A causational analysis of scholars' years of active academic careers *vis-à-vis* their academic productivity and academic influence[①]

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Abstract   Taking the scholarly activities of 73 doctoral program mentors working at the Chinese Academy of Medical Sciences & Peking Union Medical College (the CAMS & PUMC) as a sample of our investigative survey, we tried using such statistical methods as the analysis of variance (ANOVA), factor analysis and correlation analysis to compare the different characteristics of scholarship assessment of Chinese medical scholars as exhibited in their published papers in domestic and foreign journals. Our research findings show that citations per paper and A-index are more suitable for assessing the highly accomplished senior Chinese medical professionals (e.g. academicians) for their domestic and international scholarship attainment. In contrast, the m-quotient is not deemed appropriate to assess their academic influence both at home and abroad. Upon our further analysis of 6 evaluative indicators, we noticed that these indicators might be applied in two different aspects: One is from the viewpoint of Chinese scholars' academic influence at home, which has been evaluated mainly from the perspective of "total" amount and "average" amount of both publications and citations. The other is from their academic impact embodied by the means of documents retrieved from the Web of Science, which is mainly assessed from the two viewpoints of publications and citations. It is suggested that the accumulated time-length of a given scholar's active engagement in professional practice in a specific subject area be taken into consideration while assessing a researcher's performance at home and abroad.

Keywords   Research performance, Mentor of doctoral program, Length of active academic careers, h-index, Citation analysis

1   Introduction

As generally recognized by scholars at present, applied bibliometric indicators are widely used and accepted for the assessment of scholarship achievements at the

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institutional level (i.e. national, regional, organizational, etc). However, using the same criteria to measure the scholarship attainment at the level of individual scholars or research teams is either untenable or controversial due to the complicated discretional nature of such assessment as well as the inherent deficiencies of those adopted evaluative indicators[1–2]. The fact is that all indicators for scholarship measurement including the recently proposed h-index or g-index have their own inherent shortcomings, if the scholarship measurement operation is based only on a single indicator. It is unscientific for such a way of application and should be carefully avoided[3]. Thus, the combined use of several indicators is alternatively recommended[4]. As of date, approaches to the combined use of bibliometric indicators for the measurement of scholarship attainment of individual scholars or research teams has not yet been clearly established. In addition, there is no further literature evidence for the substantiation of such practice.

As a result, it makes the situation look more complicated for an explication, especially when the above mentioned evaluative indicators are integrated into the factor of the length of active academic careers for the evaluation of a scholar's scholarship attainment. Generally speaking, the more intellectually productive that the author is, the higher the number of the total citations and h-index that this author receives. In fact, when Hirsch proposed the h-index as a scholarship attainment evaluator in 2005, he also pointed out that if the h-index is divided by the time frame of an individual scholar's academic engagement (or professional practice) in a particular subject field, it could reveal the scholar's record of scholarly productivity[5–6].

Concerning the effects of the time span of a scholar's academic life in relation to that individual's scholarly productivity and intellectual impact, we have noticed several recent studies that have given indications to the element of the time-length that a scholar has entered into the professional practice are of paramount importance to that scholar's academic performance. For example, Falagas & Ierodiakonou pointed out that biomedical scientists' research productivity declines with their age advancement[6]. Costas & van Leeuwen found that the number of a researcher's publications measured at 5-year intervals corresponds to an inverted U-shape curve in the fields of Biology & Biomedicine. It showed that a researcher's scholarly productivity has "initially increased, then decreased"[7]. Cronin & Meho suggested that the creativity of researchers does not decrease with their aging process. Instead, creativity is expressed in several different ways, at different times, and with different intensities.

It has been argued that the establishment of incentive policies for researchers at different stages of their professional career can effectively sustain the rate of their scholarly productivity throughout their entire tenure of academic life[8]. Using

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information retrieved from Web of Science about 145 preliminary co-opted candidates of academicians of the Chinese Academy of Sciences (CAS) in 2007 as their sample of study, Lei & Chen argued that there is no significant correlation between age advancement *vis-à-vis* the screening process of the h-index. They also pointed out the failure caused by applying h-index in evaluating Chinese leading scientists' research performance and their academic influence[9].

The purpose of this paper is to shed light on the issues involved for the evaluation of scholarship attainment of individual scholars in a given subject field by means of combining those various applicable evaluative indicators. We used an improved method by classifying those evaluative indicators for the assessment of individual scientists' research performance. We chose 73 doctoral program mentors working at the CAMS & PUMC and took their time-length in active professional practice as the controlled variable. The level of these mentors' scholarship attainment was measured by each of their years in active professional practice, and our investigation was confined to the period of a given scientist's first and last publication year. We finally analyzed the differences of these scientists' publishing preference/behavior through an examination of their published articles in domestic and foreign journals.

2 Methods

2.1 Sample selection

Considering that the h-index and the h-type indices are not suitable for evaluating academic influence of those scientists with shorter time-length of professional engagement, we selected those doctoral program mentors who have had a long-term research experience as our sample for study. There are altogether 423 doctoral program mentors currently working at the CAMS & PUMC. We noticed that it was quite confusing to detect their real name when these authors publish their SCI papers in English.

For example, Sun & Zhou studied how Chinese authors designated their names when they published papers in English either in Chinese or in foreign biomedical journals. Their result revealed that these authors practically followed different conventions in designating their names arbitrarily regardless of the journal's own name-authority specifications, if any[10]. Mentors with only two Chinese characters in their names would cause added confusion due to the various transliteration of their first name and last name, etc. Therefore, we decided to have their names completely removed from our name list of research poll selection and resulted in the selection of 73 doctoral mentors whose names contained only three Chinese characters in their published papers.

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In order to ensure the accuracy of data used in this study as much as possible, we retrieved those scientists' papers from various relevant databases taking into consideration of their educational background and work experience. We then checked our search results one by one manually according to each author's primary institutional affiliation and subject specialty.

2.2 Data source

For those papers that were published by the above mentioned mentors in domestic journals, we retrieved them from SinoMed, China National Knowledge Infrastructure (CNKI) and WanFang Databases, respectively. Citation data were obtained from Chinese Citation Database, which is included by CNKI and Chinese Science Citation Database (CSCD). For these same mentors' papers and their paper citations published in foreign journals, we retrieved them from Science Citation Index Expanded (SCI-E). In addition, we also factored Journal Citation Report (JCR, 2009 Version) into our consideration, which provided the impact factor of all high-frequency cited journals.

2.3 Evaluation indicators

Based on the above search results, several assessment indicators, such as the number of articles, total citations, citations per paper, h-index, A-index, g-index and m-quotient were used to assess the 73 doctoral mentors' domestic and international academic influence.

- h-index.   In 2005, Hirsch proposed a new research performance indicator named h-index. It denotes that among all the papers that an author has published, at least the h amount of these published papers have been cited h times[11]. Compared with traditional citation evaluation indicators, h-index incorporates both quantity and quality of a scientist's scientific output.
- g-index.   Egghe introduced a simple variant of the h-index, named g-index in 2006. A set of published papers are ranked hierarchically in a descending order according to the amount of citations that each paper has received. It has a g-index if g is the highest ranking paper which has at least g^2 citations. This also means that the other $g + 1$ papers have less than $(g + 1)^2$ citations. If there are N publications in total and N^2 is less than the sum of all citations, one adds fictitious articles with zero citations in order to determine the g-index. Compared with h-index, g-index is only sensitive to one or several outstanding and highly-cited papers[12].
- A-index.   A-index was introduced by Jin & Rousseau in 2007[13]. It is simply defined as the average number of citations received by the published papers,

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which have been included into the Hirsch core. The A-index mainly measures the average citation strength of the publications that have been included in the Hirsch core. It overcomes some stagnant nature of h-index such as lacking sensitivity to scholarly performance changes.

- m-quotient. M-quotient was introduced by Hirsch when he proposed h-index in 2005. It provides a useful yardstick to compare scientists' academic seniority status by dividing h-index on the basis of each scientist's tenure in their academic life[11].

3 Analysis of survey results

3.1 Academic seniority

In this dataset, all 73 doctoral mentors have their first academic papers published when they just graduated from university or began their graduate study. Fig. 1 shows the distribution of years of active academic careers of those doctoral mentors.
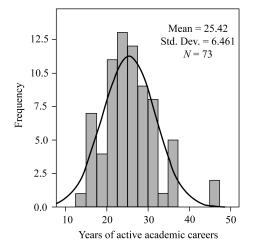

Fig. 1 Active academic engagement of our sampled doctoral mentors.

The time span of their academic life tends to have a normal distribution (Kolmogorov-Smirnov $Z = 1.102$, $p = 0.176 > 0.05$). The mean time span of a mentor's academic life is 25.42 years, in which the minimum length is 13 years and the maximum 46 years. We took the mean length of these mentors academic life (25 years) as the mid-point to formulate group divisions. Considering 5 out of 6 academicians of the CAS and/or Chinese Academy of Engineering (CAE) with an academic time span from 35 to 46 years, which accounts for ca. 10% of the sampled poll size, we assigned these mentors to a separate group who holds the longest record of academic life. In the mean time, we noticed that these academicians have

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the widest academic influence and are regarded as the most authoritative figures in their subject field of learning. The analysis of this group also reveals the critical element of time span of an individual scholar's academic life on his/her academic influence.

Parallel to this research finding, we also found that the youngest group with the time span of academic life of 13–17 years also accounts for about 10% of the sampled poll size. Taking 25 years as a yardstick of mid-point, we found that there are two other groups with a time span of academic life of 18–24 years and 25–34 years, both of which individually accounts for about 40% of the sampled poll size. The size value of these 4 groups is olive shaped, meaning it is bigger in the middle and smaller at both ends. It is in line with the characteristic of normal statistical distribution.

Table 1   Mentor groups formed by the different time-lengths of their active academic careers

Group	Active academic career/Year	Initial year of a mentor's academic research	N	Percentage (%)
Group 1	13–17	1994–1998	8	11.0
Group 2	18–24	1987–1993	28	38.4
Group 3	25–34	1977–1986	30	41.1
Group 4	35–46	1965–1976	7	9.6

3.2   The selection and classification of evaluative indicators

3.2.1   The selection of applicable evaluative indicators

We used ANOVA methods trying to find the different levels of academic performance among the above mentioned 4 mentor groups as reflected by the application of various evaluative indicators. The results showed that only the difference of "number of papers" retrieved from Chinese databases is remarkable ($p = 0.014 < 0.05$), the other six indicators, i.e., total citations, citations per paper, h-index, g-index, A-index, and m-quotient are not significantly remarkable for the papers retrieved from domestic databases ($p > 0.05$). Whereas for those papers published in international journals, the p-value of the seven indicators mentioned above is larger than 0.05 for these 4 mentor-groups. This indicates that the time span of academic life is of little significance in relation to the evaluative indicators. By means of h-index, Zhu analyzed the impact of the published research papers indexed by SCI of all researchers in an institute of resources environment at the Chinese Academy of Sciences (CAS), the result showed that the h-index is not significantly correlated to a researcher's age or his/her tenure of an academic life[14]. Our study confirms in part with Zhu's research results.

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Fig. 2 reveals that the published articles contained both in domestic and SCI/SSCI indexed journal databases showed an upward trend in terms of the paper output. With the age advancement of the academic engagement, the more senior the mentor is, the more papers he/she publishes. This is in line with the common phenomenon that the longer an academic career a mentor has, the more papers in domestic journals he/she has published. However, concerning the number of SCI/SSCI indexed journal papers, we found that the record of published articles of Group 4 is approximately the same as compared to Group 3. This research finding highlights a superior record of scholarly contributions made by Group 2 still in their junior years of academic career.
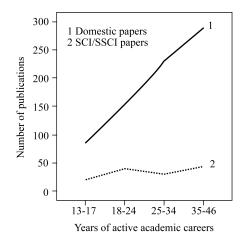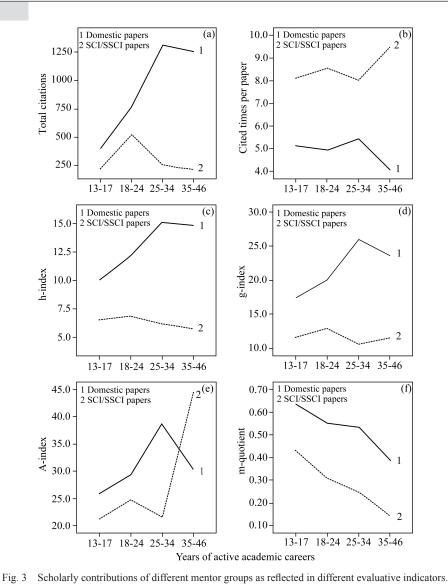

Fig. 2   Average number of published papers in domestic and foreign journals by different mentor groups.

Based on the above results derived from ANOVA, we can see clearly the scholarship attainment of each mentor group during their various stages in professional practice as reflected in the mean value of the following evaluative indicators. Concerning the montors' research performance at the indices of total citations, h-index and g-index (Fig. 3a, 3c and 3d), Groups 2 and 3 received the best academic performance at home and abroad, respectively, which are embodied by the means of documents retrieved from the above Chinese literature databases and the Web of Science.

The curve of article contribution to domestic journals shows a steady rise for Groups 1–3, but it declines for Group 4. However, in English language journal publications, the performance record is reversed. The curve shows a decline trend from Group 2. That is to say, the evaluation results are pretty consistent in terms of article contributions made by 4 mentor groups to both Chinese and English-language

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Fig. 3   Scholarly contributions of different mentor groups as reflected in different evaluative indicators.

journals. Therefore, we would like to use all these three indicators for the further analysis of the publishing record of all 4 mentor groups.

It should be noted that Group 4, who have engaged in their active academic careers for about 35–46 years, is unremarkable on the bases of the total citations, the h-index and the g-index (Fig. 3a, 3c–3d). It is worth mentioning that this mentor group is generally recognized as the most influential individuals in the medical scientific community in China. Their popular academic esteem in the scientific

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community is largely due to the average citations per paper that this group of mentors has received (Fig. 3(b)) and to the result of the A-index indicator, especially about those published papers that each has been cited by other scholars in the SCI/SSCI indexed journals (Fig. 3(e)). Since the A-index is highly-sensitive to the highly cited papers, the doctoral mentors in Group 4 probably have produced only a small amount of papers, but nevertheless, these papers normally have high academic regards and influence, which have been cited and studied by numerous other scholars in this field for a long lasting time. To some extent, the number count of citations of published papers as well as the A-index are more suitable for evaluating those mentor scientists with a high academic reputation.

The index of m-quotient takes into account the impact of the accumulated time span of a scholar's professional practice on the h-index. Fig. 3(f) shows that the m-quotient decreased significantly with the increase of time span of active academic commitment of the mentors in Group 4. In our study, most junior researchers have received higher screening results of the h- and g-indices than those of the senior scholars. In this case, it makes no sense to divide the h-index by the time-length that a scholar is actively engaged in professional work. As such being the case, the m-quotient is thus omitted.

3.2.2 Classification of indicators

From the perspective of scholarship attainment published both in Chinese- and English-language journals, we analyzed the academic performance of 73 doctoral mentors by means of six carefully selected evaluative indicators mentioned earlier for such tasks. The result of the factor analysis is shown in Table 2.

Table 2   Factor analysis: Rotated component matrix

	Domestic performance			International performance	
	F_1	F_2		F_3	F_4
Number of published papers	**.983**	−.003	Citations per paper	**.963**	.055
h-index	**.885**	.421	A-index	**.905**	.188
Total citations	**.844**	.473	Total citations	**.864**	.428
g-index	**.753**	.651	g-index	**.789**	.583
Citations per paper	.073	**.983**	Number of published papers	.069	**.966**
A-index	.528	**.823**	h-index	.618	**.732**

For domestic scholarship achievements of the 4 mentor groups, we have extracted two prime factors (F_1 and F_2). The number of published papers, the total citations, h-index and g-index all have weightier loadings on the prime factor F_1, and these

indicators refer to the "total number amount" of evaluative indicators. Meanwhile, citations per paper and A-index have larger loading on the prime factor F_2. In fact, both the average amount of citations per paper and the A-index are relevant to the "average amount". It indicates that domestic academic performance of these groups has been evaluated mainly from both the "total" and the "average" perspectives.

For the assessment of the international scholarship attainment of 4 mentor groups, we have also extracted two prime factors (F_3 and F_4). Such indicators as citations received per paper, A-index, the total number of article citations received by an author and g-index are all related to F_3.

In fact, g-index is proposed to compensate the limitations of h-index which is not sensitive to the number amount of "high value" and "long tail" article citations. By comparison, the number of published papers and the h-index have a stronger dependence on the number amount of papers that an author has published. This indicates that the evaluation of a mentor's article publication record in SCI/SSCI journals is mainly assessed from the following two criteria, i.e., "the total amount of article citations received by an author" and "the total amount of published papers by an author". In order to improve the international visibility and academic influence, many Chinese research institutions have developed a variety of incentive policies for Chinese scholars to publish their academic papers in well-known international scholarly journals (such as SCI-indexed journals), which makes the number of papers published in SCI indexed journals an important indicator for evaluating the academic attainment of researchers in China.

3.3 Characteristics of different mentor groups in their professional practice at home and abroad

In order to understand the causational relationship between a mentor's accumulated time-length in professional practice and such resulting effects for the scholarly output and academic influence, we took the time-length of active academic career as a control variable and analyzed the different academic behaviors among scholars in those four different mentor groups as reflected by the papers published in domestic and foreign journals. Fig. 4(a) shows that the record of article publication in domestic and foreign journals of these scholars coincides with the increase of time-length of their academic career. However, the academic impact-related indicators, such as h-index (Fig. 4(b)), A-index (Fig.5(a)) and g-index (Fig.5(b)) show discrepancies.

Furthermore, the the h-index also showed that the highest valued papers that published in domestic Chinese-language journals occurred when a mentor has had 33 years of professional experience. This finding is in concert with the common

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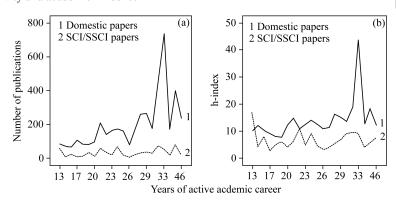
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Fig. 4   Distributions of the published papers (a) and h-index for different mentor groups (b).
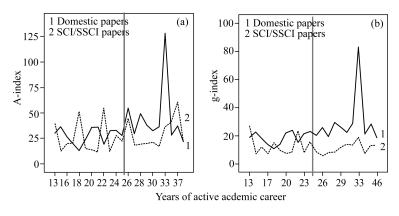

Fig. 5   The A-index (a) and g-index (b) analyses for different mentor groups.

phenomenon in Chinese academia, i.e., the longer the years of a scholar's active engagement in a profession, the higher an h-index he/she has. The highest h-index of international papers occurred with those scholars whose time-length of professional practice is relatively short, which reflects that scholars with lesser professional experience have, nonetheless, a better record of paper publication in SCI indexed journals to some extent (Fig. 4).

Fig. 5 shows that a record of 24-year professional experience is the cutoff point (shown as the middle line; the average time-length of professional life is 25 years in this dataset). The difference of scholarship attainment as measured by A-index and g-index for articles published in Chinese versus those published in English-language journals can divide the sampled polls into two components: Namely, the junior scholars and the senior scholars. Before the demarcating time-length of 24

years in professional practice, the A-index of the domestically published papers is at the peak whereas that of the internationally published papers is at the bottom scale. From 24 to 46 years of professional life, its peaks and valleys show a more consistent trend. In consideration of A-index, which only measures a small portion of the articles in the h-core for their average strength of citation occurrence and g-index is more sensitive to high-impact papers, we hold the view that the junior scholars whose professional life spans from 13 to 23 years can be divided into two subgroups: The one that pays more attention to having their papers published in international journals (thus paying less attention to domestically published journals), the other is just in the opposite practice of their papers published in domestic journals. In addition, those senior scholars whose academic life ranges from 24 to 46 years devote themselves equally to the task of writing articles for both domestic and foreign scientific journals in order to promote knowledge sharing and knowledge creation.

4   Discussion and conclusion

4.1   Effects of various time-lengths to scholars' research productivities

This paper has studied the characteristics of the doctoral mentors' scholarly output by dividing them into 4 different sampled groups based on their various tenure of academic life for a close examination. The scholarly performance of the group with the longest average professional life is reflected in its superior record in the "average impact" indicators, such as citations received per each published paper and the A-index. Compared with those scholars in lesser years of academic life, however, they do not necessarily have any significant advantage in terms of their record of scholarly productivity as reflected in the measurement process of such indicators as the total number of paper citations received, the h-index and the g-index. The reasons may be described as below:

- As researchers are growing older, they are increasingly involved in a wide range of administrative duties and curricular responsibilities (i.e. organizational administration, teaching, research assessment, project management, fund raising, tutoring students, etc.), which greatly have their time for academic research curtailed. It is only natural that their research performance is channeled through other means of scholarly communication such as books, book chapters, and internal reports, etc., other than journal articles as indexed by Web of Science database[7].
- Owing to historical factors, most Chinese scholars over 60 years old (such as many of the polled mentors under this study) took Russian, not English, as

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their first foreign language during their college years. Compared with the junior scholars, the senior scientists' record of article publication in SCI indexed journals is compromised by their English language writing deficiency, thus resulting their scholarly performance in the lower value ranking of the h-index and the g-index.

4.2 Applicability of scholarship assessment indicators for Chinese scholars

Compared with h-index and g-index, the indicators for average number of pertinent evaluation, such as citations per published paper and the A-index, are more suitable for assessing Chinese high-level academic achievers' research impact. In contrast, the m-quotient is not suitable for the evaluation of the scholarship attainment of these high-level academic achievers.

4.3 Differences of Chinese scholars' research performance at home and abroad

Young researchers can be divided into two categories: Those who focus on publishing their papers in SCI indexed journals and those who focus their attention more in having their research papers published in domestic journals. Contrary to the practice of young scholars, however, the senior scholars often give equal consideration for having their research papers published in either domestic or foreign language journals for exchange of new ideas and research findings. Thus, we should pay attention to the pivotal factor of the accumulated time-length of academic life in assessing these different group members for their true record of academic performance. In China, the age requirement for applying for a grant support from the National Science Foundation for Distinguished Young Scholars of China is currently set to be below the age of 45 years old[15].

4.4 Limitations of this study

This paper revealed a selecting and classifying method for using the evaluative indicators to assess a researcher's academic performance at the individual level. It also provides a theoretical foundation for an empirical exercise of evaluation. However, the sample selection in this study is mainly based only on the availability and convenience for us in having the data collected, verified and analyzed but at the expense of a random sampling. Furthermore, when calculating the citation number received by each and every author based on the 6 evaluative indicators, we simply used the citation number for a paper and failed to differentiate how those citation credits should be fairly distributed to the first author, the corresponding

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author, and perhaps several other supporting co-authors. It is of common sense to point out that if a paper has multiple authors, not all those authors' contributions are equal and not all of them should take full credit of the published work. Nevertheless, routinely every author of a published paper claims all citations to his or her own credit. SCI and Scopus both disregard author's academic rank and seniority when computing the total number of citations and the h-index of an author. Indeed, the measurement of scholarship for works by multiple authors is often adjudicated with an application of some arbitrarily selected evaluative indicators to the effect that it inadvertently inflicts damage to the credit system. This situation is becoming even more severe as the average number of article citations per each published paper by multiple authors continues to rise. An investigation on how to assign credit and the h-index fairly to multiple authors for their scholarship attainment based on the number of article citations that they received for each of their published work will be the new direction of our next research project.

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