Scientometrics (2021) 126:335–353
https://doi.org/10.1007/s11192-020-03769-y

Ranking of author assessment parameters using Logistic Regression

Muhammad Usman[1] · Ghulam Mustafa[2] · Muhammad Tanvir Afzal[3]

Received: 17 April 2020 / Published online: 20 November 2020

Abstract
The renowned international scientific societies nominate researchers for awards based on qualitative judgments every year. Qualitative judgment uses subjective assessments based on information that is not quantifiable. The way of assessing the quality of the work has not been established or disclosed, nor do we have any qualitative evaluation criteria. We can assess the quality of the researcher's work by mapping the quantitative parameters to qualitative judgments. To date, the scientific community has presented more than 50 research assessment quantitative parameters, including publication count, citation count, h-index, and its variants. The contemporary state-of-the-art in authors ranking does not determine the best parameter that effectively maps on experts' qualitative evaluation. Moreover, these parameters have been evaluated by using same scenarios. In such scenarios, the value and effect of each parameter over the others are complicated to ascertain. Therefore, they must be assessed in inequitable scenarios. The purpose of this research is to identify the significant parameters that map on qualitative judgments of international scientific societies in Civil Engineering (CE) for award nominations. We will identify the rank of author assessment parameters, which includes published papers, citations, No of years since 1st publication, citations in h-core, authors/paper, citations/paper, citations/year, h-index, g-index, hg-index, A-index, R-index, e-index, and f-index. We have evaluated these parameters on the dataset from the discipline of Civil Engineering (CE). The data set contains 250 non-award winners and 250 award winners from prestigious scientific societies of CE. The h-index and its variants have been ranked based on their effectiveness for awardees using Logistic Regression. The award-winning researchers have less number of average authors/paper than the non-awardees. The authors/paper has achieved the highest effectiveness of 67% for awardees. Furthermore, we have also analyzed the ratio of awardees in the ranked list of 50, 100, and 150 researchers by author assessment parameters. The authors/papers have outperformed all other indices by elevating 62% and 66% of the award recipients in its ranked list of 100 and 150 researchers. In the ranked list of 50 researchers, publications elevate 54% awardees, and Authors/papers achieved the second-highest elevation score of awardees of 50%.

✉ Muhammad Tanvir Afzal
tanvir.afzal@namal.edu.pk

Extended author information available on the last page of the article

Keywords Parameters ranking · Citation count · Citation intensity · Variants of h-index · Civil engineering subject classification · ASCE · CSCE · ACI · ICE

Introduction

A tremendous amount of research articles is being produced by researchers every day. Qualitative assessment of researchers' work allows us to address important aspects of the scholarly community, such as (1) Who is eligible for a scholarship's award? (2) Who has produced influential research studies? (3) Who should serve in a scientific conference and journal as editor or reviewer? (4) Who is more competent to become a fellow or a member of the scientific society? Besides this, such assessment also helps the student community select a supervisor to conduct a research study (Raheel et al. 2018; Crowder et al. 2002). The methods of evaluating a research work depend on the criteria and the merits of the concerned scientific community. When it comes to measuring a researcher's potential, there does not exist any standard method to adopt. Various quantitative research assessment parameters have been proposed to identify which researcher has contributed the most innovative or impactful work in the scientific community (Zhang 2009; Ayaz and Afzal 2016; (Ameer et al. 2019). All of the suggested techniques are based on their specific criteria to determine the impact of an author.

The conventional parameter that has been employed to measure researchers' output is the publication count (Cameron 2007). The number of publications is counted to determine the impact of an author's work. Later on, the research community argued that it is not an accurate parameter to assume that amount of publications is enough to find the researcher's impact. (Cameron 2007) compared two researchers from the database domain 'E.F Codd' and 'Hector Garcia-Molina.' Codd has considered more profiled compared to Molina as he has won the Turing award twice (1981, 1994). However, according to the number of publications, Molina ranked higher than the Codd as he has 248 publications, and Codd has only 49 publications. This example indicates that while the researcher's assessment, quantity is preferred over quality as a researcher having a high count of publications is ranked higher (Egghe 2006). To overcome this issue, the research community presented a method that utilizes several citations of the published article to determine the impact of researchers in the scientific community.

The number of citations the researcher gains is considered to influence the researcher in the research community. The more citations the researchers obtained, the more highly profiled they are regarded as researchers. However, there are some deficiencies in citation count such as.

(1) A researcher may increase their citations illegitimately,
(2) Researchers may cite a paper for criticism, and
(3) Survey papers typically receive more citations, which do not determine the potential of a study.

Subsequently, attention was transferred to the introduction of indices that would measure the impact of research work on quantity and quality. Hirsch (2005), presented one of the most successful researcher's assessment parameters, named Hirsch-index (h-index). H-index determines the quality of a researcher (Egghe 2006). The scientific community globally uses h-index because of its efficacy in computing. Hirsch stated that the h-index

Table 1 Shortcoming of h-index

Index papers	X1	X2	X3
h(1)	100	99	98
2	0	1	1
3	0	0	1
4	0	0	0
5	0	0	0
6	0	0	0
7	0	0	0
8	0	0	0
9	0	0	0
10	0	0	0

Table 2 Shortcoming of h-index

Index papers	X1	X2	X3
1	10	98	46
h(2)	10	2	46
3	10	0	1
4	10	0	1
5	10	0	1
6	10	0	1
7	10	0	1
8	10	0	1
9	10	0	1
h(10)	10	0	1

not only measures the current performance of researchers but also analyzes their future impact. Around 9229, researchers have discussed the h-index until the 28th of November, 2019. However, Dienes argued that there are certain shortcomings of the h-index. One of the shortcomings of the h-index is that further increase in citations for index papers does not contribute to researchers' impact. There are several situations where the h-index can be the same for numerous authors, even with different published papers and their citations. It can also be different for numerous authors, even with the same number of published articles and their gained citations. For example, we have three researchers with ten papers and their citations, as shown in Table 1 in descending order of citations.

For all of the above three researchers, the h-index will remain same as (h = 1). In another scenario, if we have three researchers with the following papers and their citations as shown in Table 2 in descending order. of citations.

However, all of the above researchers have the same number of citations and publications; they have different h-index. For X1, the h-index is 10; for X2 and X3, the h-index is 2. This illustrates the deficit of the h-index as it reflects that citations and publications are handled in two different dimensions by the h-index. Hirsch's conversion value that converges two opposite dimension values have not been explained (Hirsch 2005). The h-index also lacks to adopt the community aspects such as field experts' subjectivity, which are considered one of the critical factors in identifying potential experts from any domain (katsaros et al. 2009). Several variants and extensions of h-index have been proposed to

overcomes the shortcomings of h-index, such as g-index (Alonso et al. 2010), a-index (Jin 2006), r-index (Jin et al. 2007a), and hg-index (Alonso et al. 2009), etc.

In literature, three approaches are widely used to assess the impact of researchers' research work (Sidiropoulos et al. 2007). In the first approach, the best researcher's recommendation is based on the collective reviews of domain experts. It's like an unstructured approach, which doesn't need to be trained first. This method is quite valuable as it involves the experiences of the various professionals who identify the researcher's impact by evaluating their research work. However, it is vulnerable to objectivity because this approach is manual. In the second method, researchers are assessed by the number of their citations. The citation count technique is preferred mostly because it uses digital repositories to evaluate citation information, so there is no chance of human error. In the third approach, the award winners from prestigious scientific societies are picked to assess researchers. However, there does not exist any universally accepted criterion to rank the researchers.

Typically, when a new technique is incorporated, it is formed unconventionally or using different data sets. Since these techniques are validated on various data sets, so the importance of these techniques is difficult to observe individually because of their data set dependence. The scientific community has been focusing on proposing useful methods to rank researchers rapidly (Crowder et al. 2002). The researchers recently carried out the comprehensive empirical evaluation of the h-index and its variants to identify these indices' contribution for the award winners of prestigious scientific societies of Mathematics and Neuroscience, respectively (Ameer and Afzal 2019; Ain et al. 2019).

This study aims to rank research assessment indices (total no. of publications, their citations, authors/paper, cites/year, and cites/paper) and citation intensity-based indices (h-index, g-index, a-index, f-index, e-index, r-index, and hg-index), that contribute most to award recipient of Civil Engineering. For evaluation, 250 non-awardees and 250 awardees from Civil Engineering have been considered. Civil Engineering societies include.

1. ICE (Institute of Civil Engineering),
2. ACI (American Concrete Institute),
3. CSCE (Canadian Society of Civil Engineers), and
4. ASCE (American Society of Civil Engineers).

The subjectivity of awarding criteria of theses societies has not been exposed yet. However, the nomination of awardees is based on the researchers' contribution to the field. Such decisions are usually taken through the collective opinion of reviewers and boards of prominent experts of the field as given on official sites of these scientific societies[1,2,3,4]. This study will address the following research questions.

1. Which index holds a strong association with award winners of Civil Engineering society?
2. What is the percentage of awardees in the list, ranked by each variant of h-index individually?

[1] https://www.icevirtuallibrary.com/page/authors.
[2] https://www.concrete.org/aboutaci/honorsandawards/awards/.
[3] https://csce.ca/en/committees/honours-and-fellowships/.
[4] https://www.asce.org/awards/.

3. In the last decade. Does the qualitative judgement by the prestigious scientific societies of Civil Engineering for the nomination of awardees have any association with h-indices?

This paper organizes the rest of the contents as follows. We present a brief review of the ranking parameters in the "Literary Review" section. The "Methodology" section illustrates our proposed approach to rank the indices. Our study results are discussed in the "Evaluation," and then the conclusion will be discussed in the "Results and discussion" section.

Literature review

It is imperative to scrutinize researchers' empirical output. Based on the empirical evaluation, scientists are nominated for numerous academic policies like awards and promotions (Liang and Jiang 2016). Researchers are assessed and ranked based on different standards such as no. of publications, their citations, no. of co-author, hybrid approaches, extensions or variations of h-index such as h-index, g-index, a-index, etc. These traditional methods are focused on essential arithmetic functions like the total number of published articles or their citations, etc. Such criteria are not considered for individual assessment at the global level. The problem often occurs when it comes to comparing two researchers with different intentions, one who has published dozens of research papers every year or who is rather selective and focuses only on innovative work (Aoun et al. 2013). These indices have been subjected to intense criticism as each of them has some constraints and shortcomings.

Researchers with many publications can be considered highly active researchers, but they may not be useful in terms of quality. A researcher may publish his research articles in poorly qualified conferences and journals (West and Stenius 2004). On the other hand, the number of citations cannot depict the research work's effectiveness and can easily be oscillated by two or three, too, praised reviews. This approach is controversial. Since researchers sometimes cite their articles. Furthermore, it is not always the case that a researcher cites paper for acknowledgment of work, so citation based on critique must not be considered the researcher (Jin et al. 2007).

To address shortcomings of publication count and citation count, Hirsch advised a new technique, called h-index. The h-index attracts tremendous interest from the scientific world because of its simplicity. To assess the researchers' impact, the h-index considers both publication count and citation count. In contrast to the enormous advantages, h-index also has some disadvantages. An increase in citations of h-core papers does not further contribute to the researcher's impact. The h-index is not ideal for novel researchers as it takes some time to publish research papers and then acquires citations for those publications. Furthermore, the h-index supports inactive scientists by increasing the number of citations of his previous work (Dienes 2015). Several parameters to address the shortcomings of h-index have been introduced in the literature. Most of them focus on the intensity of citations acquired by the researcher or research paper. Citation Intensity-based indices include A-index, R-index, e-index, and f-index.

Rousseau has proposed an A-Index, considering the average Hirsch-core citations (Jin et al. 2006). H-core consists of only highly cited papers, and the a-index is based on the citations in h-core. The a-index discourages researchers who have many papers in h-core, as the a-index is measured by taking the average citations in the Hirsch-core. The higher the number of highly cited papers, the lower the a-index is. Researchers

thus concluded that using the total sum of citations' square root is better to assess the researcher than the a-index, instead of taking the average of h-core citations. This new technique is named R-index (Jin et al. 2007). The h-index does not ultimately consider the researcher's work, such as publications, which are not part of the h-core. For example, if a researcher has ten publications and 5 of his publications have five or more citations, and rest have less than 5. The remaining five publications and their citations do not contribute to the researcher's h-index and result in loss of information.

The e-index is proposed to fill up this weakness of the h-index. It also considered the publications and their citations, which are not present in h-core (Mingers 2009). Co-terminal citations are taken into account by the f-index. f-index shows the fold of h2 citations for h-core papers. It is a fractional technique that considers publications' citations (Tol 2009). Two generalizations of the original h-index, the ht-index (trend h-index), and hc-index (contemporary h-index) have been proposed by Sidiropoulos et al. (Sidiropoulos et al. 2007). They have concluded that these extensions give better performance than h-index (Sidiropoulos et al. 2007).

A new parameter called w-index has been introduced by (Wu 2010)**.** It was proposed to measure or determine the impact of an author's research in a meaningful manner. It has been concluded that there were significant differences from h-index in the papers assessed by the w-index because the w-index tends to focus on the well-cited works.

Aoun has critically analyzed h-index and its available variants for scientists and physicians from neurosurgery, using a small data set (Aoun et al. 2013). To compare the h-index and its variants, 147 chemistry research groups have been considered from Netherland by Van Raan. He focused on the research group instead of the individual researcher's performance. They have considered only three years of publications and their citations rather than the complete record to scrutinize the correlation between h-indices (Van Raan 2006).

In 2016, Ayaz and Afzal introduced a novel approach to evaluate h-indices by considering the award winners of scientific societies from the Mathematics domain as a benchmark. This study shows that when including awards in the top lists, complete-h performed better than g-index and h-index, and it also incorporates the community factor into account (Raheel et al. 2018). In another study, h-index, g-index, q2-index, etc. have been evaluated on Mathematics dataset by considering the international awardees of mathematic societies as benchmark. They have concluded that the h-index performed better than the g-index, q2-index, hg-index, R-index, and A-index, for elevating the awardees at the top of the list. However, h-index only brought 33 awardees in the list of 5753 authors. (Ain et al. 2019).

El-Adaway et al. analyzed the citation metrics parameters used to evaluate the quality and impact of research publications in the civil engineering domain, emphasizing the fields and disciplines of construction engineering and management specialists. They analyzed that the award-winning papers were not the most widely cited and currently have an average citation of 92% below the citation count of the most cited papers. However, they have not focused on which parameter is most useful for award-winning papers or award winner researchers (El-adaway et al. 2019).

The h-index and its quantitative and qualitative variants, such as g-index, hg-index, m-quotient, e-index, f-index, and r-index, respectively, are evaluated in the field of Neuroscience by Ameer and Afzal in 2019. Award winners of Neuroscience's scientific societies were considered to compare the performance of variants and extensions of h-index. This work states that the quantitative hg-index and the qualitative r-index are better than the other considered indices, both of these elevated 25 awardees in the list of 55 authors (Hariri-Ardebili and Saouma 2015).

Different studies have been discussed in this section. In all of these studies, different indices were utilized to evaluate the scientific output of researchers. It has been noted that in the literature, researchers have evaluated different parameters on the same dataset. Besides, they have used conventional methods to rank these indices instead of using modern machine learning techniques to determine each index's efficacy relative to the others for the award recipients. Therefore, there is a need to evaluate and rank these indices by using modern machine learning techniques so that the scientific community could have an idea regarding the potential of different ranking parameters.

Methodology

The scientific community has proposed a variety of research assessment parameters to rank researchers. After the critical analysis of state-of-the-art literature review, we intend to rank these parameters using Logistic regression and evaluate whether the h-index variants elevated the award winners of prestigious scientific societies or not. The diagram of the proposed methodology is shown in Fig. 1.

Domain selection

To address the aforementioned research questions, we need an extensive data set from a certain scientific field to implement this technique. For the ranking and assessment of variants of h-index, we have chosen the Civil Engineering domain. This is one of the oldest fields of human life and great research has been done in this field that is why we selected the domain of Civil Engineering for the evaluation of the proposed methodology. Furthermore, each year, various scientific societies give awards to the distinguishing researchers of the field according to the impact of their research work. However, the researchers belonging to this domain has not been comprehensively utilized for the ranking and evaluation of h-indices. Ranking of research assessment parameters may help the scientific community of this field to determine the most influential researchers and to support the development and growth of this area.

Taxonomy building

Civil engineering is one of the oldest research areas devoted to the development, construction, and maintenance of a natural and physical environment such as dams, airports, sewerage networks, and building structural components etc. (Jin et al 2007). To collect the dataset for evaluation of indices, we have utilized and filter the dataset used by (Raheel et al. 2018). In this study, we have considered 250 awardees of prestigious scientific societies of Civil Engineering from 2011 to 2019. Same award winners are also considered as a benchmark to evaluate the proposed work. To make it a balance class problem, we also have considered the same number of non awardees.

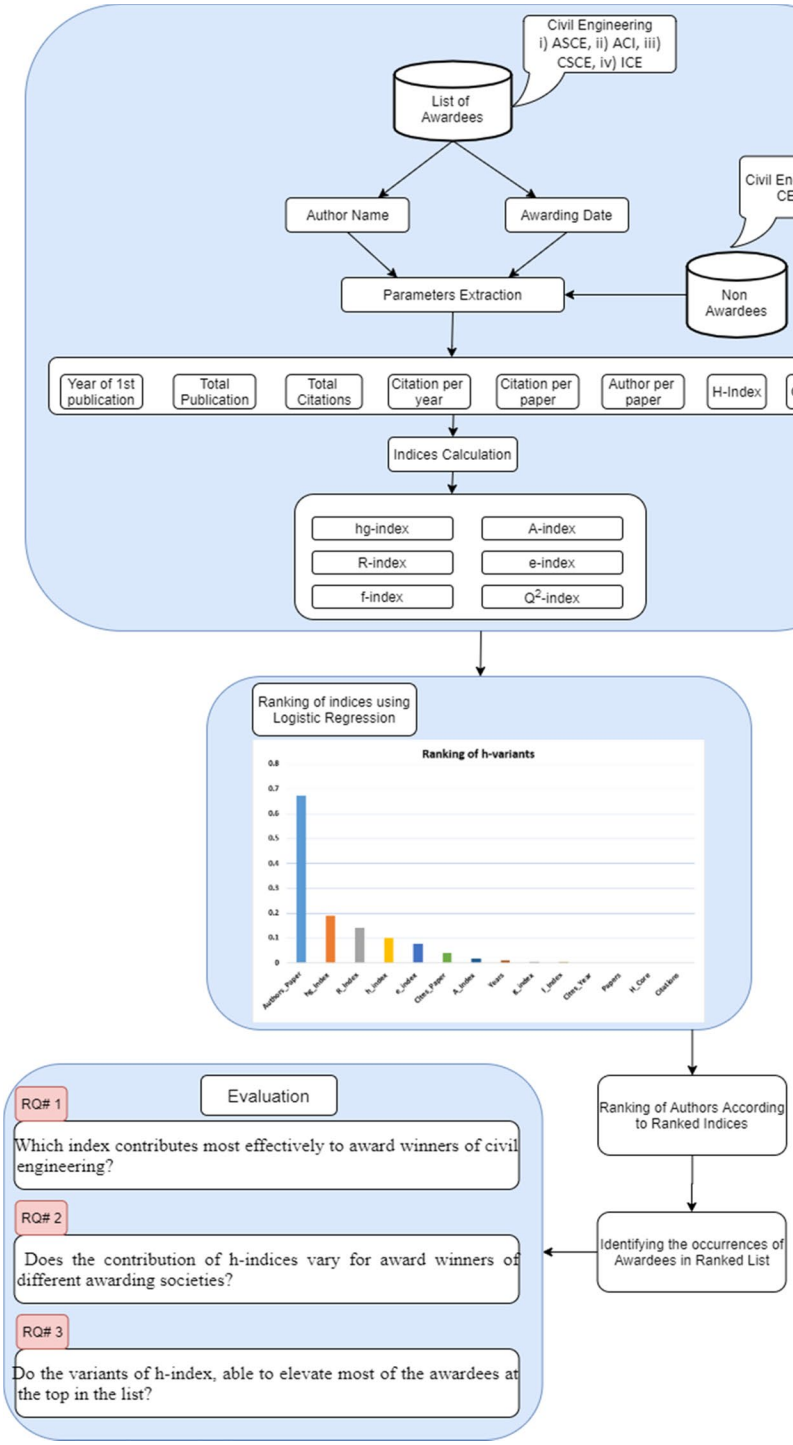

Fig. 1 Block diagram of proposed methodology

Table 3 Awards details

Awards details	Total awards
American society of civil engineers	
Collingwood prize past award	38
J. James R. Croes medal	39
Samuel Arnold Greeley award	41
Rudolph Hering medal	40
American concrete institute	
Chester Paul Siess award	23
Wason medal for materials research	21
Wason medal	20
Canadian society for civil engineering	
P.L. Pratley award	14
Donald Stanley award	14
Institution of civil engineers	
Telford medal	14
James Alfred Ewing medal	14

Dataset description

Dataset consist of the list of awardees and non-awardees researchers from civil engineering domain. We have used the dataset retrieved by (Raheel et al. 2018). They have collected the list of researchers by using accredited civil engineering database (CEDB) terms, which is a professional initiative of the ASCE (American Society of Civil Engineering). ACSE is a renowned civil engineering scientific society. To make our proposed methodology unbiased, we have filtered the dataset in a manner that, the list of 250 non-awardees comprises of high, average and low impactful researchers according to their publication count and citation count. The list of awardees also has been extracted from the dataset of (Raheel et al. 2018). However, they have considered the awardees which have been awarded for their work even before the proposal of novel h-index. The aim of this research is to determine the associativity of awardees with the parameters which are now being used to determine the impact of the researchers in the scientific community. So, we have filtered the award winners between 2011 and 2018. Furthermore, we also have included the research award winners of 2019. The award winners belong to following scientific societies, ASCE, CSCE, ACI, and ICE. The details of awards are given in Table 3. After formation of the list of researchers, we have used Google Scholar to collect information of researchers against the comprises list of awardees and non awardees. There were also other resources, such as the Scopus and WoS, however Google Scholar has a wide range of index publications (Falagas et al. 2008). Therefore, the google scholar has been used to collect the data. Open data access is offered by the Google Scholar, while other resources are not available to the public and WoS is limited. A recent study found that the growth of Google Scholar is 13% higher than the Web of Science (Moed et al. 2016).

After the extraction of the data, all the ambiguities from the authors' information have been eliminated. More than one author with the same first and last names have been considered ambiguous. This research has verified all researchers by searching their profile on their homepages to verify them.

Table 4 Dataset description

Dataset description:			
Total no of authors			500
Total no of publications			84,195
Total no of citations			4,076,722
Awardees description:			
Total no of awardees			250
No of publications			46,465
No of citations			1,770,447
Non awardees description:			
Total no of non awardees			250
No of publications			37,730
No of citations			2,306,275
Awarding societies description:			
Name	Found in	Members	Award winners (2011–2019)
ASCE	1852	152,000	158
ACI	1904	30,000	14
CSCE	1887	75,000	64
ICE	1818	90,000	14

The final dataset contains the information of 250 non-awardees and 250 awardees, which consists of 84,195 publications and their 4,076,722 citations. Awardees from ASCE, CSCE, ACI and ICE have been included. The description of the dataset is shown in Table 4.

Calculation of indices

The Google Scholar has been used to collect the author's data which consist of total publications, total citations, cites/year, cites/paper, authors/paper, h-index, g-index and hg-index. The h-index is determined as a researcher retains h citations for each paper, and the other paper has less than h citations (Egghe 2006). The g-index is calculated as the number of papers that received at least g^2 or more citations, and the other paper has less than g^2 citations (Alonso et al. 2009). All of these indices are regarded as basic techniques to evaluate the researcher's research impact. After extracting the author's data the following citation intensity-based h-variants have been calculated. Mathematical equations of all of the discussed indices are shown in Table 5.

Ranking using Logistic Regression

Various classification and feature filtering methods in the literature have been suggested to remove obsolete or redundant attributes from a feature vector. To address the first research question, we have considered the statistics-based method, Logistic Regression for ranking of author assessment parameters. Logistic regression is a technique of machine learning which is

Table 5 Indices equation

Citation intensity based parameters	
Indices	Equations
h-index	Maximum index of paper whose citations is greater or equal to its index number
g-index	Maximum index of paper whose square of citations is greater or equal to its square of its index number
hg-index	$hg - \text{index} = \sqrt{hg}$
A-index	$\text{A} = \frac{1}{h}\sum_{j=1}^{h} Cit_j$
e-index	$\text{e} - \text{index} = \sqrt{d^2 - h^2}$ where $\text{d} = \sum_{j=1}^{h} Cit_j$
f-index	$\text{f} - \text{index} = \left(\left(\frac{\text{e}}{h}\right)^2\right)$
R-index	$\text{r} - \text{index} = \sqrt{\sum_{j=1}^{h} Cit_j}$

used for numerous type of classification and ranking problem (Algamal and Lee 2019). Unlike the linear regression, it uses to solve the binary problem. The extension of the Methodology diagram which deals with Research question 1, is shown in Fig. 2.

Logistic regression can be used to addresses binary, ordinary or multinomial problem. The binary logistical regression deals with situations where only two possible types can be observed for the results for a dependent variable, either 0 or 1, awardee or non-awardee. Multinomial logistic regression is concerned with the situation, where the dependent variable has three or more forms of observed output. For example, the type of hepatitis which are not organized can be of type A, B or C. The logistic regression addresses the problems in which the observed output can result in more than two ordered outcomes. For example, the product rating can be of 1 star, two-star, three-star, four-star, and five stars.

Logistic regression uses the sigmoid function to map the variables to categorical dependent variables. The sigmoid function is defined as below.

$$h(x) = \frac{1}{1 + \text{e}^{-z}}$$

where as the z is the hypothesis equation of linear regression which is defined as.

$$z = \theta_0 x_0 + \theta_1 x_1 + \theta_2 x_2 \ldots \theta_n x_n$$

We have uses the above thesis as given below.

The sigmoid function normalizes the value between 0 and 1 to map onto the possible categorical outcome. The value of Sigmoid function at exactly $X=0$ is 0.5. for class determination, 0.5 is used as a probability threshold in Logistic Regression. when the probability is greater than 0.5 it is considered to be a positive instance otherwise negative. Figure 2 shows the block diagram of the process to answer the research question 3.

Logistic regression is a highly efficient probability estimation method. It anticipates the probability of an occurrence by applying cost function to its all samples. The cost function is given as follows:

$$J(\theta) = \frac{1}{m}\sum_{i=1}^{m} \text{Cost}(h_\theta(x), (\text{Awardee}|\text{NonAwardee}))$$

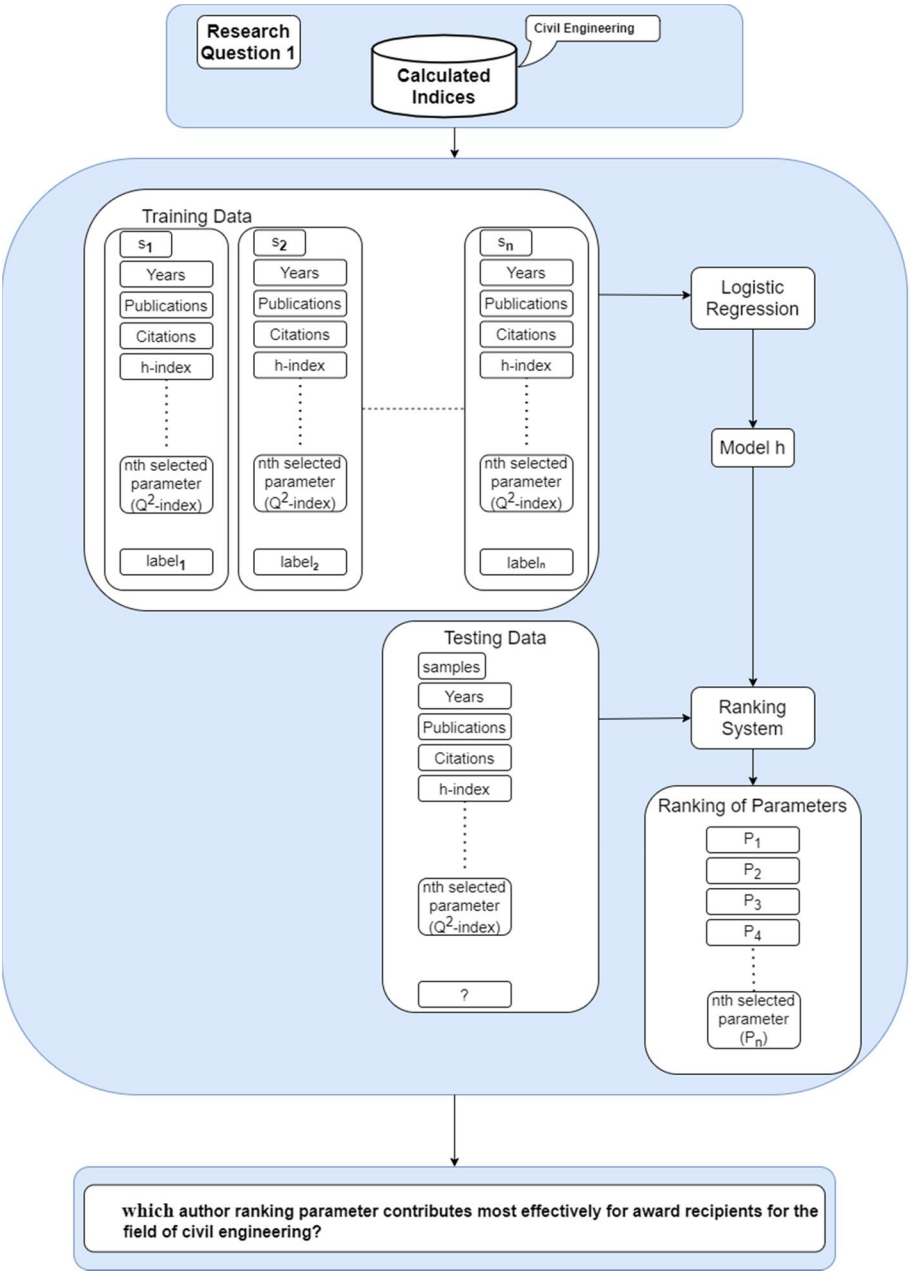

Fig. 2 Research Question 2

$$\text{Cost}\left(h_\theta(x), y\right) = \frac{1}{m}\left(-(\text{Awardee}) \log\left(h_\theta(x)\right) - (1 - (\text{Non Awardee})) \log(1 - h_\theta(x))\right)$$

Whenever there is a mismatch between the targeted class and hypothesis function. The gradient descent function comes into action to update the parameter's value to converge the hypothesis function towards the solution by using the following equation:

$$\theta_j = \theta_j - \alpha \frac{\partial}{\partial \theta_j}(j(\theta))$$

$$\theta_j = \theta_j - \alpha \frac{1}{\boldsymbol{m}} \sum_{i=1}^{\boldsymbol{m}} \left(\boldsymbol{h_\theta}\left(\boldsymbol{x}^{(i)}\right) - \boldsymbol{y}^{(i)}\right) \boldsymbol{x}_{\boldsymbol{j}}^{(i)}$$

where m is the number of samples in the dataset. xi is the parameter for which we are calculating the cost, and the $h_\theta\left(x^i\right)$ is our hypothesis. Once our model is trained. Then, based on the impact of each attribute on the accuracy of the model, we have ranked the list of selected author assessment parameters. The highest the impact of the attribute on model's accuracy, the effective the attribute is considered for award recipient.

Result

This section presents details attained after addressing research questions stated above.

Ranking of h-variants

Results attained against research question one is shown in Fig. 2. It is evident from the Fig. 4 that Authors/paper has outperformed all other parameters by achieving highest rank with 67% accuracy, hg-index has 19%, and rest of them were not even able to identify 15% of the awardees in the dataset. El-adaway et al., stated that the citation counts of awarded paper have only 8% of citations than the non-awarding papers (El-adaway et al 2019). Similarly, the citation count has proven to be least effective for the award winner recipients as shown in Fig. 4.

Evaluation

To address the second and third research question, occurrences of award recipients' researchers included in our dataset have been ranked and analyzed.

Trend of awardees in ranked list

Firstly, the positions of award winners have been identified and then their presence at the top of the ranked list has been determined for every h-variant. To answer the first research question, we first have checked the occurrences of award recipients in the ranked list of researchers according to each impact assessment parameter, in top 50 authors, top 100 authors, and the top 150 authors as shown in Fig. 3. The average number of authors/paper parameter performed

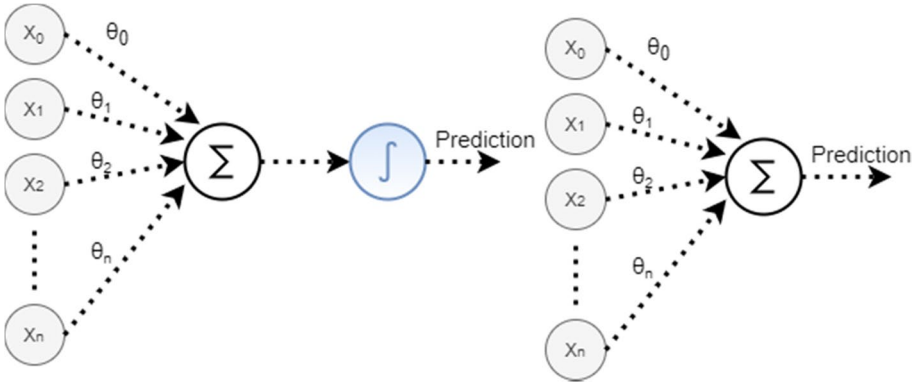

Fig. 3 Linear Regression vs Logistic Regression

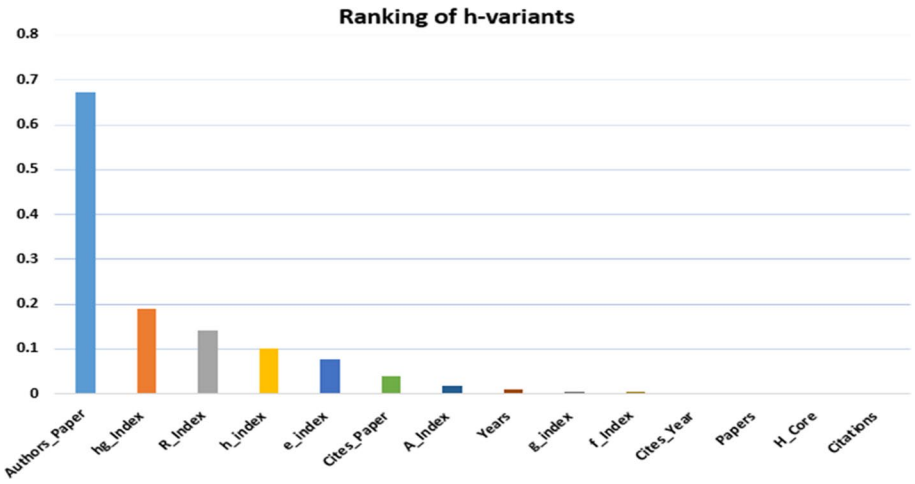

Fig. 4 Ranking of h-variants

better in elevating awardees in the top-ranked list of 100 and 150 researchers. It has brought 62 and 99 award recipients in the list of 100 and 150 ranked researchers respectively. The highest percentage of 66% of occurrences of award recipient's researchers' is found between the range of 150 in the ranked list by average author/paper. It has brought 50%, 62% and 66% of awardees in the list of 50, 100 and 150 researchers respectively.

A-index performed worst as it only brought 26%, 31% and 32.67% of the award recipients in range of 50, 100 and 150 respectively.

Qualitative judgement based on h-variants

To answer the final research question, occurrence of award-winning researchers belonging to prestigious awarding societies individually in the ranking of 50, 100 and 150 researchers by h-variant have been examined and represented in Figs. 4, 5 and 6 respectively.

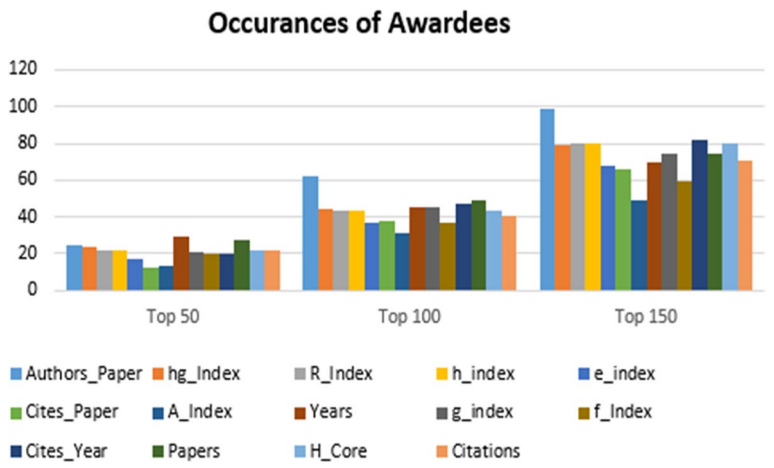

Fig. 5 Occurrences of award recipients

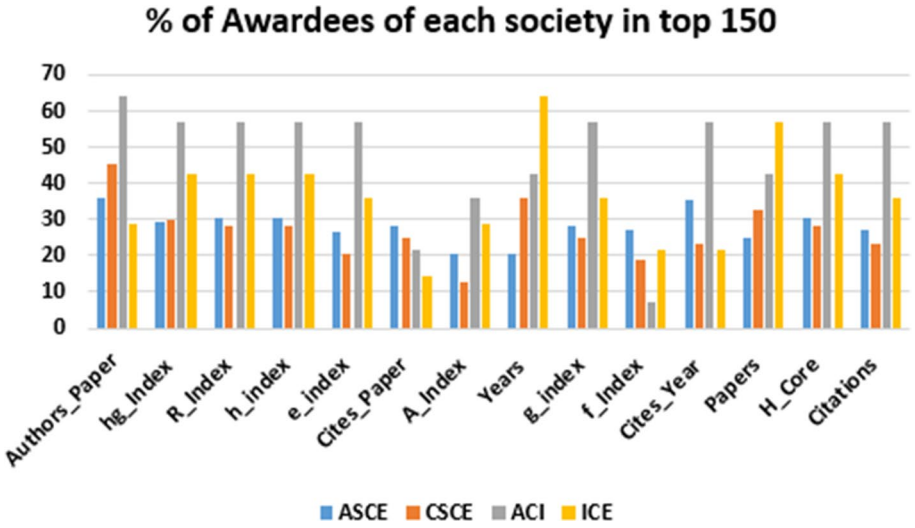

Fig. 6 Qualitative impact of indices in top 150

In our dataset, as shown above, in Table 1, there have been a total number of 250 award winners from 2011 to 2019. 158 award recipients are from the ASCE (American Society of Civil Engineers), 64 from CSCE (Canadian Society of Civil Engineers), 14 from the ACI (American Concrete Institute) and 14 from ICE (Institute of Civil Engineering). These societies were established in 1852, 1887 and 1904 respectively.

The following conclusions have been obtained as a result of our research for the qualitative judgement of awarding societies of Civil Engineering with respect to h-variants in the list of top 150 researchers.

1. **American society of civil engineers**

(a) In the ranking of 150 researchers the authors/paper, authors/paper dominated all other indices by carrying 36.08% of ASCE award recipients.
(b) Cites/Year brought 35.44% of the ASCE award winners in its ranked list.
(c) R-index, h-index and h-core carried 30.38% of ASCE award winners in its ranked list.
(d) hg-index and Cites/Paper brought 29.11% and 28.48% of the award winners respectively.
(e) g-index, h-index and h-core performed equally by elevating 28.48% of ASCE award winner in their respective ranked list of 150 researchers.
(f) f-index and number of citations performed same and brought 27.21% of awardees in the selected range.
(g) All other indices were not being able to elevate even 25% and A-index performed poorest by elevating only 20.25% of ASCE award winners in its ranked list of 150 researchers.

2. **Canadian society of civil engineers**

(a) In the ranking of 150 researchers authors/paper has dominated all other indices by carrying 45.31% of CSCE award recipients.
(b) Number of years devoted in research brought 35.93% of CSCE award winners in its ranked list.
(c) Number of published papers carried 32.81% of CSCE award winner in its ranked.
(d) hg-index elevated 29.68% of the awardees and R-index, h-index and citations in h-core performed equally by elevating 28.12% of CSCE award winners in their ranked list of 150 researchers.
(e) g-index, citations/paper achieved 25% of awardees in their ranked list.
(f) All other indices were unable to elevate even 25% and A-index performed poorest by elevating only 12.5% of CSCE award winners in its ranked list of 150 researchers.

3. **American concrete institute**

(a) In the ranking of 150 researcher, authors/paper, authors/paper dominated all other indices by carrying 64.29% of ACI award recipients.
(b) h-index, hg-Index, R-Index, e-index, g-index, Cites/Year, H-Core, and total number of Citations, all of these have individually risen 57.15% of ACI award recipients in their ranked list of researchers.
(c) Number of years devoted in research and publication count elevated 42.86% of award recipients who belong to ACI.
(d) A-index and citations/paper brought 35.71% and 21.43% of ACI award winners in ranked list respectively.
(e) f-index performed poorest as it elevated only 7.14% of ACI award winners in its ranked list of 150 researchers.

4. **Institute of civil engineering**

(a) Number of years devoted in research brought 64.81% of the ICE award winners in its ranked list.
(b) Number of published papers carried 57.14% of ICE award winners in its ranked list.
(c) h-index, hg-Index, R-Index, and H-Core, all of them have individually risen 42.86% of ACI award recipients in their ranked list of researchers.
(d) Performance of e-index and g-index remained the same as they have elevated 35.71% of awardees in ranked list.
(e) A-index and Authors/paper individually have elevated 28.57% of award recipients of ICE.
(f) Rest of all parameters were unable to elevate even 25% of award winners of ICE. However, Citations/paper have lowest accuracy of 14.28% in elevating awardees.

Conclusion

A rigorous analysis of author assessment parameters have been conducted in this research by using total publications, total citations, cites/year, cites/paper, and authors/paper, h-index, g-index, hg-index, A-index, R-index, e-index, and f-index. The employed data set contains 250 non-awardee authors and 250 awardee authors of prestigious scientific societies from the discipline of Civil Engineering. Logistic regression has been used to rank the awardees based on the value of the cost function of each parameter for award recipients. We have evaluated author assessment parameters such as the year's number since the first publication, publication count, citations count, citations/year, citations/paper, authors/paper, h-index, g-index, hg-index, A-index, R-index, e-index, and f-index.

Findings of the study suggested that the average authors/paper author assessment parameter outperformed all other indices by achieving the accuracy of 67%. The average number of authors are less in the papers published by the awardees as compared to the papers published by non-awardees.

The presences of award recipient's researchers have been examined in range of 50,100 and 150 lists of ranked researchers by each considered parameter. In the ranked list of top 50 by all of these parameters, no. of years devoted to research achieved 58% of the accuracy in bringing award recipients in the list. Total no. of papers brought 54% of awardees and 50% of awardees appears in the ranked list of 50 researchers by average authors/paper. In the ranked list of top 100 by all of these parameters, the parameter authors/papers achieved 62% of the accuracy in bringing award recipients in the list.

Occurrences of award recipients of awarding society are examined individually, to answer the third research question in the ranked list of 150 researchers. The outcomes indicate that awarding societies tend to be sensitive to such indices or they may take these indexes into account when making decisions on award winners.

Future work

In addition to these indices, researchers have suggested a large number of other author assessment parameters as well, all of those need to be ranked by modern machine learning techniques and could be evaluated on a comprehensive dataset from diverse fields to determine the dominance of each index over the others.

References

Abe, N., & Kudo, M. (2005). Entropy criterion for classifier-independent feature selection. In *international conference on knowledge-based and intelligent information and engineering systems* (pp. 689–695). Springer, Berlin, Heidelberg.

Ain, Q. U., Riaz, H., & Afzal, M. T. (2019). Evaluation of h-index and its citation intensity based variants in the field of mathematics. *Scientometrics, 119*(1), 187–211.

Algamal, Z. Y., & Lee, M. H. (2019). A two-stage sparse logistic regression for optimal gene selection in high-dimensional microarray data classification. *Advances in data analysis and classification, 13*(3), 753–771.

Alonso, S., Cabrerizo, F. J., Herrera-Viedma, E., & Herrera, F. (2009). h-index: A review focused in its variants, computation and standardization for different scientific fields. *Journal of Informetrics, 3*(4), 273–289.

Alonso, S., Cabrerizo, F. J., Herrera-Viedma, E., & Herrera, F. (2010). hg-index: A new index to characterize the scientific output of researchers based on the h-and g-indices. *Scientometrics, 82*(2), 391–400.

Ameer, M., & Afzal, M. T. (2019). Evaluation of h-index and its qualitative and quantitative variants in Neuroscience. *Scientometrics, 121,* 653.

Aoun, S. G., Bendok, B. R., Rahme, R. J., Dacey, R. G., & Batjer, H. H. (2013). Standardizing the evaluation of scientific and academic performance in neurosurgery—Critical review of the "h" index and its variants. *World Neurosurgery, 80*(5), e85–e90.

Ayaz, S., & Afzal, M. T. (2016). Identification of conversion factor for completing-h index for the field of mathematics. *Scientometrics, 109*(3), 1511–1524.

Cameron, D. L. (2007). SEMEF: A taxonomy-based discovery of experts, expertise and collaboration networks. MS thesis, The University of Georgia, ATHENS, GA 2007.

Crowder, R., Hughes, G., & Hall, W. (2002). An agent based approach to finding expertise. In *International Conference on Practical Aspects of Knowledge Management* (pp. 179–188). Springer, Berlin, Heidelberg.

Dienes, K. R. (2015). Completing h. *Journal of Informatics, 9*(2), 385–397.

Egghe, L. (2006). Theory and practise of the g-index. *Scientometrics, 69*(1), 131–152.

El-Adaway, I. H., Ali, G., Assaad, R., Elsayegh, A., & Abotaleb, I. S. (2019). Analytic overview of citation metrics in the civil engineering domain with focus on construction engineering and management specialty area and its subdisciplines. *Journal of Construction Engineering and Management, 145*(10), 04019060.

Falagas, M. E., Pitsouni, E. I., Malietzis, G. A., & Pappas, G. (2008). Comparison of PubMed, Scopus, web of science, and Google Scholar: Strengths and weaknesses. *The FASEB Journal, 22*(2), 338–342.

Hariri-Ardebili, M. A., & Saouma, V. (2015). Quantitative failure metric for gravity dams. *Earthquake Engineering and Structural Dynamics, 44*(3), 461–480.

Harzing, A. W. (2014). A longitudinal study of Google Scholar coverage between 2012 and 2013. *Scientometrics, 98*(1), 565–575.

Hirsch, J. E. (2005). An index to quantify an individual's scientific research output. *Proceedings of the National academy of Sciences, 102*(46), 16569–16572.

Jin, B. (2006). H-index: An evaluation indicator proposed by the scientist. *Science Focus, 1*(1), 8–9.

Jin, B., Liang, L., Rousseau, R., & Egghe, L. (2007). The R-and AR-indices: Complementing the h-index. *Chinese Science Bulletin, 52*(6), 855–863.

Katsaros, D., Akritidis, L., & Bozanis, P. (2009). The f index: Quantifying the impact of coterminal citations on scientists' ranking. *Journal of the American Society for Information Science and Technology, 60*(5), 1051–1056.

Liang, R., & Jiang, X. (2016). Scientifc ranking over heterogeneous academic hypernetwork. In *AAAI* (pp. 20–26).
Mingers, J. (2009). Measuring the research contribution of management academics using the Hirsch-index. *Journal of the Operational Research Society, 60*(9), 1143–1153.
Moed, H. F., Bar-Ilan, J., & Halevi, G. (2016). A new methodology for comparing Google Scholar and scopus. *Journal of Informetrics, 10*(2), 533–551.
Raheel, M., Ayaz, S., & Afzal, M. T. (2018). Evaluation of h-index, its variants and extensions based on publication age and citation intensity in civil engineering. *Scientometrics, 114*(3), 1107–1127.
Sidiropoulos, A., Katsaros, D., & Manolopoulos, Y. (2007). Generalized Hirsch h-index for disclosing latent facts in citation networks. *Scientometrics, 72*(2), 253–280.
Springer, D. B., Tarassenko, L., & Clifford, G. D. (2015). Logistic regression-HSMM-based heart sound segmentation. *IEEE Transactions on Biomedical Engineering, 63*(4), 822–832.
Teixeira, A. A., & Mota, L. (2012). A bibliometric portrait of the evolution, scientific roots and influence of the literature on university-industry links. *Scientometrics, 93*(3), 719–743.
Tol, R. (2009). The h-index and its alternatives: An application to the 100 most prolific economists. *Scientometrics, 80*(2), 317–324.
Van Raan, A. F. (2006). Comparison of the Hirsch-index with standard bibliometric indicators and with peer judgment for 147 chemistry research groups. *Scientometrics, 67*(3), 491–502.
West, R., & Stenius, K. (2004). Publishing addiction science: A guide for the perplexed. In *UK7 International Society of Addiction Journal Editors*, London
Wilsdon, J., Allen, L., Belfore, E., Campbell, P., Curry, S. H., Jones, R., et al. (2015). The metric tide: Report of the independent review of the role of metrics in research assessment and management. Technical report.
Wu, Q. (2010). The w-index: A measure to assess scientific impact by focusing on widely cited papers. *Journal of the Association for Information Science and Technology, 61*(3), 609–614.
Zhang, C. T. (2009). The e-index, complementing the h-index for excess citations. *PLoS ONE, 4*(5), e54.

Affiliations

Muhammad Usman[1] · Ghulam Mustafa[2] · Muhammad Tanvir Afzal[3]

Muhammad Usman
m.usman@nu.edu.pk

Ghulam Mustafa
ghulam.mustafa@cust.edu.pk

[1] FAST- National University of Computer & Emerging Sciences, Islamabad Campus, Islamabad, Pakistan

[2] Capital University of Science and Technology, Islamabad, Pakistan

[3] Namal Institute Mianwali, Mianwali, Pakistan