

Research productivity and impact of ASEAN countries and universities in the field of energy and fuel

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ABSTRACT

The research performances for Association of Southeast Asian Nations (ASEAN) countries and universities in the energy and fuel field were assessed using the standard bibliometric indicators proposed by the Centre for Science and Technology, University of Leiden, The Netherlands; and h-index, all the data being retrieved from the Web of Science (WoS) database during 2003-2009. The results suggested that Thailand had the highest number of published articles while Singapore was positioned first as concerns total citations and citations per publication. All the selected ASEAN countries seemed to publish their research works in a similar group of energy and fuel journals, while 15-50% of the published articles for the ASEAN universities had never been cited after publication. The research performance of Singapore was found to exceed the worldwide average reference while those of Malaysia, Thailand and Vietnam were just about average; those for the rest of the ASEAN countries were positioned below. At the university level, Nanyang Technology University (Singapore), National University of Singapore (Singapore) and King Mongkut's University of Technology Thonburi (Thailand) were the top three ASEAN universities with the highest publication volumes, total citations and h-index values. The variations in h-index values for ASEAN universities most correlated with those in total citations. There was no apparent relationship between the h-index and ratio of citation/article to average field citation score (CPP/FCSm) values observed in this work. In conclusion, the research performances of ASEAN countries and their selected universities have now been revealed and discussed for the first time in relation to worldwide references.

Key words: Bibliometrics; Research performance; Publication productivity; Citations; h-index.

INTRODUCTION

Amidst increasing global competition among students, faculties and research funding agencies, higher institutions need to assess and quantify the efficiency and quality of their researchers, and their research outputs to set strategic goals and budget allocations, and also to increase their academic visibility among potential students, faculties, collaborators and research funding agencies. Many institutions have proposed various indicators for the evaluation of university performance towards the rankings and/or ratings of the

universities across the world in a wide range of research fields (Williams and Van Dyke 2008; ARWU 2010; HEEACT 2010; PRWU 2010; Sombatsompop et al. 2010; SUR 2010; THES 2010). Examples of these indicators include research publications, the number of world-recognised awards, journal impact factors, citations, citations per publication, citations per staff, *h-index*, research funding, number of international students and faculty staff, staff-student ratio, peer-assessment survey and questionnaire, PhD completions, academy members, evaluation of employers, and graduate's salary and companies. The publication and citation-based indicators, including journal impact factors and *h-index*, are very dependent on database coverage, citation habits and characteristics (length of reference lists) and research discipline (Lancho-Barrantes et al. 2010). However, none of these indicators have provided information on the research performance carried out through cooperation between universities and industries (Ryan et al. 2008; Tijssen et al. 2009), and commercial research outputs (i.e. patents) (Wang and Guan 2010). Research evidence by Lebeau et al. (2008) clearly stated that the average scientific impact of university-industry papers was greater than that of both university-only papers and industry-only papers. Van Raan (2003, 2006a, 2006b) proposed and used standard bibliometric indicators in research performance assessment and monitoring both intra-disciplinary and interdisciplinary research performances. The indicators used were the number of papers published (*P*), the total number of citations (*C*), citations publication (*CPP*), percentage of not-cited papers (*% Pnc*), mean journal citation score (*JCSm*), and mean field citation score (*FCSm*). The *CPP/FCSm* value was used to observe the performance of a research group or institute or country in relation to worldwide reference. If such value was below 0.8, the research performance of the interested institute was below the international standard: whereas; if the value was above 1.2, the international impact standard of the field of the institute was very high. Van Raan (2003) indicated a good relationship between the *CPP/FCSm* value and *h-index*, and peer review judgment for a large number of chemistry research groups, especially for high performance research groups. The results are in line with the work by Norris and Oppenheim (2010) who found a good correlation between the *h-index* and peer review judgment in Library and Information Science discipline.

University or academic ranking has been conducted in both international and national levels. The international levels included, for example, The Times Higher Education Supplement (THES 2010) and the Academic Ranking of World Universities by Shanghai Jiao Tong University (ARWU 2010). The most recent was the Performance Ranking of Scientific Papers for World Universities by the Higher Education Evaluation and Accreditation Council of Taiwan (HEEACT 2010) which measured field-based research performance in terms of research productivity, research impact, and research excellence (number of highly cited articles). The results of these rankings are affected by not only the indicators used, but also the size of information retrieved (Liang et al. 2001). A comparative analysis of university rankings across various countries (namely, Australia, Canada, UK, and the USA) was studied by Dill and Soo (2005) who suggested that university reputation was the most controversial measure. As university ranking activities have been consistently carried out worldwide, questions about the social benefits contributed by academia in universities have frequently been tackled (López-Martínez and Rocha-Lackiz 2001). More accurate assessments would be obtained if the academic ranking were carried out in discipline levels (Norris and Oppenheim 2010; Rao and Srivastava 2010) and citation qualities and significance of cited publications were taken into account (Sombatsompop et al. 2006).

Existing university ranking reports suggest that most universities in the Association of Southeast Asian Nations (ASEAN) countries, except for those in Singapore, have been ranked very poorly and most of them have never been listed in any world ranking systems

as a result of being taken out of a short-listing process from the initial university selection. As a result, the research performance of most ASEAN universities has not been revealed and is not exactly known, especially in some niche disciplines under ASEAN research environments (such as energy, agriculture, sustainable development and emerging diseases) In other words, there has been no sufficient research data available for the purposes of setting strategic research goals, budget allocations, policy making and decisions for improvements of research performance among ASEAN universities. This work, therefore, is aimed to assess the research performances of ASEAN countries and universities, focusing on the research in the energy and fuel field as a case study (the reason for this selected research field is given in the research methodology section) using the standard bibliometric indicators proposed by Van Raan (2003), and *h-index*. Preliminary data were also given to show that the research performance in the energy and fuel field for the Asiatic region has been very competitive compared to in other parts of the world. All the data used for such assessments were retrieved from the Web of Science (WoS) database from 2003 to 2009. This is the first time that the research performances of ASEAN universities have been reported in discipline level, and discussed in relation to worldwide reference.

OBJECTIVES

The objectives of the study are twofold:

- a) To use the standard bibliometric indicators to measure research performance in terms of productivity and impact of the ASEAN countries and universities; and
- b) To compare the research performances of ASEAN countries and universities in the field of energy and fuel.

RESEARCH METHODOLOGY

Data Search, Retrieval and Processing

In this work, the assessment of the research performances for all ASEAN countries and selected ASEAN universities focused on the energy and fuel field. This field selection was preliminarily based on our studies on comparisons of publication volumes of scholars from different continents (Asiatic, Western and Eastern Europe, and North America) in the SCImago database during 1996-2008, as given in Figure 1. The preliminary results suggested that the publication volumes for researchers in the Asiatic region for the energy and fuel field were substantial and higher than those in other parts of the world, especially after 2003 onwards. In addition, the energy and fuel field is more applicable to the characteristics and environments of Asian countries, but surprisingly has been neglected by other existing research rankings (Williams and Van Dyke 2008; ARWU 2010; HEEACT 2010; PRWU 2010; SUR 2010; THES 2010). The ten ASEAN countries used in this study were Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic (Laos), Malaysia, Myanmar, the Philippines, Thailand, Singapore, and Vietnam. It should be noted that, since there were no publications related to the energy and fuel field in the WoS database during 2003-2009 for Laos and Myanmar, these two countries were automatically excluded from this study. In terms of university level, only those ASEAN universities that had a reasonable number of publications and citations in the WoS database during 2003-2009 were selected and used for such research performance evaluation. Only research articles, reviews, short communications and letters were considered.

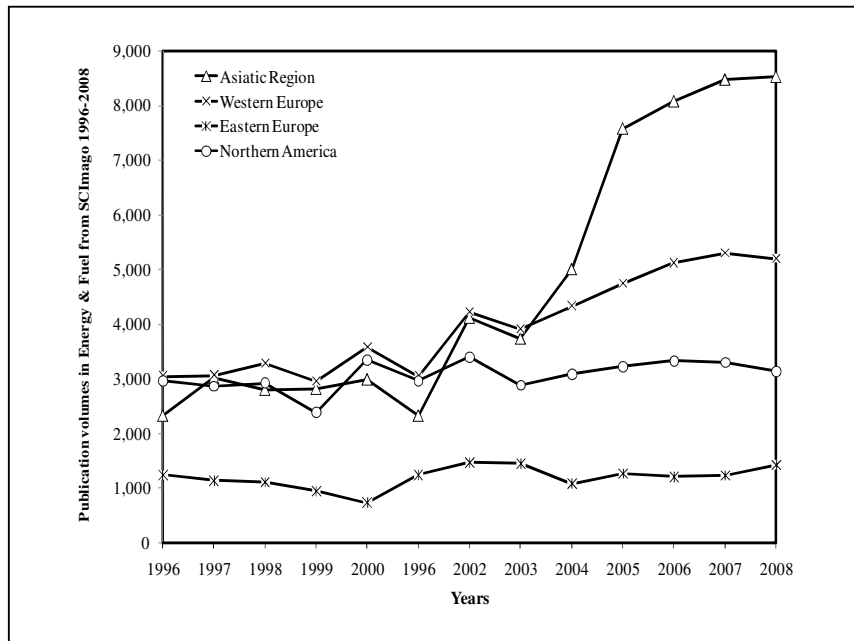


Figure 1: Comparisons of Publication Volumes of Researchers Indexed by SCImago

In this work, published articles and their citations were searched and retrieved via “Advanced Search” from the WoS database using “year” and “country name”, then “research field”, and then “university name” under the selected publication period (year span), all the data being retrieved as of March 10th, 2010. All the data during 2003-2009 were transferred into a spreadsheet application for further sorting and processing and the categorization was made by country and by university. The research performance evaluations were carried out for all ASEAN countries and the selected universities for three evaluation years from 2007 to 2009 using the data from 2003 to 2009, i.e., the number of published articles and citations for each evaluation year were obtained by summing up the number of published articles and citations during the past five years. For example, the number of published articles for country (or university) X in the evaluation year of 2009 were obtained from the total number of articles published from 2005 to 2009, and the total citations of the published articles during 2005-2009. This calculation method was also applied to sorting and processing the data for the evaluation years of 2007 and 2008.

Metrics for Research Performance Evaluation

This work made use of the data on publications and citations of the selected universities related to the energy and fuel field, and the data were then processed and calculated so that the productivity and impact of the ASEAN countries and universities could be compared and discussed both qualitatively and quantitatively in relation to worldwide reference, and for field-normalized impact. To achieve this, the standard bibliometric indicators proposed by Van Raan (2003) were used and such indicators are listed below;

- a) Number of published articles during the past five years (P)
- b) Total number of citations during the past five years, excluding self-citations (C)
- c) Citation per publication (CPP)
- d) Percentage of non-cited articles ($\%Pnc$)

- e) Average (mean) journal citation score (*JCSm*) for journal-based worldwide reference, which was defined as the average citation rate of all papers (worldwide) in the journals in which the country or university has published.

$$JCSm = \frac{\text{Citation of all papers (worldwide) in the journals within the field of energy and fuel in which the country or university has published}}{\text{Number of papers (worldwide) in the journals within the field of energy and fuel in which the country or university has published}}$$

- f) Average (mean) field citation score (*FCSm*) for field-based world-wide reference, which was defined as the citation rate of all papers (worldwide) published in all journals within the energy and fuel field.

$$FCSm = \frac{\text{Citation of all papers (worldwide) published in all journals within the field of energy and fuel}}{\text{Number of papers (worldwide) published in all journals within the field of energy and fuel}}$$

- g) *h-index* for published articles during the past five years; *h-index* is defined that a scientist has index *h* if *h* of his *N* papers have at least *h* citations each, and the other (*N-h*) papers have no more *h* citations each (Hirsch 2005)

RESULTS AND DISCUSSION

Bibliometric Analysis by Countries

As mentioned earlier, Laos and Myanmar did not have publications in the energy and fuel field during 2003-2009. Therefore, the research performances of only eight (out of ten) ASEAN countries were assessed, and comparatively discussed in relation to worldwide reference. Table 1 shows the bibliometric analysis of the eight ASEAN countries in alphabetical order for the field of energy and fuel indexed in the WoS database during 2003-2009. The results show that Thailand had the highest publication volume (*P*), followed by Singapore, Malaysia and the Philippines, respectively. Brunei Darussalam and Cambodia had relatively low publications. However, Singapore took the lead in receiving higher citations (*C*) during the same period, followed by Thailand and Malaysia. When considering the citation per publication (*CPP*), it was found that Singapore came first, followed by Malaysia and Thailand. Again, Brunei Darussalam and Cambodia showed very low *CPP* values. Looking at the percentage of non-cited articles (*%Pnc*), it was observed that among the eight ASEAN countries, there was a range of 15-50% of published articles that were never cited during 2003-2009. This *%Pnc* range was found to be much higher than that reported by van Raan (2003) who studied this kind of bibliometric analysis for German medical research institutes. Cambodia had zero non-cited articles. This data was invalid because of the exceptionally low number of published articles (only two articles during 2003-2009). The mean Journal Citation Score (*JCSm*) values for the eight ASEAN countries were very similar, ranging between 4.05 and 5.55. This suggests that these ASEAN countries probably had used similar groups of journals within the energy and fuel field.

Table 1: Bibliometric Analysis for Eight ASEAN Countries in the Field of Energy and Fuel during 2003-2009.

BRUNEI DARUSSALAM										
Years	P	C	CPP	%Pnc	JCSm	FCSm	CPP/JCSm	CPP/FCSm	JCSm/FCSm	h-index
2003-2009	6	15	2.50	50	4.05	4.69	0.62	0.53	0.86	2
2003-2007	3	7	2.33	33	2.03	1.77	1.15	1.32	1.15	2
2004-2008	2	5	2.50	50	2.57	2.79	0.97	0.90	0.92	1
2005-2009	4	7	1.75	50	3.20	3.64	0.55	0.48	0.88	1
CAMBODIA										
Years	P	C	CPP	%Pnc	JCSm	FCSm	CPP/JCSm	CPP/FCSm	JCSm/FCSm	h-index
2003-2009	2	6	3.00	0	5.39	4.69	0.56	0.64	1.15	1
2003-2007	1	2	2.00	0	3.71	1.77	0.54	1.13	2.10	1
2004-2008	1	3	3.00	0	3.71	2.79	0.81	1.08	1.33	1
2005-2009	2	6	3.00	0	5.39	3.64	0.56	0.82	1.48	1
INDONESIA										
Years	P	C	CPP	%Pnc	JCSm	FCSm	CPP/JCSm	CPP/FCSm	JCSm/FCSm	h-index
2003-2009	60	243	4.05	43	5.55	4.69	0.73	0.86	1.18	9
2003-2007	31	61	1.97	48	1.88	1.77	1.05	1.11	1.06	5
2004-2008	43	103	2.40	49	3.22	2.79	0.74	0.86	1.15	7
2005-2009	47	138	2.94	51	4.28	3.64	0.69	0.81	1.18	5
MALAYSIA										
Years	P	C	CPP	%Pnc	JCSm	FCSm	CPP/JCSm	CPP/FCSm	JCSm/FCSm	h-index
2003-2009	311	1,529	4.92	30	5.19	4.69	0.95	1.05	1.11	18
2003-2007	175	377	2.15	47	1.89	1.77	1.14	1.22	1.07	9
2004-2008	203	629	3.10	41	3.05	2.79	1.02	1.11	1.09	12
2005-2009	257	1,034	4.02	35	4.06	3.64	0.99	1.11	1.12	16
PHILIPPINES										
Years	P	C	CPP	%Pnc	JCSm	FCSm	CPP/JCSm	CPP/FCSm	JCSm/FCSm	h-index
2003-2009	34	127	3.74	24	4.67	4.69	0.80	0.80	1.00	6
2003-2007	25	33	1.32	56	1.98	1.77	0.67	0.75	1.12	4
2004-2008	21	53	2.52	33	2.60	2.79	0.97	0.90	0.93	4
2005-2009	18	60	3.33	33	4.80	3.64	0.69	0.92	1.32	6
SINGAPORE										
Years	P	C	CPP	%Pnc	JCSm	FCSm	CPP/JCSm	CPP/FCSm	JCSm/FCSm	h-index
2003-2009	382	2,893	7.57	26	5.54	4.69	1.37	1.61	1.18	26
2003-2007	233	833	3.58	40	2.04	1.77	1.75	2.02	1.15	14
2004-2008	280	1,310	4.68	35	3.29	2.79	1.42	1.68	1.18	17
2005-2009	314	1,894	6.03	39	4.33	3.64	1.39	1.66	1.19	23
THAILAND										
Years	P	C	CPP	%Pnc	JCSm	FCSm	CPP/JCSm	CPP/FCSm	JCSm/FCSm	h-index
2003-2009	501	2357	4.70	28	5.39	4.69	0.87	1.00	1.15	19
2003-2007	277	528	1.91	49	2.04	1.77	0.93	1.08	1.15	9
2004-2008	338	932	2.76	40	3.19	2.79	0.86	0.99	1.14	12
2005-2009	422	1592	3.77	32	4.13	3.64	0.91	1.04	1.13	16
VIETNAM										
Years	P	C	CPP	%Pnc	JCSm	FCSm	CPP/JCSm	CPP/FCSm	JCSm/FCSm	h-index
2003-2009	26	115	4.42	15	4.96	4.69	0.89	0.94	1.06	7
2003-2007	21	19	0.90	67	2.26	1.77	0.40	0.51	1.28	3
2004-2008	18	30	1.67	56	2.89	2.79	0.58	0.60	1.04	3
2005-2009	22	106	4.82	14	3.92	3.64	1.23	1.32	1.08	7

In order to assess and compare the research performances of the ASEAN countries in comparison to the international average, the $CPP/JCSm$ and $CPP/FCSm$ were considered. According to the work by van Raan (2003, 2006a), if the ratio of the $CPP/JCSm$ or $CPP/FCSm$ is above 1.0, the citation rate and the impact of the publication exceed the field-based world average. The results in Table 1 indicate that Singapore had $CPP/JCSm$ and $CPP/FCSm$ values of 1.37 and 1.61, respectively. This suggests that the research performance of Singapore exceeded the worldwide average reference. Malaysia, Thailand and Vietnam had $CPP/JCSm$ and $CPP/FCSm$ values around 1.0 (between 0.90 and 1.05), suggesting that they were positioned at the worldwide average. In order to evaluate the prestige of the journals in the energy and fuel field used by ASEAN scholars, the ratio of $JCSm/FCSm$ was considered. It was noted that although Singapore had the highest $CPP/JCSm$ and $CPP/FCSm$ values, its $JCSm/FCSm$ value was very similar to those for the rest of the ASEAN countries, except for Brunei Darussalam. It could be stated that there was no difference in choosing the journals to publish research works among most of the ASEAN countries, but that the publications from Singaporeans most likely receive more citations than other ASEAN scholars. This was found to be true when considering the citation counts (C).

Having considered the growth of the publication and impact of the research works from the evaluation years of 2007 to 2009, it was clearly found that for all ASEAN countries, the number of publications (P), citations (C) and citation per publication (CPP) increased, together with a progressive decrease in the percentage of non-cited articles ($\%Pnc$) for the evaluation years from 2007 to 2009. This indicated that the research performance for the ASEAN countries has improved both quantitatively and qualitatively. Relative to worldwide reference, the $CPP/JCSm$ and $CPP/FCSm$ values for almost all ASEAN countries, except for Vietnam, declined or slightly changed with time.

Bibliometric Analysis by Universities

In this section, the research performance of ASEAN scholars was assessed at the university level. It should be noted that only some universities that had published above 20 articles during 2003-2009 were selected. This was because universities with too small a number of publications would produce unrealistic values of $CPP/JCSm$ and $CPP/FCSm$. For example, a university that published only 3 articles (P) with 30 citations (C) would have an excessively high CPP value (equal to 10). Such values were invalid due to the fact that these values had come from a small number of journals as compared to the whole set of journals in the energy and fuel field.

Table 2 shows the bibliometric analysis for the selected ASEAN universities from Malaysia, Thailand, and Singapore in the field of energy and fuel during 2003-2009. In general, the results show that NTU (Singapore), NUS (Singapore) and KMUTT (Thailand) were the top three universities in the ASEAN countries that had the highest publication volumes and total citations. However, NTU and NUS from Singapore obtained exceptionally high values of CPP at around 4.00. When considering the $\%Pnc$ value, the two universities in Singapore had a $\%Pnc$ of 33-35%, while those in Thailand had a $\%Pnc$ of 30-53% and those in Malaysia 42-80%. Higher $\%Pnc$ values usually refer to lower qualities of published articles.

Table 2: Bibliometric Analysis for Eight ASEAN Universities in the Field of Energy and Fuel

Evaluation for Year 2007 (2003-2007)								
Institutes	P	C	CPP	%Pnc	CPP/JCSm	CPP/FCSm	JCSm/FCSm	h-index
Malaysia								
USM	43	125	2.91	42	1.32	1.64	1.24	7
UM	40	79	1.98	55	0.92	1.12	1.21	6
UKM	20	43	2.15	40	1.07	1.21	1.14	4
UTM	15	14	0.93	80	0.52	0.53	1.01	2
UPM	13	28	2.15	54	0.96	1.22	1.27	3
Singapore								
NTU	103	412	4.00	35	1.69	2.26	1.34	11
NUS	99	392	3.96	33	2.19	2.24	1.02	11
Thailand								
KMUTT	94	157	1.67	53	0.71	0.94	1.33	6
AIT	54	127	2.35	43	0.92	1.33	1.45	4
CU	49	119	2.43	49	0.97	1.37	1.41	6
TU	29	63	2.17	38	1.08	1.23	1.14	5
CMU	20	40	2.00	30	0.78	1.13	1.45	4
Evaluation Year of 2008 (2004-2008)								
Institutes	P	C	CPP	%Pnc	CPP/JCSm	CPP/FCSm	JCSm/FCSm	h-index
Malaysia								
USM	55	217	3.95	35	1.05	1.41	1.35	8
UM	40	146	3.65	35	0.97	1.31	1.35	8
UKM	19	71	3.74	32	0.85	1.34	1.57	5
UTM	18	27	1.50	61	0.40	0.54	1.36	2
UPM	16	67	4.19	31	0.97	1.50	1.55	6
Singapore								
NTU	131	631	4.82	32	1.26	1.73	1.37	13
NUS	112	600	5.36	29	1.66	1.92	1.16	12
Thailand								
KMUTT	115	335	2.91	40	0.79	1.04	1.33	10
CU	72	302	4.19	38	1.05	1.50	1.43	9
AIT	48	96	2.00	31	0.66	0.72	1.09	5
TU	34	119	3.50	24	0.94	1.25	1.33	6
CMU	21	63	3.00	52	1.03	1.08	1.04	3
Evaluation Year 2009 (2005-2009)								
Institutes	P	C	CPP	%Pnc	CPP/JCSm	CPP/FCSm	JCSm/FCSm	h-index
Malaysia								
USM	76	370	4.87	22	0.95	1.34	1.40	9
UM	48	188	3.92	31	0.82	1.08	1.32	7
UKM	26	120	4.62	58	0.89	1.27	1.43	5
UTM	20	39	1.95	60	0.40	0.54	1.35	3
UPM	19	94	4.95	37	0.93	1.36	1.46	5
Singapore								
NTU	146	927	6.35	24	1.31	1.74	1.34	16
NUS	129	852	6.60	29	1.48	1.81	1.23	16
Thailand								
KMUTT	144	568	3.94	32	0.84	1.08	1.29	11
CU	103	536	5.20	32	1.10	1.43	1.30	12
AIT	48	167	3.48	21	0.87	0.96	1.10	6
TU	33	111	3.36	27	0.71	0.92	1.31	7
CMU	28	98	3.50	39	0.92	0.96	1.04	5

Key:

No.	Full name	Abbreviation	Country
1	Universiti Kebangsaan Malaysia	UKM	Malaysia
2	Universiti Malaya	UM	Malaysia
3	Universiti Putra Malaysia	UPM	Malaysia
4	Universiti Sains Malaysia	USM	Malaysia
5	Universiti Teknologi Malaysia	UTM	Malaysia
6	Nanyang Technology University	NTU	Singapore
7	National University Singapore	NUS	Singapore
8	Asian Institute of Technology	AIT	Thailand
9	Chiang Mai University	CMU	Thailand
10	Chulalongkorn University	CU	Thailand
11	King Mongkut's University of Technology Thonburi	KMUTT	Thailand
12	Thammasat University	TU	Thailand

In order to evaluate and compare the research performances among the selected ASEAN universities in relation to worldwide reference, the *CPP/FCSm* for the selected ASEAN universities were considered. For better comparison, the *CPP/FCSm* values for ASEAN universities for the evaluation years of 2007, 2008 and 2009 are given in Table 2. According to van Raan (2003), a *CPP/FCSm* value of 0.8-1.2 indicates an average international impact for a given field. A *CPP/FCSm* value of greater than 1.2 means that the research performance is regarded to be above the world impact standard, while scores of less than 0.8 indicates that the research performance is below such standard. The results suggest that the research performances of NTU and NUS from Singapore in the evaluation year 2007 were far above the world impact standard, but the performance slightly dropped in the evaluation years of 2008 and 2009. Those considered to have research performances just above the international impact standard included CU (Thailand), TU (Thailand), USM (Malaysia), UPM (Malaysia) and UKM (Malaysia). The rest of the ASEAN universities were classified as ranking below the world standard. The research performance evaluation for UTM (Malaysia) was found to be far below the world impact standard.

h-index

The *h-index* has been increasingly accepted as a useful tool for research performance assessment especially at the micro-level, such as the research performance of an individual researcher, department, faculty or university (Hirsch 2005; Tijssen et al. 2009; Rao and Srivastava 2010). The values of *h-index* for the selected ASEAN universities in the energy and fuel fields for the evaluation years of 2007, 2008 and 2009 are also reported in Table 2. It can be seen that the greatest *h-index* values were observed for NTU and NUS from Singapore, the *h-index* ranging from 11 to 16 for the evaluation years from 2007 to 2009. The *h-index* values for NTU and NUS were very similar to each other, and found to improve with time. Changes in the *h-index* over time were also the case for the rest of the Thai and Malaysian universities, but at a slower rate of the *h-index* improvement. The *h-indexes* for Thai and Malaysian universities ranged from 3 to 11 and from 2 to 9, respectively.

Figure 2 and 3 show the relationship between the values of *h-index* and the total number of publications and citations respectively for the selected ASEAN universities for three evaluation years (2007-2009). It can be seen that the *h-index* values, in general, correlated with those for number of publications (Figure 2) and total citations (Figure 3), but the correlation was more apparent and pronounced with the total citations.

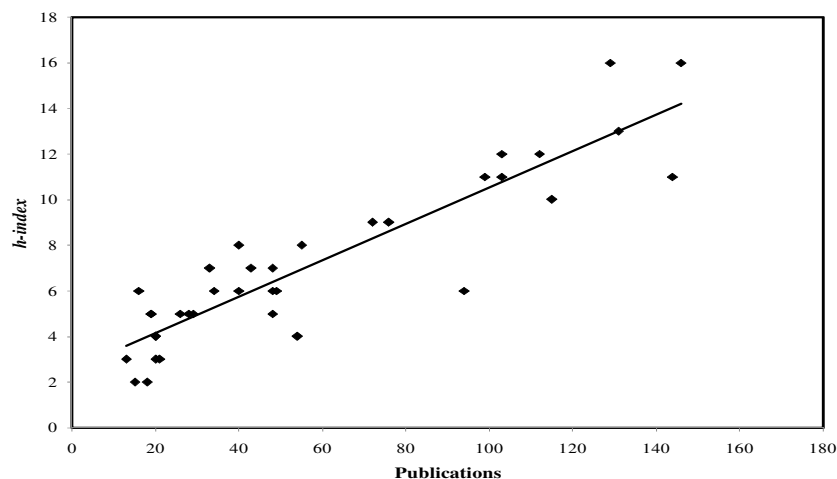


Figure 2: *h-index* versus Total Number of Publications for ASEAN universities: 2007-2009

This view was in good agreement with van Raan (2006a). Having considered the correlation of *h-index* with other citation-based indicators (*CPP*, *CPP/JCSm* and *CPP/FCSm*) in Table 2, the results suggest that these correlations are very poor. This was expected since the *h-index* values for the selected ASEAN universities were very low (mostly less than 10). This explanation is in line with that given by van Raan (2006a) who stated that the *CPP/FCSm* indicator would have a good correlation with the *h-index* only for those research units with high *h-index* and peer review judgment, and by Norris and Oppenheim (2010) who stated that there was a good correlation between the *h-index* and peer review judgment for the academic rankings for 100 international scholars in Library and Information Science.

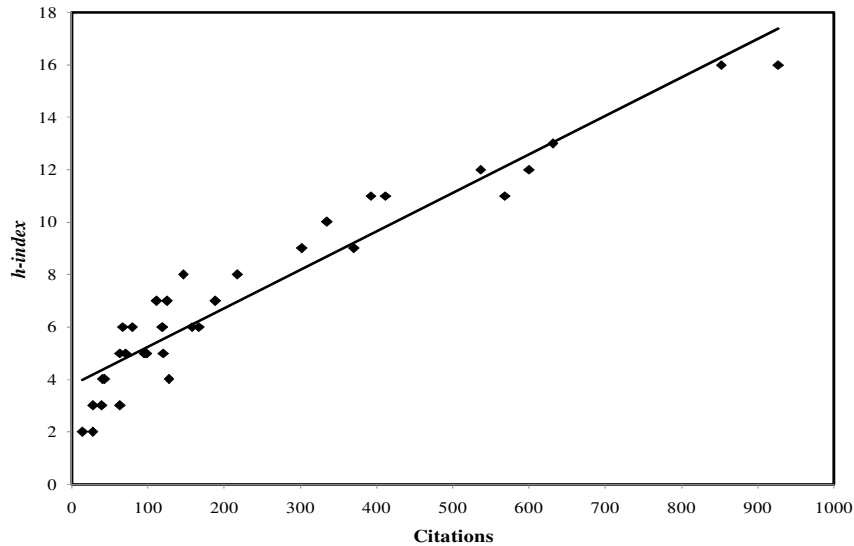


Figure 3: *h-index* versus Total Number of Citations for ASEAN universities: 2007-2009

CONCLUSION

The research performances in energy and fuel field for all ASEAN countries and universities were assessed, revealed and discussed in comparison to international reference. These findings were noted:

- a) Thailand had the highest publication volume whereas Singapore took the lead in receiving the highest total citations and citations per publication.
- b) The average value of non-cited articles for the selected ASEAN countries was 15-50% of the published articles.
- c) The results suggested that all the selected ASEAN countries published their research works in a similar group of journals in the energy and fuel field.
- d) Singapore had the *CPP/JCSm* and *CPP/FCSm* values of 1.37 and 1.61, respectively, indicating their research performance to be above worldwide reference. Malaysia, Thailand and Vietnam had *CPP/JCSm* and *CPP/FCSm* values of around 1.0. The research performance of scholars in ASEAN countries had improved from the years 2007 to 2009.
- e) Among ASEAN universities, NTU (SG), NUS (SG) and KMUTT (TH) were the top three universities in the ASEAN countries that had the highest publication volumes and total citations. With regard to *CPP/FCSm* values, the research performances of NTU and NUS from Singapore were far above the world impact standard.

- f) NTU and NUS from Singapore yielded the greatest *h-index* value of 16 for the evaluation year of 2009. The values of *h-index* for ASEAN universities had a closer correlation with total citations than other indicators. No linear relationship between the *h-index* and *CPP/FCSm* values was observed.

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