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Schubert András

schuba@iif.hu

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A Hirsch-type index of co-author partnership ability

András Schubert
Institute for Research Policy Studies, Hungarian Academy of Sciences, Budapest, Hungary

Summary

The partnership ability index (φ) combines the number of co-authors and the times each of them acted as co-authors with a given author exactly the same way as Hirsch's h-index combines the number of publications and their citation rate. The index φ was tested on the sample of the Hevesy Medal awardees. It was found that φ is consistent with Glänzel's model of h-index, and that higher φ values – at least until a certain limit – may be accompanied with higher citation visibility (h-index). Some further possibilities of application both within and outside the area of scientometrics are suggested.

"...the isolated man does not develop any intellectual power.
It is necessary for him to be immersed in an environment of other men..."
[Alan Turing]

Introduction

What Alan Turing has formulated so clearly more than 60 years ago, appears to be truer than ever nowadays. If Garvey (1979) wrote about "Communication: The Essence of Science", we can speak now about "collaboration: the essence of science". The quantitative study and assessment of scientific activity (i.e., scientometrics) must, therefore, focus its attention much more on the connections among individual actors than on the individual actors themselves.

Techniques of network analysis, centrality and other network-based indicators became part of the standard toolkit of scientometrics, mentioning Abassi et al. (2010) or Guns et al. (2011) just as examples from the recent literature.

The h-index was originally introduced by Hirsch (2005) to "quantify an individual's scientific output". It was shown, however, that indices built on a same basis can effectively be used to characterize networks and network elements both within the realm of scientometrics and in completely different areas (Korn et al., 2009; Schubert et al., 2009). Recently, Zhao et al. (2011) proposed a new framework based on the concept of 'h-degree' that leads to a new set of indicators characterizing nodes in a network. The basic idea of the present paper fits into this framework. The mathematical nature of the h-index was illuminated by Glänzel (2006); suggesting also an embarrassingly simple relation between the h-index and – in the original citation frequency representation – the number of publications and the citation rate per paper.

In this paper, the h-index concept is used to define a measure of a social feature that is, as outlined above, of utmost importance also in the enterprise of science: the ability of creating and maintaining effective partnerships for joint activity. This feature will be called "partnership ability".

Definition and basic properties of the indicator

The partnership ability index will be denoted by φ (PHI for PartnersHIp).

An actor is said to have a partnership ability index φ, if with φ of his/her n partners had at leas t φ joint actions each, and with the other (n–φ) partners had no more than φ joint actions each.

In the most obvious scientometric example, "joint action" means joint authorship, i.e., an author is said to have a co-author partnership ability φ, if with φ of his/her n co-authors had at least φ joint papers each, and with the other (n–φ) co-authors had no more than φ joint papers each.

The basic properties of the indicator are analogous with those of the 'classical' h-index.

The partnership ability is 0 if and only if the author had only single-authored papers.

The partnership ability is 1 (a) if the author had an arbitrary number of double-authored papers with the very same co-author each, OR (b) if the author had an arbitrary number of co-authored papers with no co-authors occurring more than once.

In all other cases, the partnership ability is an integer larger than 1.

Apparently, cases (a) and (b) represent two diametrically opposing extremes in behavior: perfect monogamy vs. total promiscuity. On the other hand, both cases represent a kind of dysfunction in (a) creating, (b) maintaining co-author partnership. Whether one can find one or more optimal scheme(s) between the two extremes is a delicate question worth studying.

An empirical study: the Hevesy Medal awardees

Background and data sources

The George Hevesy Medal Award is the premier international award of excellence to honour outstanding achievements in radioanalytical and nuclear chemistry.

Founded originally in 1968 by Tibor Braun, the Editor-in-Chief of the Journal of Radioanalytical and Nuclear Chemistry (JRNC), the Hevesy Medal Award has been given in recognition of excellence through outstanding, sustained career achievements in the fields of pure and applied nuclear and radiochemistry, particularly applications to nuclear analytical chemistry.

From 1968 till 2011, 34 outstanding researchers were awarded with the medal. They formed the sample of the present study.

For all of them, their publication list for the period 1975–2011 was compiled from the Thomson–Reuters' Web of Science database together with their summary citation records. Efforts were made to clean the data in the sense that different name variants were merged, and homonyms were attempted to be separated. The cleaning procedure extended only for the name variants in the case of the co-authors.

The data

Table 1 contains the main bibliometric data of the awardees in alphabetic order. Some of the earliest awardees had no or just minimal publication activity after 1975, nevertheless, all what found was included in the analysis.

Table 1 Bibliometric data of the Hevesy Medal awardees

Results

Based on a mathematical interpretation of the h-index, Glänzel (2006) suggested a simple relation among the h-index, h, the sample size (in the 'classical' Hirsch representation, the number of publications, n) and the density (mean citation rate per paper, x):

$$h = c \cdot n^{1/3} x^{2/3},$$

where c is a positive constant of the order of 1.

Supposing that the presumptions of Glänzel's model hold also in the co-authorship example, an analogous relation might be expected among φ, a (the total number of co-authors) and z (the mean number of occurrence of the co-authors):

$$\varphi = c \cdot a^{1/3} z^{2/3},$$

Figure 1 shows the fit between the theoretical and empirical values. A fairly strong correlation and a slope rather close to 1 clearly provides a strong support for the validity of Glänzel's model also in this case. This implicitly means that the distribution of the number of partners (co-authors) follows a Zipfian (inverse power) law. This is well in accord with the 'preferential attachment' model of the generation of co-authorship networks (Barabási et al., 2002).

Figure 1. The theoretical (φ*) and the empirical (φ) values of the partnership ability of the Hevesy Medal awardees

An even more subtle question is whether the so defined indicator has any relation with other scientometric characteristics. Figure 2 shows the relation between the partnership ability index (φ) and the citation h-index in the sample under study. In the full sample (full plus empty circles; dashed regression line), there is an obvious, although not very strong correlation between the indicators. If, however, the points representing the three outlying highest φ values are disregarded, the strength of the correlation increases dramatically (full circles, solid line). A possible interpretation is that higher collaboration activity (as measured by φ) is accompanied by higher citation visibility (as indicated by the h-index) up to a certain limit, after which its effect lessens. This hypothesis, however, should be supported by further studies.

Figure 2. Relation between the partnership ability index (φ) and the citation h-index of the Hevesy Medal awardees

Discussion

The partnership ability index (φ) introduced in this paper gives an additional dimension to the usual scientometric analysis. Just as the h-index is a combined measure of publication counts and citation rates, φ combines the number of co-authors of a given author with the frequency of joint activity with each. This combination appears to reflect usefully the author's position and role in the collaboration network. While low values indicate either a scanty or an inconstant set of co-authors, high values suggest a wide and persistent co-authors network. From the empirical sample studied it might be inferred that higher φ values – at least until a certain limit – may be accompanied with higher citation visibility (h-index).

As a 'by-product' of the determination of φ, the top section of the co-author list, those having at least φ joint papers with the 'main' author (a set of size φ, or larger in the case of ties) may be defined as the 'φ-core' of co-authors. Thereby, a kind of 'natural' delimitation of closest co-authors can be attained, which might be useful, e.g., in some kind of comparative, evaluative analyses. A similar strategy has been used to define a reference-based Hirschian similarity measure for journals (Schubert, 2010), which served as a useful basis to perform a clustering procedure (Schubert & Soós, 2010) further refining existing taxonomies of science.

It should be stressed that the possible use of the φ-index is far not restricted to scientometrics. As suggested in the definition, actors in all kind of co-activity network can be characterized this way. The word "actor" may be, e.g., taken literally as Barabási & Albert (1999) did it in their analysis of the Internet Movie Database (IMDb). A partnership ability index analysis of movie actors is in preparation by the present author.

A delicate possible area of application might be that of sexual encounter networks widely studied nowadays to understand and control the propagation of sexually transmitted diseases. Since the 'preferential attachment' scheme seems to prevail also in this case (see, e.g., Kampis & Gulyás, 2010), φ is expected to follow again Glänzel's (2006) model.

As to the further tasks in scientometrics, upscaling the present 'test-tube' study to larger samples, extending the area of analysis to various fields and subfields of science, and studying the dynamic behavior of the partnership ability index may be mentioned at first places.

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References

Abbasi, A., Altmann, J., Hwang J. (2010). Evaluating scholars based on their academic collaboration activities: two indices, the RC-index and the CC-index, for quantifying collaboration activities of researchers and scientific communities. Scientometrics, 83(1), 1–13.
Barabási, A.L., Albert, R. (1999). Emergence of scaling in random networks. Science, 286(5439), 509–512.
Barabási, A.L., Jeong, H., Néda, Z., Ravasz, E., Schubert, A., Vicsek, T. (2002). Evolution of the social network of scientific collaborations. Physica A, 311, 590–614.
Garvey, W. D. (1979). Communication: The Essence of Science. Elmsford, NY: Pergamon Press, Inc.
Glänzel, W. (2006). On the h-index – A mathematical approach to a new measure of publication activity and citation impact. Scientometrics, 67(2), 315–321.
Guns R., Liu, Y.X., Mahbuba, D. (2011). Q-measures and betweenness centrality in a collaboration network: a case study of the field of informetrics. Scientometrics, 87(1), 133–147.
Hirsch, J. E. (2005). An index to quantify an individual's scientific output. Proceedings of the National Academy of Sciences of the United States of America, 102, 16569–6572.
Kampis, G. & Gulyás, L. (2010). Generative characterization of sexual contact networks. Presented at NetSci 2010 The International School and Conference on Network Science, 10-14 May, 2010, MIT, Boston.
Korn, A., Schubert, A., Telcs, A. (2009). Lobby index in networks. Physica A, 388, 2221–2226.
Schubert, A., Korn, A., Telcs, A. (2009). Hirsch-type indices for characterizing networks. Scientometrics, 78(2), 375–382.
Schubert, A. (2010). A reference-based Hirschian similarity measure for journals. Scientometrics, 84, 133–147.
Schubert, A. & Soós, S. (2010). Mapping of science journals based on h-similarity. Scientometrics, 83, 589–600.
Zhao, S. X., Rousseau, R., Ye, F. Y. (2011) h-Degree as a basic measure in weighted networks. Journal of Informetrics, 5, 668–677.

Table 1 Bibliometric data of the Hevesy Medal awardees

Name	Year of award	Number of papers	Citations per paper	h-index	Number of co-authors	Mean occurrence per co-author	φ
Albert, Philippe	1972	5	2.20	2	15	3.40	2
Alimarin, Ivan Pavlovich	1970	82	2.80	9	88	2.46	6
Amiel, Saadia	1977	24	12.38	10	19	1.79	4
Amsel, Georges	1984	60	27.48	22	68	2.67	6
Bode, Peter	2011	133	10.69	20	172	3.11	6
Braun, Tibor	1975	251	12.32	27	164	0.87	7
Chai, Zhifang	2005	258	8.67	23	370	5.81	16
Chatt, Amares	2001	85	10.39	18	112	2.38	5
Choppin, Gregory	2005	445	15.43	42	425	2.00	10
De Corte, Frans	2000	136	19.59	24	131	3.42	9
De Goeij, Jeroen J.M.	2003	121	10.06	20	183	3.36	7
Girardi, Francesco	1976	20	10.00	10	40	3.15	3
Greenberg, Robert R.	2007	81	13.68	19	112	3.44	6
Guinn, Vincent P.	1979	62	4.34	10	35	1.02	3
Harbottle, Garman	1983	57	11.30	14	129	3.02	4
Hoffman, Darleane C.	2010	230	11.50	31	383	10.50	23
Hoste, Julian	1972	119	23.86	27	88	2.99	9
Jervis, Robert E.	1978	75	7.03	11	66	2.08	5
Kucera, Jan	2006	94	6.64	15	159	3.28	6
Lindstrom, Richard M.	2009	98	15.52	20	135	3.07	7
Lyon, William S.	1981	106	4.15	7	22	0.51	3
Meinke, W. Weine	1968	8	10.75	4	15	3.38	2
Peisach, Max	1981	144	10.08	19	121	2.38	8
Qaim, Syed M.	2008	278	13.03	29	204	2.86	11
Sabbioni, Enrico	2002	214	17.17	33	435	4.86	11
Sayre, Edward V.	1983	26	13.69	10	27	2.19	3
Schweikert, Emile A.	1986	203	8.54	18	183	3.19	9
Smales, Albert A.	1969	0	0.00	0	0	0.00	0
Spyrou, Nicholas M.	2005	196	5.89	15	189	2.47	7
Steinnes, Eiliv	2001	280	19.11	43	455	3.08	7
Suzuki, Nobuo	1985	178	10.92	23	97	1.79	8
Tölgyessy, Juraj	1975	81	3.42	8	72	2.81	7
Vértes, Attila	2004	358	6.10	20	464	4.96	15
Wainerdi, Richard E.	1977	4	4.00	2	2	0.50	1

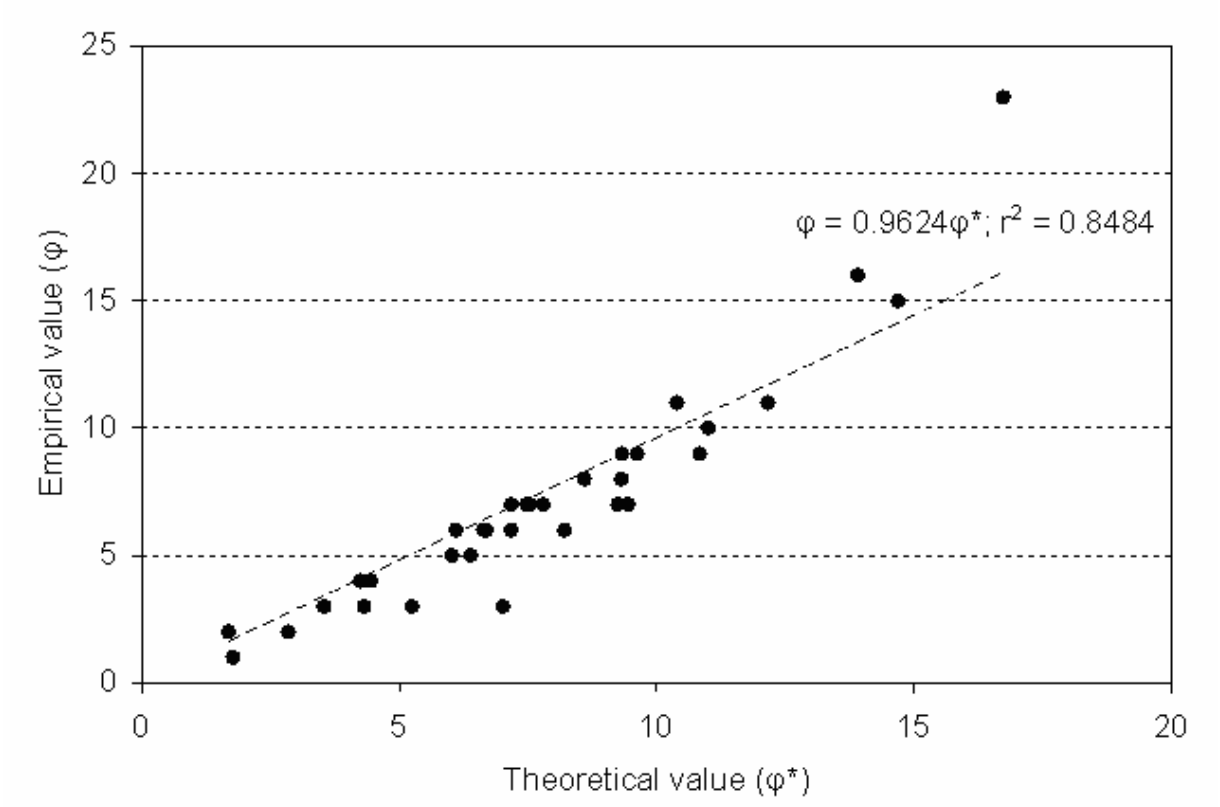

Figure 1. The theoretical (φ*) and the empirical (φ) values of the partnership ability of the Hevesy Medal awardees

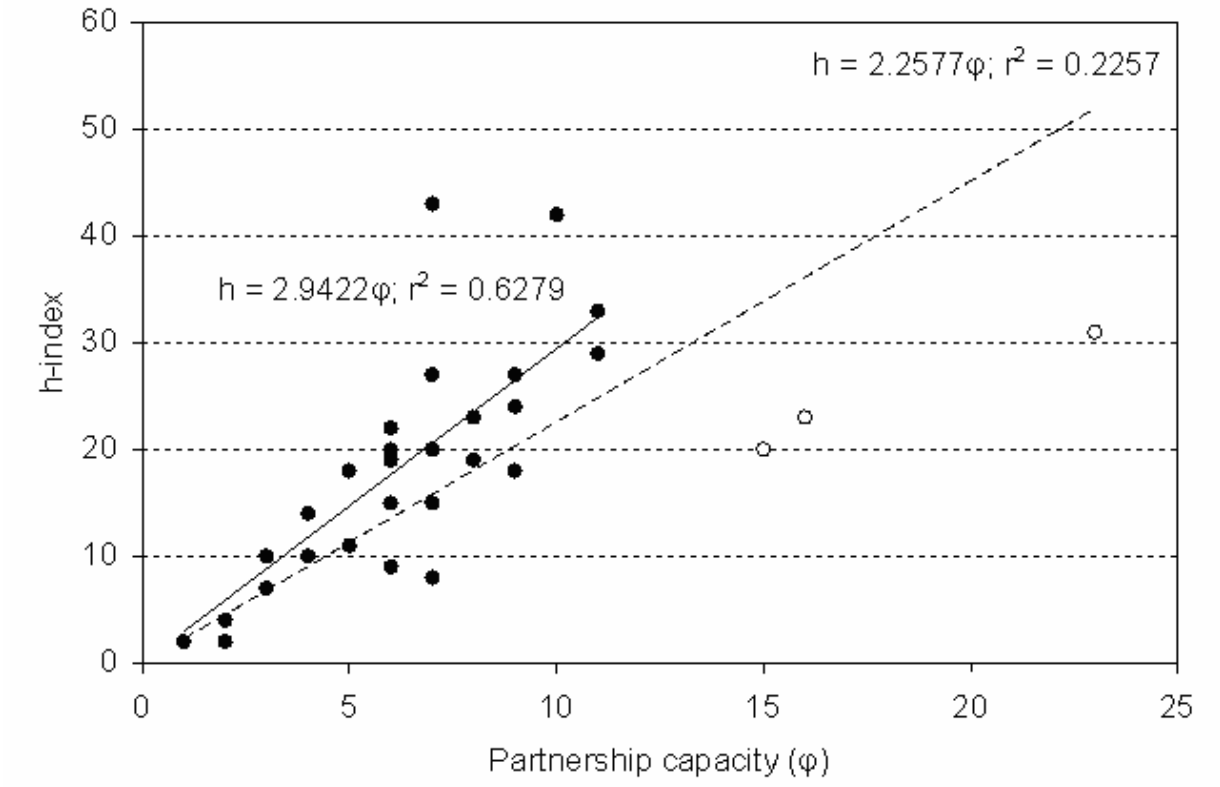

Figure 2. Relation between the partnership ability index (φ) and the citation h-index of the Hevesy Medal awardees