Garcia Melon	MGM	19	3.74	1.95	2.70	59th	75th	67th
26.	Fernando Jimenez Sacz	FJS	62	3.21	2.29	3.30	76th	60th	68th
27.	Aurora Lopeh Fouges	ALF	2	2.00	1.5	1.32	9th	75th	26th
28.	Maria Luz Lopez Terrada	MLLT	1	2.00	2.00	1.00	3rd	50th	12th
29.	Jordi Molas Gallart	JMG	75	2.45	1.68	3.40	79th	72nd	75th
30.	Julia Osca Lluch	JOL	4	3.00	2.00	1.68	21st	67th	38th
31.	Jordi is Blanes	JPB	21	3.95	2.62	2.65	56th	59th	57th
32.	Irene Ramos- Vielba	IRV	3	3.67	1.67	1.73	24th	82nd	44th
33.	Carolin Schmitz	CS	2	1.50	1.00	1.32	12th	100th	35th
34.	Enrique Tortosa Martorell	ETM	24	1.79	1.75	2.24	44th	58th	51st

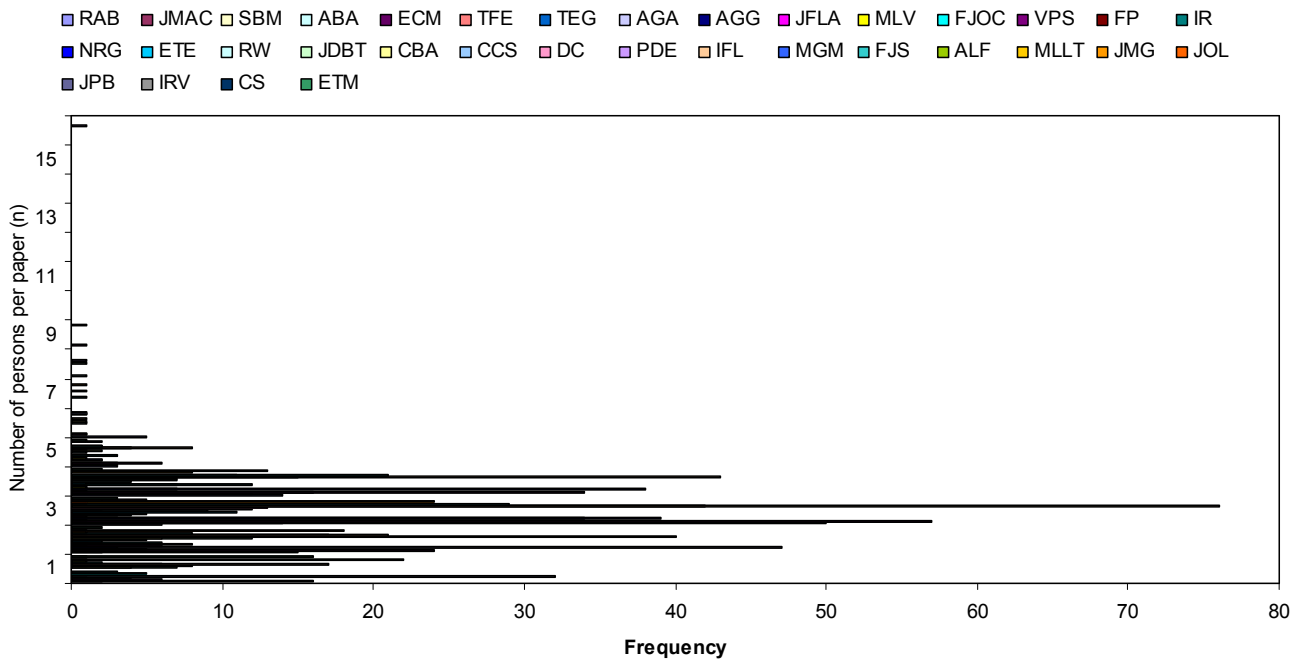

Figure 2. *Frequency distribution of n for the study.*

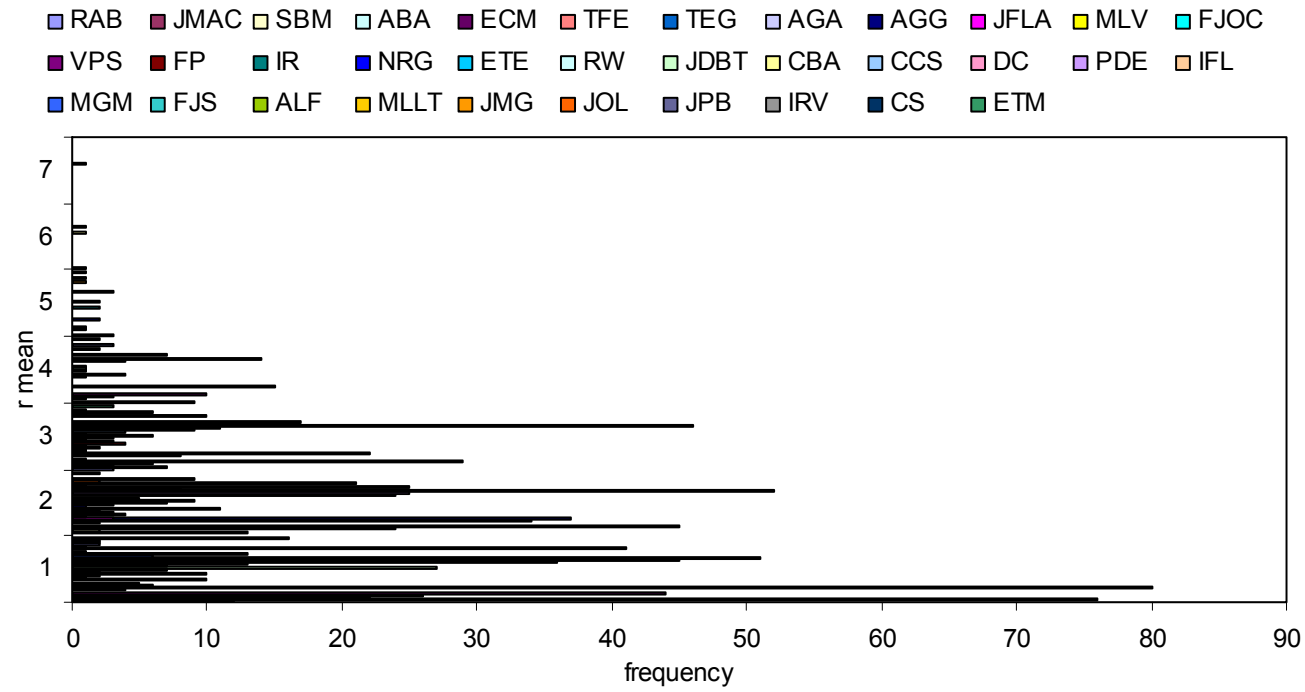

Figure 3. *Frequency distribution of r for the study.*

Figures 4 to 10; in respective order, present information on distributions of C_S, $n_{mean,}$ $r_{mean,}$ total number of publication per researcher, P_{Org}, P_{Peer}, and P_{Avg}. From these Figures, Ignacio Fernandez de Lucio has the highest collaborative strength. He has a total of 166 publications. This means he has been able to utilize about 166 collaborative opportunities. Although in Figures 5 and 6, Monique Leivas Vargas has the highest average collaborations per publication while Carolin Schmitz has the strongest position rank, however, the total number of publications by these staffs is rather very small, and the reason for their observed weak collaborative strength.

Considering Davide Consoli and Fernando Jimenez Sacz, these two staffs have the same collaborative strength despite that Davide Consoli has published 70 papers which is more than the total of 60 papers published by Fernando Jimenez Sacz. Ordinarily, Sacz collaborates mostly with about 3 persons per publication while Consoli collaborates mostly with 2 persons. The two staffs are mostly listed as the second

author in their collaborative groups.

In Figures 8 and 9, Ignacio Fernandez de Lucio has the highest Organization Percentile Rank (P_{Org}) of 100th Percentile, while Carolin Schmitz has the highest Peer Percentile Rank (P_{Peer}) of 100th Percentile.

Overall, Joaquin Maria Azagra Caro has the highest Average Percentile Rank ($P_{Avg.}$) of 92nd Percentile. Going by the study of Ready et al., [3](2010) reported in the June issue of Harvard Business Review, that research has shown that companies tend to think of the top 3 to 5% of their talents as the KOLs, this implies that there are NO research Key Opinion Leaders at INGENIO. Joaquin Maria Azagra Caro is only very close to being a KOL. However, if the definition of KOL permits the top 10 to 20%, then Joaquin Maria Azagra Caro will be the most authoritative KOL at INGENIO, followed by Adela Garcia Aracil (P_{Avg} = 86th), Pablo D'Este (P_{Avg} = 81st) and Elena Castro Martinez (P_{Avg} = 80th).

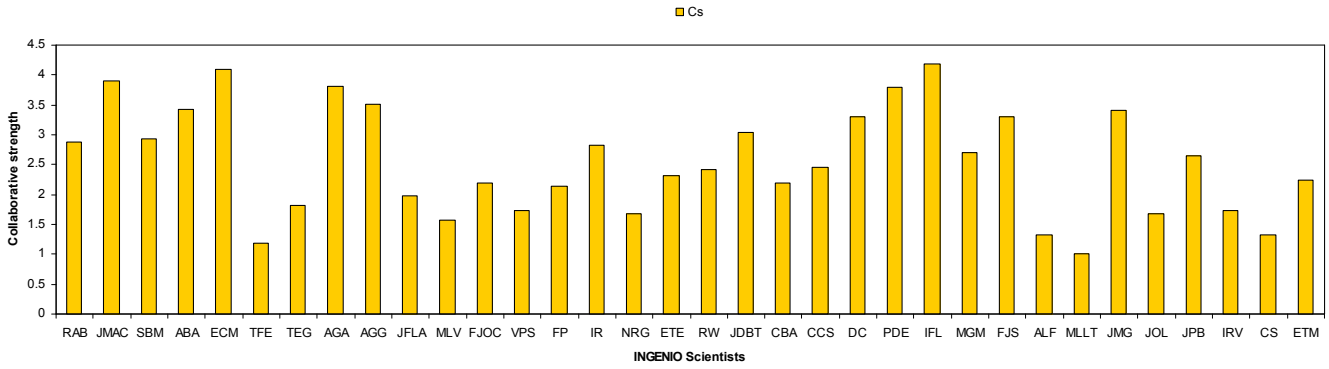

Figure 4. *Distribution of collaborative strength.*

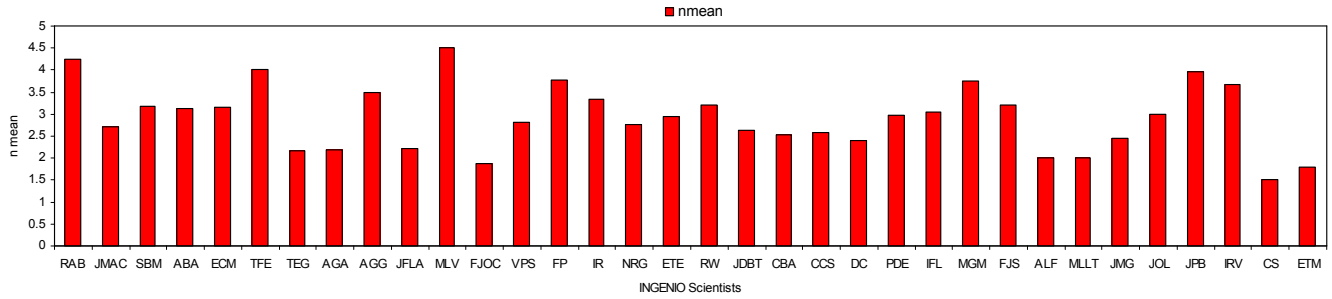

Figure 5. *Distribution of average collaborations.*

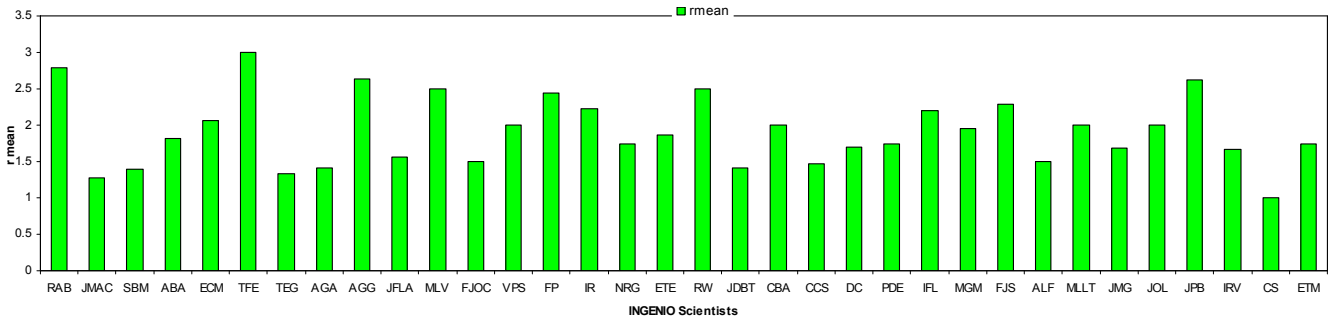

Figure 6. *Distributions of average position rank.*

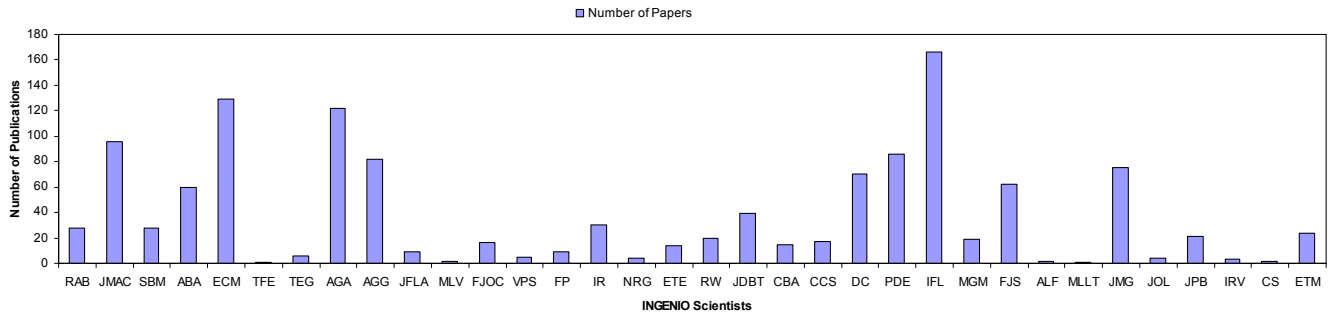

Figure 7. *Distributions of total number of publications.*

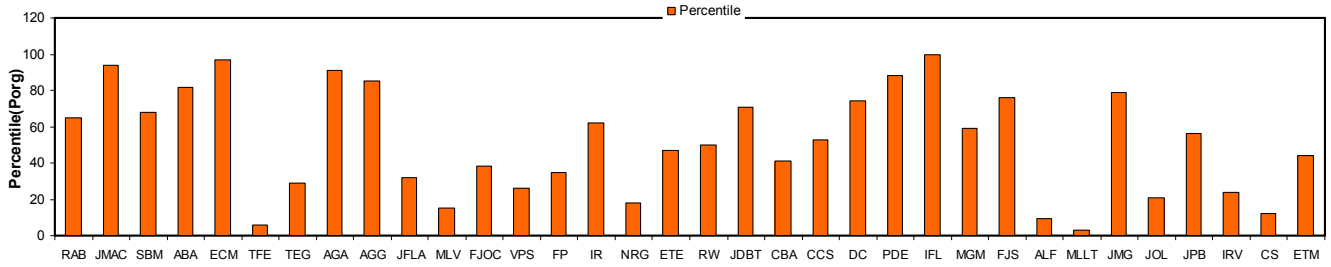

Figure 8. *Distributions of* $P_{Org.}$

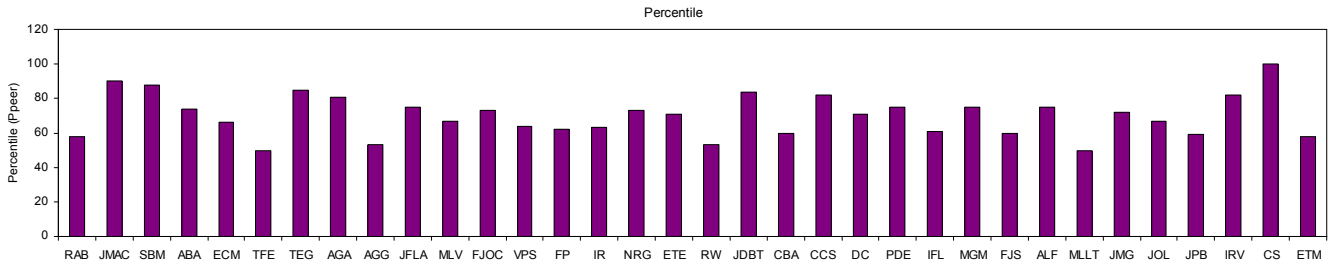

Figure 9. *Distribution of* $P_{Peers.}$

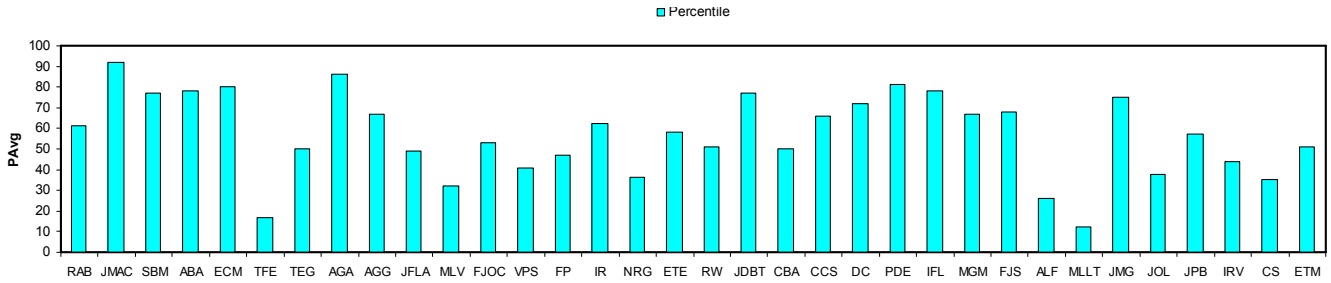

Figure 10. *Distribution of* $P_{Avg.}$

4. Conclusion

Another scheme to determine research KOL status of individual researchers, through measuring research collaborations in published works has been introduced. The study has identified important parameters useful in this scheme to determine the KOL status of researchers. These identified parameters include: collaborative strength (C_S), total number of publications (P), number of collaborations per publication (n), average collaborations (n_{mean}), position rank (r) average position rank (r_{mean}), Organization percentile rank (P_{Org}), Peer percentile rank (P_{Peer}) and Average percentile rank, all which are important and useful in the determination of research KOL status. Overall, the study showed that research KOL status of a researcher improves with improved collaborative strength, organization percentile rank and peer percentile rank.

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