New Research Performance Evaluation Development and Journal Level Indices at Meso Level

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Abstract

This study applies scientometric approach to meso level data. The objective was to evaluate Institutional level h-index's (IHI) reliability with respect to other Journal Related Indices (JRI). Most of the studies in the literature considered journal's h-index as contrasted measure. Nevertheless, there has been no study that explores the relation between IHI and institutional level JRI. To get further evidence, we have explored the inter-correlation of IHI with a set of JRI. For this purpose data from Web of Science, Journal Citation Report and time cited features were used. Our unit of analysis was Malaysian engineering research with a wider time span of 10 year's data (2001-2010) and a larger set of journals (1381 journals). Previous studies are are used for comparative analysis. This paper puts forward a better understanding to considering new impact indices at meso level for evaluation purpose.

Conference Topic

University policy and institutional rankings, Science policy and research assessment

Introduction

Journal Impact Factor (JIF) was introduced by the Institute of Scientific Information (ISI) via Journal Citations Report (JCR) about 30 years ago. It has a long tradition as an Impact Factor (IF) indicator for scholarly research output. Alike, h-index and many of its variants have been introduced and displayed on JCR site (www.webofknoweldge.com). IF can be used as a measure of research quality/impact of journals (Braun, Glanzel & Schubert, 2006). In general research performance evaluation (RPE) practices, it has become a "chief quantitative measure of the quality of researcher, and even the institution" but, it cannot be used as a direct measure of quality (Amin & Mabe, 2003; Bornmann et al., 2011). JIF remains the primary criterion when it comes to assessing the quality of journals and authors (Raj & Zainab, 2012). IF should not be used as a sole measure of a journal rank (Bornmann, et al., 2011).

To overcome the limitations, of IF, researchers suggested that it should be used with new alternative tools (Braun, Glanzel, & Schubert, 2006; Prathap, 2011; Bornmann et al., 2011; Yang Yin, 2011) or as a measure of research quality / impact of journals (Braun, Glanzel & Schubert, 2006). An interesting debate was started by Braun, Glanzel, and Schubert, (2006) who suggested that the h-index can be used as a measure of research quality or impact of a journal. The notion of Journal h-index was introduced by (Braun, Glanzel, & Schubert, 2005). Who found it a promising measure for the journal (Braun, Glanzel, & Schubert, 2006). After the introduction of h-index, a number of studies made a comparative analysis of both measures and their variants. Both impact indices (h and IF) are easily comprehensible (Leydesdorff, 2009) and have received worldwide recognition. However, prior studies, as reviewed in the subsequent paragraphs were concerned with the evaluation of journal's h-index to JRI.

Mingers, Macri and Petrovici (2012) examined Journal level h-index against Impact Factor 2year (JIF), Impact Factor 5 year (IF5y) and peer judgment for management journals. They preferred journal h-index to IF because of the former's selective time frame and the formulaic problem. Another study in the field of management was carried out by Moussa and Touzani (2010) using Google-Scholar (GS) as source data. They used a variant of the h-index, the hg-index along with two and five years IF. There was a substantial agreement found (>0.85) between JIF 5y and the hg -index ranking. They suggested hg-index as an alternative to the GS based journals. Soutar and Murphy (2009) studied 40 marketing journals and ranked them according to IF and h-index, and compared their list with Australian journal ranking. They suggested these indices as the basis for moving some journals up and other journals down. Their study supported the use of GS as an alternative way to measure citations in marketing. Harzing and Van der Wal compared h-index calculated from GS with the impact factors computed from the Web of Science (WoS™) and with peer reviewed journal ranking (2009) by undertaking a larger-scale investigation of over 800 business and management journals.

A comparative analysis of IF and h-index was carried out by Bador and Lafouge (2010) on pharmacology and psychiatry journals from JCR with two-year publications. The journals correlation coefficient between IF and h-index was high. They inferred that IF and h-index can be totally corresponding when analyzing journals of the similar scientific subject. Bornmann, Mutz and Daniel (2009) studied the journal's h-index of twenty organic chemistry journals from WoS™ database for two years time span. They analyzed a number of impact indicators including the IF, and journal's h-index and its variants *g* index, h^2 index, A, and *R* index. They found "a high degree of correlation between the various measures" (Bornmann, Mutz & Daniel, 2009).

Yang Yin (2011) analyzed 20 top journals in the field of science and engineering using data from WoS™. The researcher hypothesized "that the combination of complementary journal indicators could provide a simple, flexible and practical alternative approach for evaluating scientific journals" (p.2). Yang Yin considered the journal h-index with another JRI e.g. EigenFactor score. There is a positive correlation although not strong among these indices. They suggested getting published research work in high Eigenfactor scores journals. These indices can also be combined to complement each other.

Research Objectives

The objective of past studies was to evaluate a journal's h-index validity and reliability with respect to other JRI. Most of these studies considered journal's h-index as contrasted measure with JIF, JIF (5Y), and EigenFactor Score (EF). These studies are meaningful to understand the properties of newly introduced indices and potential use of journal's h-index as a complement aid with IF and its variants (Bador & Lafouge, 2010; Bornmann et al., 2012; Yang Yin, 2011) or, as a supplement (Braun, Glanzel, & Schubert, 2006).

Nevertheless, there has been no study to explore the relation of IHI with JRI. To have further evidence of validity of h-index at the institutional level, we hypothesized that IHI is a potential index for RPE that can be used to complement or as a supplement along with JRI for RPE at the institution level.

Methods and Materials

The empirical part of this study focuses on one non-Western country, Malaysia, which has a developed and well-defined scholarly publishing industry based in its universities. Research productivity, citations record, and institutional journal data of twelve Malaysian universities are retrieved from WoS™ and JCR'2011 from the Web of Science. Only those universities that have at least fifty publications during the past ten years were selected. "The statistical methodology of EFA can be used to examine for latent associations present in a set of observed variables, and reduce the dimensionality of the data to a few representative factors" (Schreiber et al., 2012, p.349). It is mainly used to identify a smaller set of salient variables from a larger set and to explore the underlying dimensions or factors that explain the correlations among a set of variables (Conway and Huffcutt, 2003). Initially, we used eleven indices for the present study. These are Total publications (TP), Total Citations (TC) Citation Per Publications (CPP), Institutional H-Index (IHI), JIF, Cumulative Journal Impact Factor (CIF), Journal Impact Factor 5y (JIF5y), Cumulative Journal Impact Factor 5y (CJIF5y), Average Impact Factor (AIF), Median Impact Factor (MIF), Immediacy-index (Imm-index) and EigenFactor Score (EF).The definitions and the acronym used are described in Table 1.

Table 1. Definitions of indices used at Meso level.

Indicators	*Definition*
1. Total Publications (TP)	Total publications of a university over the set criteria
2. Total Citations (TC)	Total citations of a university over the set criteria
3. Institutional H-Index (IHI)	An institution has index h if h of institutional publication has at least h citation each and other publication have fewer than or equal to h citations each.
4. Journal Impact Factor (JIF)	The average number of times articles from the journal published in the past two years has been cited in the JCR year (Thomson- Reuters 2015).
5. Cumulative Journal Impact Factor (CIF)	This is the cumulative value of Journal Impact Factor of each university.
6. Impact Factor five Years (IF5y)	The average number of times articles from the journal published in the past five years have been cited in the JCR year (Thomson-Reuters 2015).
7. Cumulative Impact Factor Five Years (CIF5y).	This is the cumulative value of five years Journal Impact Factor of each university.
8. Average Impact Factor (AIF)	This is the average of the Impact Factor of each university.
9. Median Impact Factor (MIF)	This is the median of the Impact Factor of each university.
10. Immediacy-index (Imm-index)	This is calculated by dividing the number of citations to articles published in a given year by the number of articles published in that year Thomson-Reuters 2015).
11. EigenFactor Score(EF)	"Eigenfactor score is calculated by the ratio of the total number of citations for the JCR year to the total number of articles published in the last 5 years". Thomson-Reuters 2015).

Data Processing

To get a meaningful evaluation, we used a wider set of WoS^{TM} engineering journals (1381 journals) considered by our sample (12 Malaysian universities) institutions with a wider horizon of ten years (2001-2010) under specified nine categories. Our research term was "Malaysia" in "Address", limited to document type research article and reviews only and refined by nine engineering research categories. These engineering categories are engineering electrical, electronic, engineering manufacturing, engineering biomedical, engineering industrial, engineering civil, engineering chemical, engineering mechanical, engineering environmental and engineering multidisciplinary.

Data were suffered from affiliation problem, change of journal title and abbreviation of a journal name. All the data were checked manually for publications, citations, institutional affiliation, and journal name change or emergence cases. The selected twelve universities got their articles published in 1381 journals. According to JCR'2011, almost all journals in our data set were IF. There were only 22 journal articles published in six journals, and ten proceedings had no impact factor. It is assumed that the said journals/proceedings may have IF prior to 2011. These records were included in the journal list for analysis purpose. Firstly, all the records were retrieved in a spreadsheet file, and IBM SPSS version'19 was used for statistical analysis purpose.

Table 2 provides the university-wise total journal records. The publication share of research university (RU) status was 66 % (908) while; the non-RU status universities shared 34 % (473) of the total journals.

Table 2. Distribution of journals (N=1381).

No	*University*	*Total journals and proceedings*	*University Status*	*Contribution%*
1	University of Malaya (UM)	191		
2	Universiti Sains Malaysia (USM)	188		
3	Universiti Putra Malaysia (UPM)	187	Research	
4	Universiti Teknologi Malaysia (UTM)	184	Universities= 908 journals	66
5	Universiti Kebangsaan Malaysia (UKM)	158		
6	Universiti Teknologi Mara (UiTM)	87		
7	University of Multimedia (MMU)	81	Non-Research Universities=473 Journals	34
8	Universiti Teknologi PETRONAS (UTP)	78		
9	International Islamic Universiti Malaysia (IIUM)	77		
10	University of Nottingham Malaysia Campus (UNMC)	61		
11	MONASH Universiti Sunway Campus (MONASH)	51		
12	Universiti Tenaga Nasional (UNITEN)	38		
	Total	1381		100

The RU universities are more bound to published in IF journals to get more research funding. These universities receive a big amount of budget for R&D purposes and have to face pressure and make policies accordingly (http://www.hir.um.edu.my), and this is especially prevalent in Asian countries (Leydesdorff, 2009). The first five public universities (RU) published in 150-200 journals. Comparatively the private universities had fewer publications and published in 50 to 100 journals. The average number of journals for RU and non-RU universities is 182 and 68 respectively.

Analysis and Findings

Exploratory Factor Analysis (EFA)

In a tie with the problem, this section proceeds accordingly with descriptive statistics, data normality and EFA for our set of indices as presented in Table 3.

Descriptive Statistics and Normality Analysis of Complete Dataset

Descriptive statistics along with Skewness and Kurtosis are presented in Table 4. The results of the normality test based on raw data (excluding outliers) are reported in Table 5. The Skewness and Kurtosis are valid tests to find the normality of data. Their values show a normal distribution of data adequately normal. Keeping in view the requirement of EFA statistical application we used two other options as well. We also examined the relation between the raw, logarithmically transformed shifted (ln(x + 1) and square root transformation.

Table 5 shows a better Kaiser-Meyer-Olkin (KMO) results and a slight better-explained variance for log data. For this reason, we found the logarithmic transformed data more adequate for EFA. Bornmann, Mutz and Daniel (2008; 2009) used a cut-off threshold >0.6 for extraction loading factors while Schreiber, Malesios and Psarakis (2012) fixed it at > 0.685 for Varimax rotation.

Schreiber *et al*. (2012) argued that small sample size for EFA can produce reliable results. Quite a few factors and high communalities are in favour of small sample sizes (Preacher and MacCallum, 2002). Further, to measure a sampling adequacy, a specific test Kaiser-Meyer-Olkin (KMO) of value >5 is acceptable (Kaiser, 1974). KMO value (Table 6) of the present data sample is >0.5 with high communalities (>0.85) (Table 7). Based on KMO values and variance explained (Table 6 and 7), we finally utilized logarithmically transformed data. We identified two unknown factors through Eigen values (>1) via variance explained.

This is evident that EFA can be used and is appropriate for our formulated problem and dataset. Initially, we considered eleven indices, TP, TC, IHI and 8 of JRI (JIF, CIF, IF avg, MIF, CIF, CIF5Y, Imm-Index, and EF). This set of indices produced inadequate results for EFA. After omitting the TP, we applied EFA to TC, IHI, and 8 JRI (IF, CIF, IFavg, MIF, CIF, CIF5Y, Imm- Index, and EF).

Table 3. Analysis of Complete dataset for institutional level indices applied

University	*TP*	*TC*	*IHI*	*JIF*	*CIF*	*AIF*	*MIF*	*IF(5Y)*	*CIF(5Y)*	*Imm-Index*	*EF*
USM	724	4027	26	311.36	1609.71	2.229	1.35	331.43	1705.82	49.752	2.506
UPM	551	2309	20	255.12	879.04	1.600	1.12	262.86	886.18	40.100	2.070
UM	495	2388	23	337.45	948.07	1.950	1.50	318.54	871.69	52.598	2.481
UTM	475	2259	23	262.16	883.14	1.883	1.12	280.76	910.61	39.835	2.277
UKM	386	1490	17	233.65	624.13	1.634	1.25	246.65	629.14	36.081	1.975
UiTM	139	359	9	144.85	239.58	1.815	1.39	154.08	248.73	21.922	1.318
IIUM	138	251	7	100.01	174.87	1.270	1.02	103.96	177.20	14.640	0.960
MMU	532	2231	19	120.22	583.83	1.099	1.17	128.66	576.70	18.130	0.874
UNMCC	126	616	13	102.82	248.58	1.973	1.55	100.34	241.58	15.450	0.776
UTP	142	329	9	122.97	263.12	1.853	1.31	134.24	287.38	19.896	1.179
MONASH	76	302	10	87.87	131.94	1.713	1.59	94.86	140.93	13.533	0.887
UNITEN	71	139	6	50.86	91.77	1.293	1.22	55.65	100.24	7.460	0.351

Analysis of EFA

Table 6 reports the results of KMO values of the transformed data for the appropriateness of factor analysis. The next table 7 reveals the results of communalities for 3 EFA models that are the "variance in observed variables accounted for by a common factor" (Hatcher, 1994).

Table 4. Descriptive statistics

Indices	*Descriptive Statistics*					*Skewness*	*Kurtosis*
	Mean	*St.dev*	*Median*	*Min*	*Max*		
TP	321.25	229.079	264.00	71	724	0.364	-1.47
TC	1391.67	1246.835	1053.0	139	4027	0.776	-0.17
IHI	15.17	7.004	15.00	6.00	26.0	0.151	-1.60
IF	177.44	96.683	133.90	50.85	337.45	0.452	-1.34
CIF	556.48	457.445	423.47	91.77	1609.7	1.115	1.02
MIF	1.30	0.182	1.28	1.02	1.59	0.239	-1.01
AIF	1.69	0.332	1.76	1.10	2.23	-0.427	-0.44
IF(5Y)	184.34	97.047	144.15	55.65	351.43	0.351	-1.58
CIF(5Y)	564.68	471.04	432.04	100.24	1705.8	1.317	1.87
Imm-index	27.45	15.356	20.91	7.46	52.60	0.471	-1.32
EF	1.47	0.748	1.249	0.35	2.51	0.179	-1.56

Overview of Statistical Procedure for EFA

Table 5. Test for normality of data

	Kolmogorov-Smirnov[a]			*Shapiro-Wilk*		
	Statistic	*Df*	*Sig.*	*Statistic*	*df*	*Sig.*
TP	.283	12	.009	.863	12	.053
TC	.233	12	.071	.852	12	.038
IHI	.186	12	.200*	.918	12	.267
IF	.208	12	.158	.881	12	.090
CIF	.235	12	.067	.856	12	.043
AIF	.183	12	.200*	.929	12	.369
MIF	.114	12	.200*	.960	12	.782
IF(5Y)	.228	12	.085	.876	12	.078
CIF(5Y)	.212	12	.143	.829	12	.020
Imm-index	.228	12	.086	.904	12	.178
Eigen Factor	.180	12	.200*	.937	12	.458

*At a 5% Significance Level

Table 6. Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy

	X	*√x*	*ln(x + 1)*
KMO	0.564	0.540	0.695
Sig.	0.00	0.00	0.00

Table 8 provides Initial Eigenvalues >1 and indicates that the total variance explained by first two factors is 75%, and 17 % of cumulative variance explained by both factors are 91%.
Component matrix (Table 8) illustrates that the set of indices clearly loads on two extracted factors. Rotated Component Matrix Table (9) for EFA model shows that the indices have

substantial loading on two established factors. It indicates the loading of two institutional 'impact of the productive core indices' (TC and IHI) and six others JRI have high loading (> 0.90) and a slight less for EF (>0.891).

Table 7. Communalities for 3 EFA models

	X		*√x*		*ln(x + 1)*	
Indices	*Initial*	*Extraction*	*Initial*	*Extraction*	*Initial*	*Extraction*
TC	1	0.893	1	0.9	1	0.896
IHI	1	0.883	1	0.877	1	0.866
IF	1	0.94	1	0.951	1	0.953
CIF	1	0.934	1	0.958	1	0.962
IF(avg)	1	0.854	1	0.865	1	0.841
MIF	1	0.869	1	0.844	1	0.87
IF(5Y)	1	0.954	1	0.963	1	0.967
CIF(5Y)	1	0.879	1	0.925	1	0.950
Imm- Index	1	0.918	1	0.943	1	0.955
EF	1	0.869	1	0.861	1	0.870

AIF and MIF both have substantially high loading on the second factor>0.9. MIF is more accurate measure than the average value, due to the impact factor's skewed distribution (Costas & Bordons, 2007). IF and CIF and IF5y and CIF5y require two years and five years time span with different strengths of productivity. EF is another index based on 5-year data excluding journal self-citation to rate the total importance of journal. Journals generating higher impact on the field have larger Eigenfactor scores (Bergstrom, 2007). "EF improves upon JIF and somewhat robust indicators of quality and prestige of the journal due the inclusion of 5 year's data, exclusion of journal self-citations" (YangYin, 2010, p.3). Rather a high journal EF depicts producing of high-impact scientific findings in a specific area (YangYin, 2010; Saad, 2006). IF (5y) indicates the speed with which citations to a specific journal appear in the published literature. Immediacy index that is based on one-year data shows the same value as CIF on the first factor. They both require a different strength of data. Surprisingly they all loaded on the same factor along with IHI.

Table 8: Total variance explained for 3 EFA models.

Data type		*Initial Eigenvalues*			*Extraction Sums of Squared Loadings*			*Rotation Sums of Squared Loadings*		
		Total	*% of Variance*	*Cumulative %*	*Total*	*% of Variance*	*Cumulative %*	*Total*	*% of Variance*	*Cumulative %*
Raw indices	1	7.401	74.006	74.006	7.401	74.006	74.006	7.269	72.687	72.687
	2	1.594	15.940	89.946	1.594	15.940	89.946	1.726	17.259	89.946
√x	1	7.432	74.325	74.325	7.432	74.325	74.325	7.314	73.142	73.142
	2	1.655	16.547	90.872	1.655	16.547	90.872	1.773	17.730	90.872
ln(x+1)	1	7.457	74.569	74.569	7.457	74.569	74.569	7.343	73.427	73.427
	2	1.672	16.720	91.290	1.672	16.720	91.290	1.786	17.862	91.290

Table 9. Rotated component matrix

Indices	*Components*	
	1	*2*
C	**.945**	-.055
IHI	**.929**	.059
IF	**.965**	.147
CIF	**.978**	-.074
AIF	-.133	**.907**
MIF	.309	**.880**
IF(5Y)	**.970**	.159
CIF(5Y)	**.974**	-.038
Imm-index	**.950**	.230
EF	**.891**	.275
Eigenvalues	**7.401**	1.595
Variance explained	**75%**	17%

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Values >.5 are bold.

Conclusions

The caveats of h-index, JIF, and traditional metrics have been discussed in the abundant literature. Previous studies are meaningful to understand the properties of newly introduced indices and potential use of Institutional's h-index as a complement aid with IF and its variants. (Bador & Lafouge, 2010; Bornmann et al., 2012; Yang Yin, 2011) or, as a supplement (Braun, Glanzel & Schubert, 2006).

The present study describes the case of Malaysian engineering research applying the scientometric approach, method and techniques for RPE. Based on the ten years data analysis from WoS^{TM}, we applied a set of comparatively new indices. To achieve the research objectives, empirical analyses were carried out, and hypotheses were examined statistically.

The major findings of the study demonstrate that there seems to be increasing the trend to get published in IF journals. A steady increase of IF publications is observed from 2001 in the Malaysians scientific productivity of all studied disciplines including engineering. The ambition to publish in IF WoS^{TM} recognized publications is reinforced by the Malaysian Research Assessment (MyRA) exercise, which requires institutions to publish papers that are indexed in the citation database. This is due to the Malaysian Ministry of Education policies towards research and publications during two five years plans (2001-2005; 2006-2010). RU status universities (shared 68% and 74% publications and citations). These universities have published in 66% of total journals. Overall, the RU universities lead in positioning order with the application of indices. USM is an exceptional case and remained in position one with respect to almost all indicators. While others showed a noteworthy change in their positioning order. IHI has stronger functional relation with institutional citation data followed by publication record. Institutional citation data is the best predictor of IHI. Often used metric C (as total impact indicator) and the EF (as prestige indicator) have a high association with IHI. This establishes the property of h- index as prestige impact measure of scientific productivity. This index appears a useful yardstick, because of good functional relationship with C and P and has shown some discriminatory power for ranking purpose. The EFA suggests the same distinguishing behaviour of IHI like P and C. The findings put forward a better understanding about the consideration of new impact metric for RPE at the meso level. Malaysian engineering institutional case indicates that h-index and others metric have not only strong association for total institutional citation data but also with institutional cumulative journal indices. However, the total variance explained for two components yields about 75% for its first component and 16% for the second component. Therefore, findings are based within the limitations of the statistical analysis.

Publishing in high-quality IF journals is important if a country is to realize its ambition to have its universities amongst the top rated universities in the world. This is not peculiar to Malaysia. The Ministry of Education Malaysia is targeting two research universities in the country to be in the top world 100 best universities by 2020. Other countries also place a high emphasis on publishing in IF journals and would want to be ranked as top world universities, even if they are not always explicit in saying so. Given the significant number of papers that have now been published by Malaysian institutions (56, 571 in Web of Science, Essential Science Indicators, Web of Science 2015), there is an opportunity to carry out further analysis. It would be interesting, for example, to provide analysis at a discipline level to get a feeling for the strengths of the institution at a lower level. It would also be informative to consider other normalization measures to ascertain if they provide a better correlation with the MyRA ranking.

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