Journal Impact Factor, Eigenfactor, Journal Influence and Article Influence

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Abstract

This paper examines the practical usefulness of two new journal performance metrics, namely the Eigenfactor score, which may be interpreted as measuring "Journal Influence", and the Article Influence score, using the Thomson Reuters ISI Web of Science (hereafter ISI) data for 2009 for the 200 most highly cited journals in each of the Sciences and Social Sciences, and compares them with two existing ISI metrics, namely Total Citations and the 5-year Impact Factor (5YIF) of a journal (including journal self citations). It is shown that the Sciences and Social Sciences are different in terms of the strength of the relationship of journal performance metrics, although the actual relationships are very similar. Moreover, the journal influence and article influence journal performance metrics are shown to be closely related empirically to the two existing ISI metrics, and hence add little in practical usefulness to what is already known. These empirical results are compared with existing results in the literature.

Keywords: Journal performance metrics, Research assessment measures, Total citations, 5-year impact factor (5YIF), Eigenfactor, Journal and Article influence.

JEL Classification: A12.

"They're digging in the wrong place!"
Indiana Jones, *Raiders of the Lost Ark*

1. Introduction

Evaluating research quality is fundamental to the Sciences and Social Sciences. Research assessment rankings are essential to evaluate the research performance of individuals and the quality of academic journals. The perceived research performance of individual researchers is crucial for hiring, firing, tenure and promotion decisions. In the absence of clear signals regarding the inherent, and frequently latent, quality of research, the perceived quality of a journal may frequently be used as a proxy, albeit inappropriately, for the quality of a research paper.

Most journal performance metrics are based on alternative transformations of citations and journal influence. The Thomson Reuters ISI Web of Science database [16] (hereafter ISI) is a leading high quality database for generating research assessment measures, especially citations, to evaluate the research performance of individual researchers and the quality of academic journals. Although there are caveats regarding the methodology and data collection methods underlying any database (see, for example, Seglen [18], Chang and McAleer [6, 7, 8, 9, 10, 11] for caveats regarding ISI), the ISI citations database is the oldest source of rankings criteria and the benchmark against which other databases are compared.

This paper examines the novelty and usefulness of two new journal performance metrics, namely the Eigenfactor score, which may be interpreted as measuring "Journal Influence", and Article Influence score, using ISI data for 2009 for the 200 most highly cited journals in each of the Sciences and Social Sciences, and compares them with two existing ISI metrics, namely Total Citations and the 5-year Impact Factor (5YIF) of a journal (including journal self citations).

It is shown that the Sciences and Social Sciences are different in terms of the strength of the relationship of journal performance metrics, although the actual relationships are nevertheless very similar. Moreover, the Journal Influence and Article Influence metrics are shown to be

closely related empirically to the two existing ISI metrics, so that they add little to what is already known about journal impact. These empirical results are compared with existing results in the literature.

The plan of the remainder of the paper is as follows. Section 2 presents four key research assessment measures (RAM), namely the 2-year impact factor (2YIF) of a journal (including journal self citations), 5-year impact factor (5YIF) of a journal, Eigenfactor (or Journal Influence) score, and Article Influence score. Section 3 reports some empirical analyses of the key RAM, as well as Total Citations, and compares the results with those that are available in the literature. Section 4 gives some concluding remarks.

2. Key Research Assessment Measures (RAM)

Leading journal performance measures for an ISI Journal Citations Reports (JCR) calendar year, which is the year before the annual Research Assessment Measures (RAM) are released, are as follows:

(1) 2-year impact factor including journal self citations (2YIF):

The classic 2-year impact factor including journal self citations (2YIF) of a journal is typically referred to as "the impact factor", is calculated annually, and is defined as "Total citations in a year to papers published in a journal in the previous 2 years / Total papers published in a journal in the previous 2 years". The choice of 2 years by ISI is arbitrary. Rightly or wrongly, it is widely held in the academic community, and certainly by the editors and publishers of journals, that a higher 2YIF is better than lower.

(2) 5-year impact factor including journal self citations (5YIF):

The 5-year impact factor including journal self citations (5YIF) of a journal is calculated annually, and is defined as "Total citations in a year to papers published in a journal in the previous 5 years / Total papers published in a journal in the previous 5 years." The choice of 5 years by ISI is arbitrary. Although 5YIF is not widely reported, a higher value would be preferred to lower. [It is worth noting that 5-year impact factor excluding journal self citations is not presently available.]

(3) Eigenfactor score:

The Eigenfactor score (see Bergstrom [2], Bergstrom and West [3], Bergstrom, West and Wiseman [4]) is calculated annually (see www.eigenfactor.org), and is defined as: "The Eigenfactor Score calculation is based on the number of times articles from the journal published in the past five years have been cited in the JCR year, but it also considers which journals have contributed these citations so that highly cited journals will influence the network more than lesser cited journals. References from one article in a journal to another article from the same journal are removed, so that Eigenfactor Scores are not influenced by journal self-citation." Even though Eigenfactor does not check how much time researchers spend reading hard copies of journals, which would require extensive surveys across a wide range of disciplines, it does indicate how much time researchers might spend reading or scanning articles on a journal's website. Thus, Eigenfactor might usefully be interpreted as a "Journal Influence" measure (see Chang, Maasoumi and McAleer [5]). A higher Eigenfactor score would be preferred to lower.

(4) Article Influence:

Article Influence (see Bergstrom [2], Bergstrom and West [3], Bergstrom, West and Wiseman [4]) measures the relative importance of a journal's citation influence on a per-article basis and, as the name suggests, is an "Article Influence" score. Article Influence is a standardized Eigenfactor score, is calculated annually, and is defined as "Eigenfactor score divided by the fraction of all articles published by a journal." A higher Article Influence would be preferred to lower.

3. Empirical Analysis

3.1 Existing empirical results

Davis [12] used two simple linear regressions to relate the logarithm of the Eigenfactor score to the logarithm of Total Citations, and the logarithm of 2YIF to the logarithm of the Eigenfactor score, giving a high $R^2 = 0.950$ and a reasonably high $R^2 = 0.860$, respectively. These are interesting empirical findings, even though it might be argued that the results

would have been more informative if the Eigenfactor score had been related to 5YIF as both bibliometric measures are calculated over a 5-year citation period, although they are defined differently.

Using a simple linear regression in levels rather than logarithms, Fersht [14] showed that there was a high R^2 = 0.968 between the Eigenfactor score and Total Citations for the top 200 most highly cited ISI journals (based on 2YIF) in the Sciences, based on ISI Total Citations data for 2007. This is very similar to the results obtained for the Eigenfactor score and Total Citations in Davis [12], even though the simple linear regressions used in the two papers differed in terms of the data transformations.

Rousseau et al. [17] calculated the Spearman correlation coefficients between the pairs 2YIF and Eigenfactor score, 2YIF and Article Influence score, and Eigenfactor and Article Influence scores to be 0.827, 0.918 and 0.827, respectively. It might be argued that these interesting empirical results might have been more relevant if 5YIF had been related to the Eigenfactor and Article Influence scores as each of these three bibliometric measures is calculated over a 5-year citation period.

Franceschet [15] considered three pairs of variables for calculating correlation coefficients, namely 2YIF and Eigenfactor score, 5YIF and Eigenfactor score, and the Eigenfactor and Article Influence scores, giving correlations of 0.770, 0.770 and 0.760, respectively. Two simple linear regressions in the levels of three RAM were considered, with R^2 = 0.810 for a simple linear regression of Article Influence score on 2YIF, and R^2 = 0.880 for a simple linear regression of Article Influence score on 5YIF. The marginal effects of 2YIF and 5YIF on the Article Influence score were 0.446 and 0.452, respectively.

Elkins et al. [13] and Arendt [1] both considered the relationship between 2YIF and Article Influence score, with the former calculating a correlation coefficient of 0.790 and the latter a relatively low R^2 = 0.596 from a simple linear regression based on the median values across a range of scientific fields. It might be repeated that these interesting empirical results would have been more meaningful if the Article Influence score had been related to 5YIF rather than 2YIF so that the bibliometric measures would have been calculated over the same citation period.

3.2 Additional empirical results

In order to contribute to the existing literature on empirical findings regarding alternative RAM, in Figures 1-4 we evaluate the 200 most highly cited journals, according to 2YIF, in both the sciences and social sciences for 2009. These figures relate the Eigenfactor score to Total Citations and the Article Influence score to 5YIF. The Total Citations data for 2009 for the Sciences and Social Sciences were downloaded from ISI on 19 June 2010 and 20 June 2010, respectively.

A simple linear regression, with the Eigenfactor score as a function of Total Citations, is given in Figures 1 and 3 for the Sciences and Social Sciences, respectively. The estimated model shows that the Eigenfactor score increases, on average, by 0.000004 and 0.000003 for each unit increase in Total Citations for 2009 for the Sciences and Social Sciences, respectively. The goodness-of-fit measures, namely R^2 = 0.931 and R^2 = 0.659 for the Sciences and Social Sciences, respectively, show that the Eigenfactor score can be estimated accurately, especially for the Sciences, on the basis of a simple linear regression against Total Citations.

The approximate relationships between the Eigenfactor score and Total Citations for the Sciences and Social Sciences, respectively, can be expressed as:

$$\textit{Eigenfactor score} = k\,(\textit{Total Citations})$$

where k = 0.0000033 and k = 0.000002 for Sciences and Social Sciences, respectively. The estimated value of k = 0.00000396 in Ferscht [14] for the Sciences, based on ISI Total Citations data for 2007, is broadly similar to the result obtained in the present paper, as is the value of R^2.

Another simple linear regression, with the Article Influence score as a function of 5YIF, is given in Figures 2 and 4 for 2009 for the Sciences and Social Sciences, respectively. The estimated models show that the Article Influence score increases, on average, by 0.489 and

0.479 for each unit increase in 5YIF for 2009 for the Sciences and Social Sciences, respectively.

The goodness-of-fit measures, as given by R^2 = 0.923 and R^2 = 0.572 for 2009 for the Sciences and Social Sciences, respectively, show that the Article Influence score can be approximated very accurately for the Sciences, and reasonably accurately for the Social Sciences, on the basis of a simple linear regression relationship of Article Influence score against 5YIF, namely:

Article Influence score = 5YIF/2.

Although the goodness-of-fit value of R^2 obtained in the present paper is slightly higher than in Franceschet (2009), namely R^2 = 0.880, in relating the Article Influence score to 5YIF, the latter paper had an effect of 5YIF on Article Influence score of 0.452, which is very similar to that proposed above.

4. Conclusion

Although the Sciences and Social Sciences are dramatically different in terms of the strength of the underlying relationship of the journal performance metrics considered in this paper, the actual empirical relationships are broadly similar. As Article Influence is a modification of 5YIF, although they have different definitions, it is perhaps not surprising that the two scores are highly and positively correlated.

Given the very high correlations between the Eigenfactor score and Total Citations, and between the Article Influence score and 5YIF, and the corresponding high R^2 values for the simple linear regressions, the Eigenfactor score and Article Influence score would not seem to be entirely necessary for the Social Sciences, and not at all necessary for the Sciences, relative to the leading journal performance measures that are already available, namely Total Citations and 5YIF, respectively.

As the journal performance measures captured in the Eigenfactor and Article Influence scores, which are said to measure “importance” and “prestige”, respectively, add little to what is already available in the ISI Total Citations and 5-year impact factor (5YIF) of a journal, we have no hesitation in concurring with Indiana Jones, who made the following remark regarding his competitors who were searching for the Lost Ark of the Covenant: “They’re digging in the wrong place!”

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Table 1

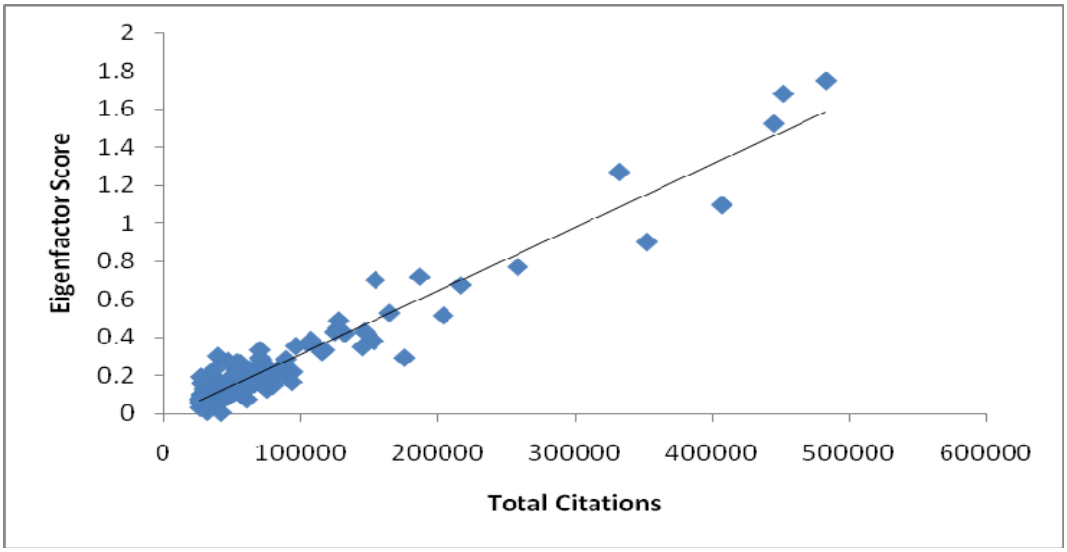
Correlations and R^2 for Various Research Assessment Measures (RAM)

Authors	**Correlated Variables**	**Correlation**	R^2
Davis [12]	(log Eigenfactor, log TC)	-	0.950
	(log 2YIF, log Eigenfactor)	-	0.860
Ferscht [14]	(Eigenfactor, TC)	-	0.968
Rousseau et al. [17]	(2YIF, Eigenfactor)	0.827	-
	(2YIF, AI)	0.918	-
	(Eigenfactor, AI)	0.827	-
Franceschet [15]	(2YIF, AI)	-	0.810
	(5YIF, AI)	-	0.880
	(2YIF, Eigenfactor)	0.770	-
	(5YIF, Eigenfactor)	0.770	-
	(Eigenfactor, AI)	0.760	-
Elkins et al. [13]	(2YIF, AI)	0.790	-
Arendt [1]	(2YIF, AI)	-	0.596
This paper	(Eigenfactor, TC)	-	0.931
	(5YIF, AI)	-	0.923

Note: AI denotes Article Influence and TC denotes Total Citations. The correlations are Spearman's correlation coefficients, and the R^2 values are calculated from simple linear regression models.

Figure 1

Eigenfactor Score and Total Citations for 200 Most Highly Cited Journals in Sciences for 2009

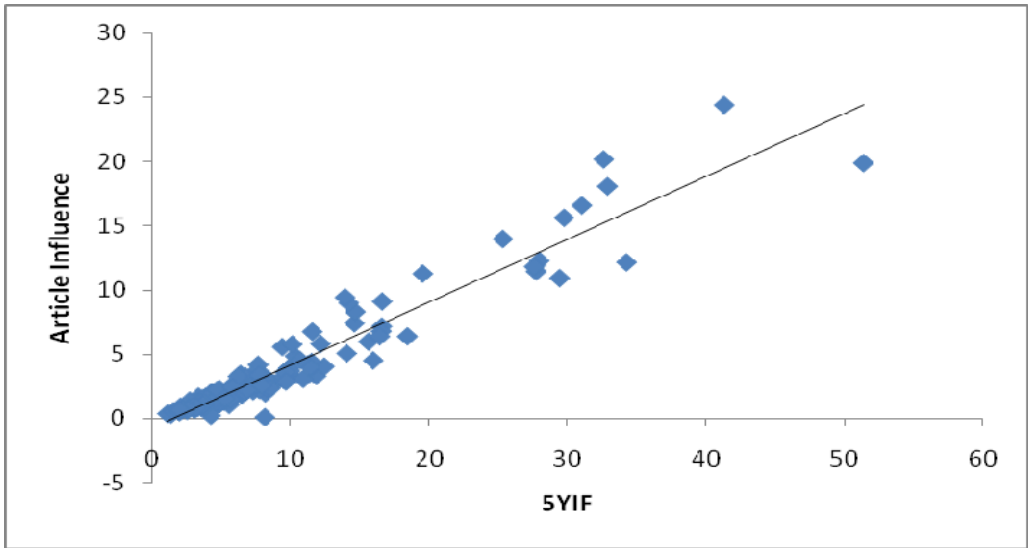


Note: Citations data were downloaded from ISI on 19 June 2010. The OLS regression results are as follows (t-ratios in parentheses):

$$\underset{\text{(-3.42)}}{\text{Eigenfactor Score}} = \underset{\text{(51.59)}}{-0.022 + 3.32\text{E-}06 \times \text{Total Citations}} + \text{error}, \qquad R^2 = 0.931$$

Figure 2

Article Influence Score and 5YIF for 200 Most Highly Cited Journals in Sciences for 2009

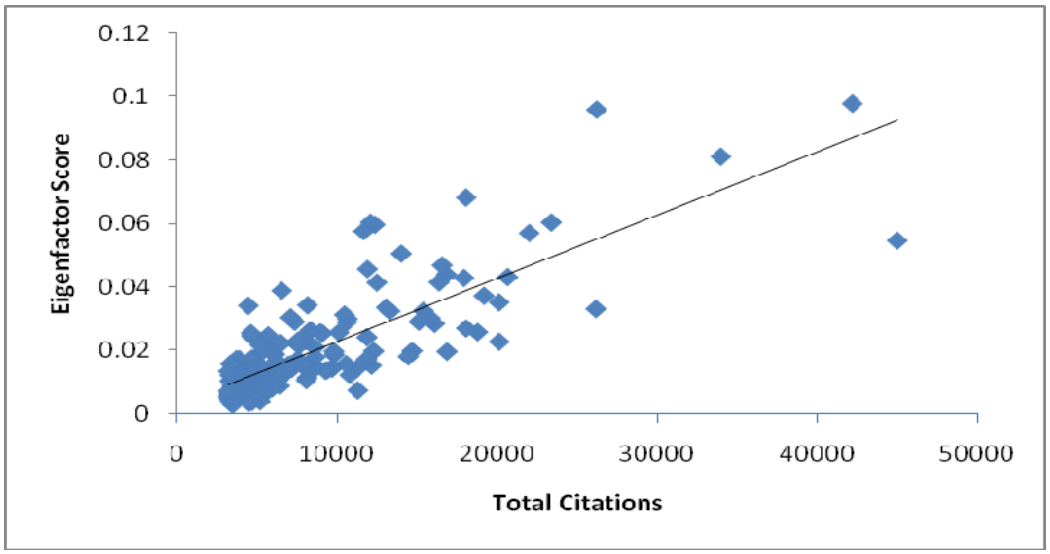


Note: Citations data were downloaded from ISI on 19 June 2010. The OLS regression results are as follows (t-ratios in parentheses):

$$\underset{\text{(-6.65.)}}{\text{Article Influence}} = \underset{\text{(48.54)}}{-0.719 + 0.489 \times 5\text{YIF}} + \text{error}, \qquad R^2 = 0.923$$

Figure 3

Eigenfactor Score and Total Citations for 200 Most Highly Cited Journals in Social Sciences for 2009

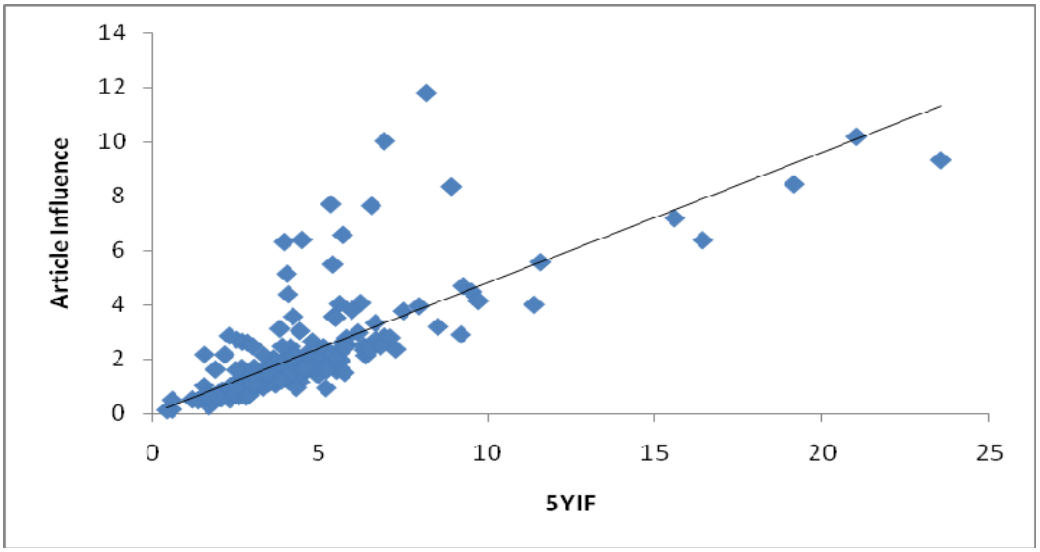


Note: Citations data were downloaded from ISI on 20 June 2010. The OLS regression results are as follows (t-ratios in parentheses):

$$\underset{}{\text{Eigenfactor Score}} = \underset{(2.85)}{0.029} + \underset{(19.55)}{1.99\text{E-}06} \times \text{Total Citations} + \text{error}, \qquad R^2 = 0.659$$

Figure 4

Article Influence Score and 5YIF for 200 Most Highly Cited Journals in Social Sciences for 2009



Note: Citations data were downloaded from ISI on 20 June 2010. The OLS regression results are as follows (t-ratios in parentheses):

$$\underset{}{\text{Article Influence}} = \underset{(0.10)}{0.160} + \underset{(16.25)}{0.479} \times 5\text{YIF} + \text{error}, \qquad R^2 = 0.572$$