International Journal of Information Science and Management

Various Correlations between the H-Index and Citation Rate (CPP) in Neuroscience and Quantum Physics: New Findings

S. RUCH, B.Sc.
University of St. Gallen, Library, Dufourstrasse
email: Sandra.Ruch@unisg.ch

R. BALL, Ph.D.
Research Centre Juelich, Central Library
Corresponding Author:
rafael.ball@bibliothek.uni-regensburg.de

Abstract

Traditional bibliometric indicators are only partially suitable for evaluating the scientific achievements of individual people. They are either not definitive or they are too complicated to use due to technical and methodological difficulties. There is still no definite evidence for the correlation between the citation rate (CPP) and the H-Index. In order to obtain a reliable assessment of what the relation is between the H-Index and the citation rate, we performed a study on 30 relevant scientists from the disciplines of "particle physics" and "neurology". The foregoing discussions on the different correlations revealed that the form and degree of correlation do not just vary considerably between the individual comparisons but also amongst the disciplines. In both disciplines, the correlation between the citation rate CPP and the H-Index was relatively low. We also found varying degrees of correlation here.

Keywords: H-Index, Scientometrics, Evaluation, Bibliometrics.

Introduction

Traditional bibliometric indicators are only partially suitable for evaluating the scientific achievements of individual people. These indicators are either not definitive (Garfield, 2006) or they are too complicated to use due to technical and methodological difficulties (Van Raan, 2005). The cry for a "simple indicator, which scientists can apply themselves and which remains objective in the process" (Ball, 2006), has become particularly loud for evaluations of individual scientists. This was the reason why Hirsch proposed the H-Index in 2005 – an easy-to-apply indicator that caters for the individual achievements of a scientist (Ball, 2005). Since its introduction at the end of 2005, this indicator has received major attention both on the part of the scientific community and on the part of the general public. (Kaube, 2006; Barnmann & Daniel, 2007),“It is a simple single number incorporating both publication (quantity) and citation (quality or visibility) scores and hence has an advantage over these single separate measures […]” (Egghe, 2006). The H-Index does not just take the number of publications into account; it also incorporates the number of citations. The H-Index therefore provides information on both the productivity and the influence of a scientist (Sidiropoulus, Katsaros & Manolopoulos, 2007).

However, not all publications contribute to the H-Index. "Some papers with low citations will never contribute to a researcher's h, especially if written late in the career, when h is already appreciable. […] most papers earn their citations over a limited period of popularity and then they are no longer cited. Hence, it will be the case that papers that contributed to a researcher's h early in his or her career will no longer contribute to h later in the individual's career. Nevertheless, it is of course always true that h cannot decrease with time. The paper or papers that at any given time have exactly h citations are at risk of being eliminated from the individual's h count as they are superseded by other papers that are being cited at a higher rate. It is also possible that papers 'drop out' and then later come back into the h count, as would occur for the kind of papers termed 'sleeping beauties' (Hirsch, 2005).

A scientist's H-Index is not solely influenced by the number of publications and citations but also by the length of his/her career (Ball, 2006). It is assumed that the H-Index and career length behave proportionally to each other (Burrell, 2007). The size of the discipline (Banks, 2006) and whether each subject area is application-oriented or theory-oriented (Imperial & Rodriguez-Navaroo, 2007) also influence the H-Index.

Hirsch expects the H-value to increase linearly over the length of a career (Hirsch, 2005). The requirement for this is that a scientist publishes p papers per year, which then receive c citations per subsequent year. Based on this, Hirsch expects the following basic values: a scientist who has a H-Index of 20 after 20 years of scientific activity is a successful scientist. Scientists with an H-Index of around 40 after 20 years of work are likely to be found in elite universities or internationally respected research centres. Only very few outstanding scientists achieve a H-Index of 60 after 20 years of activity. From this, Kaube (2006) deduces that the H-value of an outstanding scientist increases by three units every year. This type of assumption relates more to an ideal situation than to the reality because the productivity of a scientist is not constant over the length of his/her career (Liang, 2006).

Another reason for the non-linear increase in the H-Index is that the H-Index only grows when citations of publications <h rise. The higher the H-value, the higher the number of citations of publications; <h must be in order to see the H-value increase further. However, since publications <h are often publications from an earlier date, a delay is to be expected because publications must first be perceived by the scientific community.

One of the biggest weaknesses of the H-Index is that only general statements can be made about the scientific significance of two scientists with similar H-values but a different number of publications or citations (Hirsch, 2005). If both scientists have a similar number of publications or citations and different H-values, then the one with the highest H-value is taken to be the more influential scientist. The H-Index is also considered a suitable measure for young successful scientists by some (Bornmann & Daniel, 2007), despite the fact that others advise against this because they consider the H-Index to be more suitable for the evaluation of more advanced scientists who have already published more than 50 papers and have a H-value of at least 10 (Kosmulski, 2006). Van Raan (2006) receives comparable results in his studies for the "crown indicator", the H-Index and for peer judgements. In a direct comparison between his crown indicator and the H-Index, Van Raan (2006) discovered that the correlation was very low.

Sidiropoulos et al. (2007) apply the H-Index to conference papers. Using different life cycles and a different number of articles, their index is calculated by dividing the H-Index by the number of articles published (Rousseau, 2006). Banks (2006) also uses the H-Index as a trend recognition system. In their research, Kelly and Jennions (2006) come to the conclusion that there is a close correlation between the H-Index and the total publication output. Burrell (2007) investigates this correlation in more depth and concludes from his calculations that the H-Index does not increase linearly with the publication rate.

With regard to correlations between the H-Index and indicators based on citation analyses, Hirsch (2005) has already outlined his observations and performed initial calculations. Ursprung and Zimmer (2007) do not consider either the correlation construed by Burrell (2007) or the dependency suggested by Hirsch (2005) between the H-Index and the sum of citations as suitable. Building on these findings and taking Glänzel’s (2006) mathematical explanations on the H-Index into account, Csajbók et al. (2006) create a formula that links the H-Index to the two fundamental bibliometric indicators: "number of publications" and "citation rate":

$$h = c * n^{1/3} * x^{2/3}$$

where n = number of publications, x = average citation rate, and
c = positive constant.

Most of these adaptations of the H-Index have yet to be properly implemented in practice. There is therefore a lack of empirical studies that could provide information on the validity of these indexes.

Objective and Method of the Study

In order to obtain a reliable assessment of what the relation is between the H-Index and the citation rate, we performed a study on 30 relevant scientists from the disciplines of "particle physics" and "neurology". Both disciplines have a high number of articles and exhibit steady growth. (Mittermaier, Plott, Tunger Bukard, & Lexis, 2006 & 2007)

In selecting the scientists, it was important that the scientists worked predominantly within the respective disciplines, that they were mainly senior researchers as they tend to have a higher number of publications, a longer career, and therefore a higher response, and that no overlaps occurred as a result of very common names.

The following parameters were developed from Thomson Scientific's Science Citation Index (SCI):

- publication (author[s], title)
- source
- year of publication
- citation rate per article
- number of publications (N_p)
- total number of citations ($N_{c,tot}$)
- average citation per publication (CPP)
- H-Index (h)
- number of citations of the h article ($N_{c,h}$)
- a-index (a)

The correlation was determined using the following statistical methods:

- scatter diagram
- Pearson's correlation coefficient (r)
- coefficient of determination resp. determination coefficient (R2)
- mean
- median

Results and Discussion

The results of the indicators (N_p, $N_{c,tot}$, CPP, h) were automatically generated in the SCI database and adopted unchanged. The values $N_{c,h}$ and A were calculated for the individual scientists using raw data exported from SCI in a separate process (Tables 1 and 2).

Table 1

Data from SCI for the Discipline of Neurology. (N1-N30 stay for individual scientists of neurology)

	N_p	$N_{c,tot}$	CPP	h	$N_{c,h}$	a
N_1	156	554	3.55	12	268	22.33
N_2	156	618	3.96	12	392	32.67
N_3	152	264	1.74	10	152	15.2
N_4	142	416	2.93	12	263	21.92

N_{5}	120	430	3.58	12	254	21.17
N_{6}	106	490	4.62	12	266	22.17
N_{7}	106	469	4.42	14	299	21.36
N_{8}	101	452	4.48	12	302	25.17
N_{9}	100	222	2.22	9	149	16.56
N_{10}	97	211	2.18	8	127	15.88
N_{11}	92	157	1.71	7	111	15.86
N_{12}	91	869	9.55	15	701	46.73
N_{13}	90	458	5.09	11	331	30.09
N_{14}	86	783	9.10	18	473	26.28
N_{15}	85	206	2.42	7	110	15.71
N_{16}	84	303	3.61	11	183	16.64
N_{17}	81	172	2.12	8	119	14.88
N_{18}	79	782	9.90	17	550	32.35
N_{19}	77	236	3.06	8	168	21
N_{20}	76	257	3.38	9	182	20.22
N_{21}	76	92	1.21	6	69	11.5
N_{22}	75	339	4.52	10	235	23.5
N_{23}	74	220	2.97	8	108	13.5
N_{24}	72	305	4.24	10	199	19.9
N_{25}	71	411	5.79	8	354	44.25
N_{26}	70	229	3.27	7	178	25.43
N_{27}	69	214	3.10	8	159	19.88
N_{28}	69	269	3.90	8	223	27.88
N_{29}	67	102	1.52	6	56	9.33
N_{30}	67	275	4.10	10	173	17.3

Table 2

Data from SCI for the Discipline of Particle Physics. (N1-N30 stay for individual scientists of particle physics)

	N_{p}	$N_{c,tot}$	CPP	h	$N_{c,h}$	a
T_{1}	470	5848	12.44	31	2491	80.35
T_{2}	380	5776	15.20	33	3127	94.76
T_{3}	382	10110	26.47	54	6187	114.57
T_{4}	372	4417	11.87	29	1876	64.69
T_{5}	338	4868	14.40	31	2536	81.81
T_{6}	326	4355	13.36	29	2172	74.9

T_7	329	7977	24.25	26	6168	237.23
T_8	320	4329	13.53	29	2172	74.9
T_9	320	4330	13.53	29	2172	74.9
T_{10}	320	3599	11.25	27	1450	53.7
T_{11}	317	4189	13.21	28	2102	75.07
T_{12}	315	4382	13.91	28	2104	75.14
T_{13}	312	4159	13.33	28	2102	75.07
T_{14}	309	6559	21.23	32	4333	135.41
T_{15}	305	4127	13.53	28	2074	74.07
T_{16}	301	3899	12.95	27	2046	75.78
T_{17}	292	3039	10.41	26	1095	42.12
T_{18}	278	4730	17.01	33	2836	85.94
T_{19}	268	3499	13.06	28	1783	63.68
T_{20}	258	4081	15.82	29	2186	75.38
T_{21}	260	2624	10.09	24	1081	45.04
T_{22}	258	2075	8.04	22	726	33
T_{23}	256	4497	17.57	31	2579	83.19
T_{24}	254	2742	10.80	25	958	38.32
T_{25}	257	3191	12.42	27	1399	51.81
T_{26}	253	3886	15.36	28	2102	75.07
T_{27}	249	3894	15.64	28	2102	75.07
T_{28}	248	2078	8.38	22	754	34.27
T_{29}	243	2760	11.36	25	1141	45.64
T_{30}	308	3670	11.92	27	1671	61.69

Correlation between CPP and the H-Index

The data generated were then analysed for a potential correlation between CPP and the H-Index.

Neurology

The scatter diagram in Figure 1 shows the correlation between the H-Index and CPP for neurology.

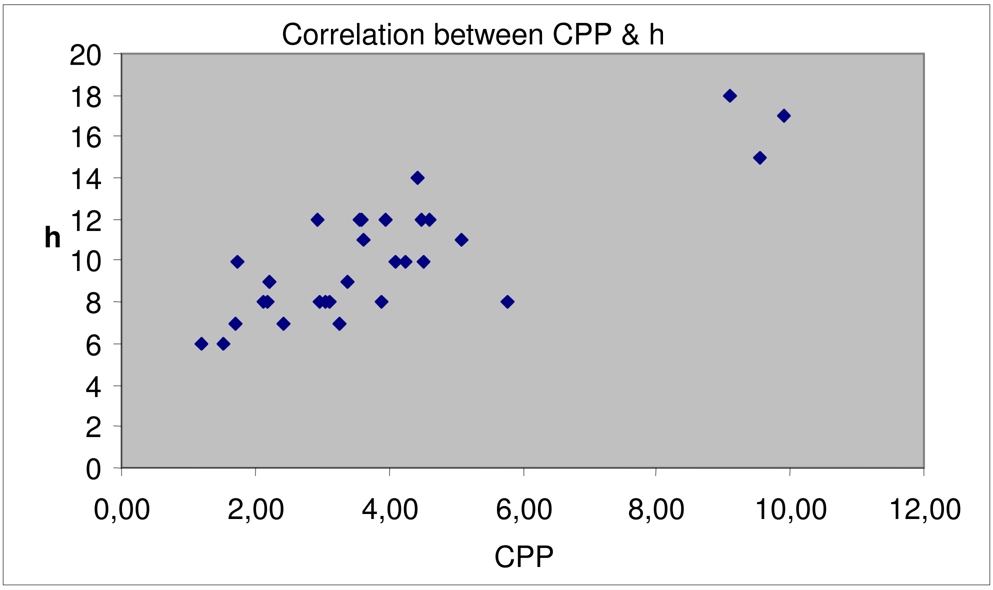

Figure 1. Correlation between CPP and h (neurology).

The form of the point cloud indicates that there is a linear correlation here. If we calculate Pearson's correlation coefficient, we get a value of 0.81684039 for r. The closer this value is to 1, the higher the correlation. Since in this case, the value only lies at 0.8, we can conclude on the basis of the coefficient of determination R^2 that there is a polynomial correlation with the determination coefficient R2 = 0.6682 and function h = -0.0162CPP2 + 1.3144CPP + 5.314.

Particle physics

The correlation between CPP and h in particle physics is illustrated in the scatter diagram shown in Figure 2.

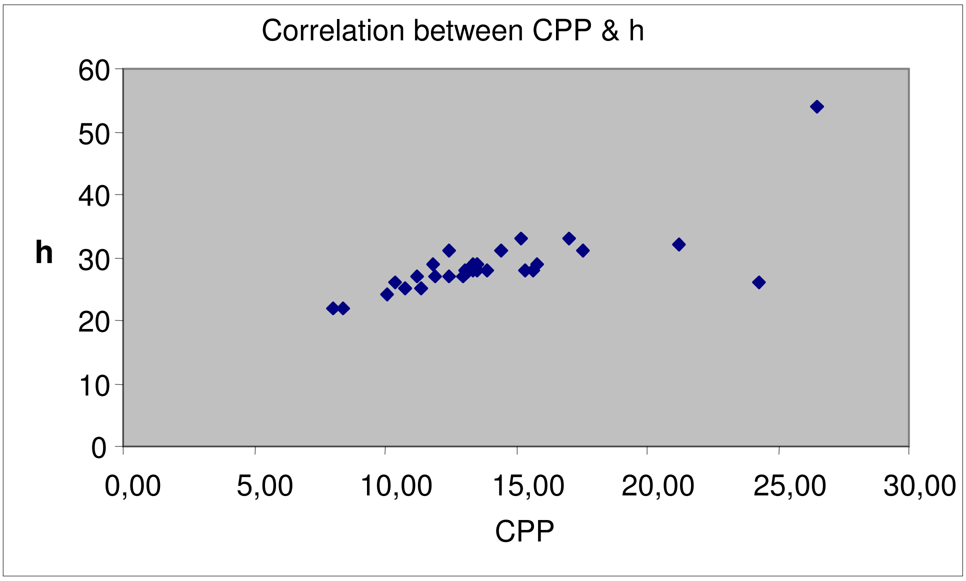

Figure 2. Correlation between CPP and h (particle physics).

The results suggest a non-linear correlation. The average deviation of the measured H-Index from the calculated H-Index in a potential correlation lies at 1.96005171.

Although this value is relatively high and the determination coefficient (R2 = 0.5667) is relatively low, we can assume that there is more than likely a potential correlation with the function h = 8.8143*CPP0.4486.

In our investigations, however, we failed to verify that a clear and simple correlation exists between the H-Index and CPP. It would appear that there is a complex correlation between the two parameters. If relevant parameters are to be sought against this background, then it makes sense to determine other correlations.

Further Correlations between CPP and the H-Index

The H-Index combines both output and response measurements. We must also assume that the correlation is not just determined by the number of citations resp. the citation rate, but also by the number of publications. This is the reason why we have applied two formulas to our sample, which describe the correlation between CPP and the H-Index and incorporate the number of publications.

Hirsch formula

In his introductory article on the H-Index, Hirsch (2005) outlined his observations on the correlation between previous indicators and the new index. "The relation between Nc,tot and h will depend on the detailed form of the particular distribution, and it is useful to define the proportionality constant A as $N_{c,tot} = ah^2$. I find empirically that A ranges between 3 and 5."

From this proposed correlation, the following correlation between CPP and h can be derived.

$$CPP = \frac{N_{c,\,tot}}{N_p}$$ | solve according to $N_{c,tot}$

$N_{c,tot} = CPP^* N_p$ | insert into formula $N_{c,tot} = ah^2$

$CPP^* N_p = ah^2$| solve according to h

$$h = \sqrt{\frac{CPP * N_p}{a}}$$

If the median is used for calculations of the H-value, then the average deviation is small. Both the mean a' and the median a'' lie in the region suggested by Hirsch (2005). In comparison to our results, when the Hirsch formula is applied, the average deviation of the calculated H-value from the measured H-value is smaller. This formula is therefore more precise than the formula we calculated when applied to 30 scientists from the area of neurology.

In the discipline of particle physics, the average deviation was also smaller when the median a'' was used to calculate the H-value. Contrary to Hirsch (2005) where a lies between 3 and 5, the mean a' and the median a'' both lie slightly above 5 here.

When this formula is applied, the average deviation of the calculated H-value from the measured H-value is marginally smaller than the correlation determined by us. Therefore, we cannot conclusively determine which of the two formulas is more suitable in this case. By including the number of publications when calculating the correlation between CPP and the H-Index, this can be made more precise. Since the average deviations are still relatively large, it is expected that a more precise formula can be found for the correlation between CPP and the H-Index. The next stage of our investigation involved analysing the Csajbók formula as a possible improvement.

Csajbók formula

In their research, Csajbók et al. (2007) determined the following formula for the relation of the number of publications and the average citation rate to the H-Index:

$$h = c * N_p^{1/3} * CPP^{2/3}$$

where c is a positive constant.

This formula is quite new and has not yet been widely applied in practice. This function will therefore be assessed in a similar manner and then compared.

The two disciplines will also be examined independently of each other here. The first step involves calculating the values of $N_p^{1/3}$ $CPP^{2/3}$ for each scientist.

By dividing this value by the H-value in each case, we get a value for c. From 30 values for c, the mean c' is calculated and the median c'' determined. These values are then inserted into the above formula in order to obtain the H-value.

This is performed twice. The first time, the mean c' is used, and the second the median c'' is inserted. Likewise, we obtain two calculated H-values: h' which is calculated with the mean c' and h'' with the median c''. Based on deviations from the measured H-value, we get an indication as to the precision of this formula.

The use of this formula to calculate the correlation results in large deviation figures compared to the previous calculations. Furthermore, there are no more freak values. However, the average deviation still lies above that for the Hirsch formula. Compared to the average deviations of the self-calculated correlations, the deviations calculated with the Csajbók formula are much smaller (Tables 3 & 4).

Unlike neurology, the average deviations in particle physics are larger than when the Hirsch formula is used. This can be attributed to the freak values for scientist T_7. If the deviations median is used at this point, the values would lie well under the mean (1.1849887 and 1.14725279).

Except for a few freak values, the deviations are relatively small. If we now exclude scientists T_3, T_7 und T_{14} from the calculations because they all show large deviations as a result of their high CPP values, the average deviation decreases to 1.15191056 and 1.05405224.

For the purpose of providing an overview, all of the values obtained for average deviations from the correlation calculations performed are listed once again below:

Table 3

Average Deviations from the Correlation Calculations (Neurology)

Neurology		Average Deviation	
		Using the Mean	Using the Median
Self-calculated correlation	linear	1.41804453	-
	poly	1.41201848	-
Hirsch Formula		0.897442198	0.886152969
Csajbók Formula		1.2338169	1.160432159

Table 4

Average Deviations from the Correlation Calculations (Particle Physics)

Particle Physics	Average Deviation	
	Using the Mean	Using the Median
Self-calculated Correlation	1.96005171	-
Hirsch Formula	1.842595591	1.82979815
Csajbók Formula	1.9533422	1.9411357

The application of the formulas defined by Hirsch and Csajbók reveal that the correlation between CCP and the H-Index is also dependent on the number of publications. Therefore, there must also be a correlation between the H-Index and the number of publications (N_p). This is the reason why this chapter will go on to work out other correlations in connection with the H-Index.

Close Analysis of Correlation between CPP and H-Index

Due to the investigations performed above, the degree of correlation between N_p and the H-Index will be analysed more closely at this point again.

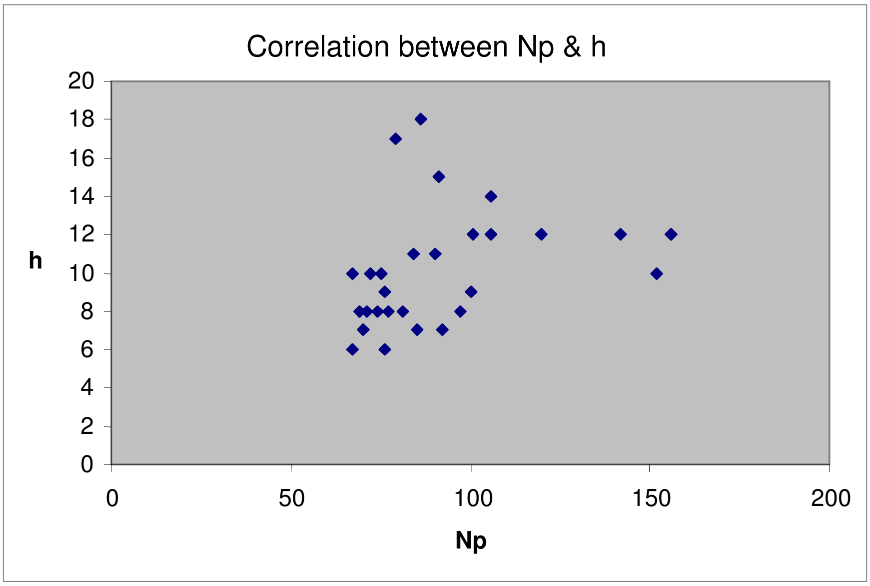

Figure 3. Correlation between N_p and h (neurology).

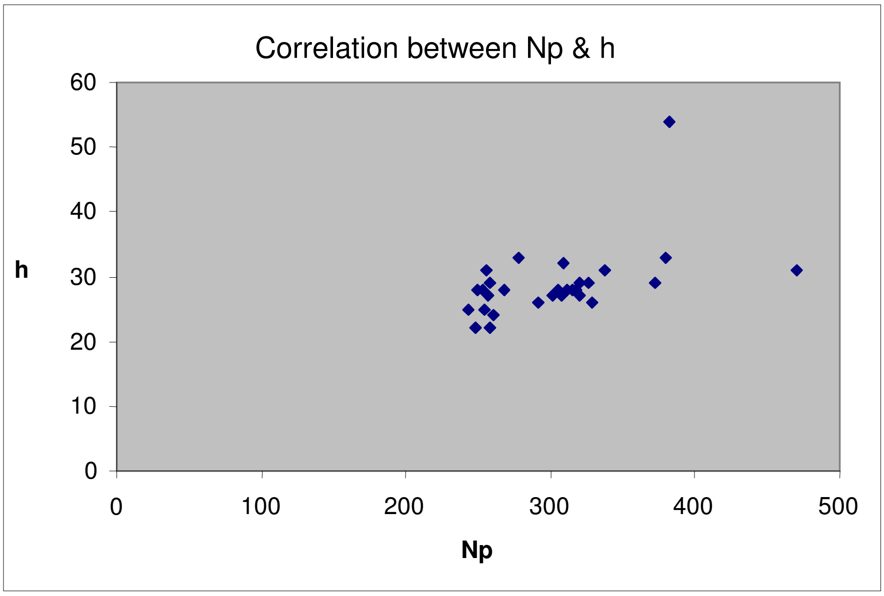

Figure 4. Correlation between N_p and h (particle physics).

Both graphics (Figures 3 & 4) clearly show that there is no direct correlation between N_p and h. This observation is confirmed using the correlation coefficient: 0.34794481 (neurology) and 0.49021623 (particle physics). Even Van Raan (2006) comes to the conclusion in his studies on 147 research groups in the field of chemistry that the correlation between the H-Index and the number of publications is less pronounced than the correlation between the H-Index and the citation rate.

Nevertheless, the relation between N_p and h can provide us with interesting information. By dividing h by N_p and multiplying the result by 100, we get a value for h as a percentage of N_p (Tables 5 & 6).

Table 5

Proportion h/ N_p (neurology)

h/ N_p	%	h/ N_p
N_1	0.08	7.69
N_2	0.08	7.69
N_3	0.07	6.58
N_4	0.08	8.45
N_5	0.10	10.00
N_6	0.11	11.32
N_7	0.13	13.21
N_8	0.12	11.88
N_9	0.09	9.00
N_{10}	0.08	8.25
N_{11}	0.08	7.61
N_{12}	0.16	16.48
N_{13}	0.12	12.22
N_{14}	0.21	20.93
N_{15}	0.08	8.24

h/ N_p	%	h/ N_p
N_{16}	0.13	13.10
N_{17}	0.10	9.88
N_{18}	0.22	21.52
N_{19}	0.10	10.39
N_{20}	0.12	11.84
N_{21}	0.08	7.89
N_{22}	0.13	13.33
N_{23}	0.11	10.81
N_{24}	0.14	13.89
N_{25}	0.11	11.27
N_{26}	0.10	10.00
N_{27}	0.12	11.59
N_{28}	0.12	11.59
N_{29}	0.09	8.96
N_{30}	0.15	14.93
Average	0.11	11.35

Table 6

Proportion h/ N_p (particle physics)

	h/ N_p	%
T_1	0.07	6.60
T_2	0.09	8.68
T_3	0.14	14.14
T_4	0.08	7.80
T_5	0.09	9.17
T_6	0.09	8.90
T_7	0.08	7.90
T_8	0.09	9.06
T_9	0.09	9.06
T_{10}	0.08	8.44
T_{11}	0.09	8.83
T_{12}	0.09	8.89
T_{13}	0.09	8.97
T_{14}	0.10	10.36
T_{15}	0.09	9.18

	h/ N_p	%
T_{16}	0.09	8.97
T_{17}	0.09	8.90
T_{18}	0.12	11.87
T_{19}	0.10	10.45
T_{20}	0.11	11.24
T_{21}	0.09	9.23
T_{22}	0.09	8.53
T_{23}	0.12	12.11
T_{24}	0.10	9.84
T_{25}	0.11	10.51
T_{26}	0.11	11.07
T_{27}	0.11	11.24
T_{28}	0.09	8.87
T_{29}	0.10	10.29
T_{30}	0.09	8.77
Average	0.10	9.60

In neurology the average percentage was found to be 11.35 %, while in particle physics, the average was 9.6 %. These results are interesting in that particle physics has a higher number of publications than neurology.

On average, the scientists investigated have 92.2 publications in the discipline of neurology and 303.27 publications in the discipline of particle physics. This allows us to formulate the hypothesis that a high number of publications do not necessarily mean a high value for h as a proportion of N_p.

Correlation between $N_{c,tot}$ and $N_{c,h}$

We also looked at the relation between the response to the complete works of a scientist and that of the h-core (Figures 5 & 6). We determined the correlation between the sum of all citations ($N_{c,tot}$) and the number of citations in the h-core ($N_{c,h}$).

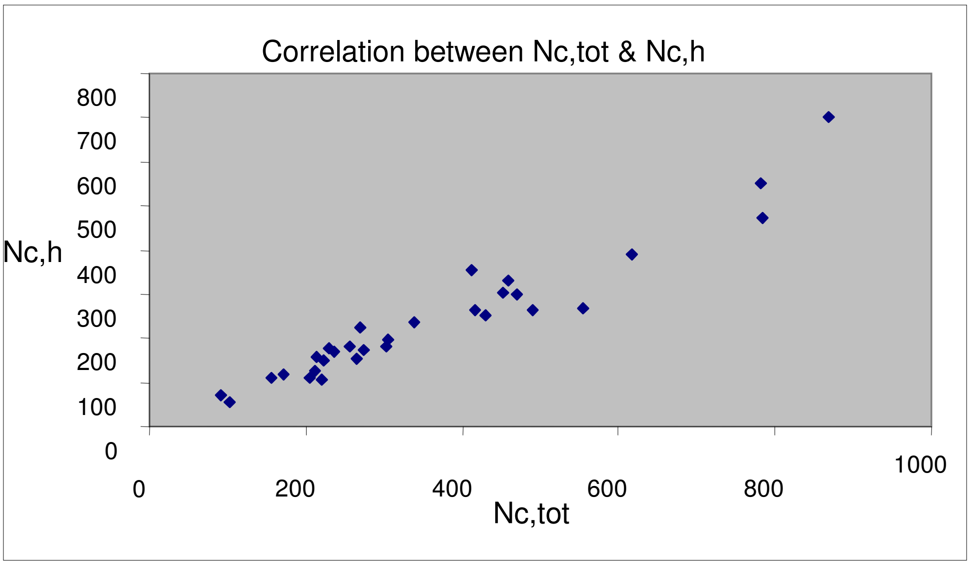

Figure 5. Correlation between $N_{c,tot}$ and $N_{c,h}$ (neurology).

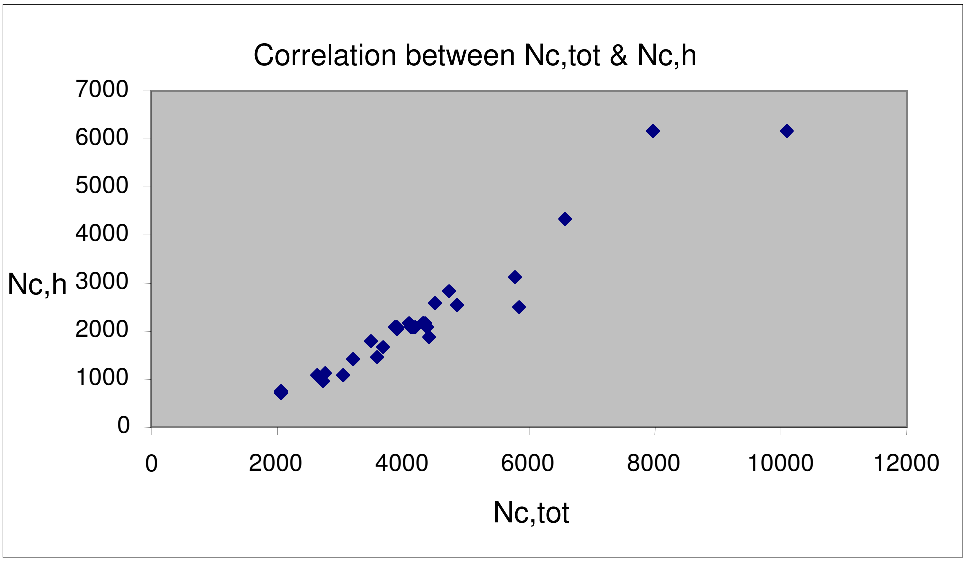

Figure 6. Correlation between $N_{c,tot}$ and $N_{c,h}$ (particle physics).

The correlation in both disciplines appears to be of a similar form. This observation was confirmed by comparing each of the determination coefficients (Table 7).

Table 7

Determination Coefficient for $N_{c,tot}$ and $N_{c,h}$ (neurology & particle physics)

	R^2(neurology)	R^2(particle physics)
Linear	0.9218	0.9331
Potential	0.9364	0.9523
Exponential	0.8594	0.8606
Polynomial	0.931	0.9332
Logarithmical	0.8016	0.8498

In both disciplines, the correlation is highest in a potential form. This is noteworthy for two reasons. First of all, the disciplines studied display very different publication behaviour. Second of all, no high or even similar correlation was found when the H-Index was compared with N_p.

Similar to the relation between the H-Index and N_p, the relation between $N_{c,h}$ and $N_{c,tot}$ provides information on $N_{c,h}$ as a relative proportion of $N_{c,tot}$.

Table 8

Proportion $N_{c,h} / N_{c,tot}$ (neurology)

	$N_{c,h}/N_{c,tot}$	%
N_1	0.48	48.38
N_2	0.63	63.43
N_3	0.58	57.58
N_4	0.63	63.22
N_5	0.59	59.07
N_6	0.54	54.29
N_7	0.64	63.75
N_8	0.67	66.81
N_9	0.67	67.12
N_{10}	0.60	60.19
N_{11}	0.71	70.70
N_{12}	0.81	80.67
N_{13}	0.72	72.27
N_{14}	0.60	60.41
N_{15}	0.53	53.40

	$N_{c,h}/N_{c,tot}$	%
N_{16}	0.60	60.40
N_{17}	0.69	69.19
N_{18}	0.70	70.33
N_{19}	0.71	71.19
N_{20}	0.71	70.82
N_{21}	0.75	75.00
N_{22}	0.69	69.32
N_{23}	0.49	49.09
N_{24}	0.65	65.25
N_{25}	0.86	86.13
N_{26}	0.78	77.73
N_{27}	0.74	74.30
N_{28}	0.83	82.90
N_{29}	0.55	54.90
N_{30}	0.63	62.91
Average	0.66	66.02

Table 9

Proportion $N_{c,h} / N_{c,tot}$ (particle physics)

	$N_{c,h}/N_{c,tot}$	%		$N_{c,h}/N_{c,tot}$	%
T_1	0.43	42.60	T_{16}	0.52	52.47
T_2	0.54	54.14	T_{17}	0.36	36.03
T_3	0.61	61.20	T_{18}	0.60	59.96
T_4	0.42	42.47	T_{19}	0.51	50.96
T_5	0.52	52.10	T_{20}	0.54	53.57
T_6	0.50	49.87	T_{21}	0.41	41.20
T_7	0.77	77.32	T_{22}	0.35	34.99
T_8	0.50	50.17	T_{23}	0.57	57.35
T_9	0.50	50.16	T_{24}	0.35	34.94
T_{10}	0.40	40.29	T_{25}	0.44	43.84
T_{11}	0.50	50.18	T_{26}	0.54	54.09
T_{12}	0.48	48.01	T_{27}	0.54	53.98
T_{13}	0.51	50.54	T_{28}	0.36	36.28
T_{14}	0.66	66.06	T_{29}	0.41	41.34
T_{15}	0.50	50.25	T_{30}	0.46	45.53
			Average	0.49	49.40

If this relation is calculated as a percentage for each scientist (Tables 8 & 9), then the average percentage of citations in the h-core is 66.02 % for neurology and 49.4 % for particle physics. It should be noted that the percentage is lower for particle physics although the number of citations exceeds that for neurology many times over.

Nonetheless, this value can be taken as a measure of the distribution of citations received for each scientist. This distribution can vary considerably from scientist to scientist: "Scientific publications are cited to a variable extent. Distributions of article citedness are therefore found to be very skewed even for articles written by the same author (Seglen, 1992)."

Correlation between CPP and A-Index

As the H-Index, N_p, $N_{c,tot}$ and $N_{c,h}$ vary considerably in their correlation behaviour, we decided to investigate the relations and their correlations with each other (Figures 7 & 8).

CPP to $N_{c,tot}$ and N_p has already been compared with the H-Index above. This revealed that the correlation was relatively high despite the fact that these indicators are based on different measurements. Similar to CPP, the A-Index measures the average citation rate. In contrast to CPP, the A-Index is limited solely to the h-core. "This index is simply defined as the average number of citations received by the publications included in the Hirsch core." (Jin et al., 2007). In other words, it represents the relation between $N_{c,h}$ and the H-Index.

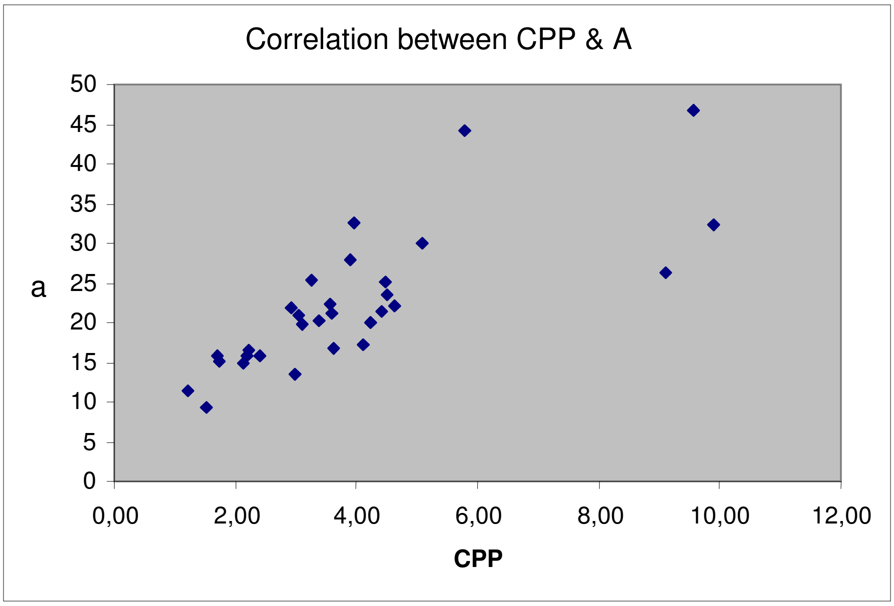

Figure 7. Correlation between CPP and A (neurology).

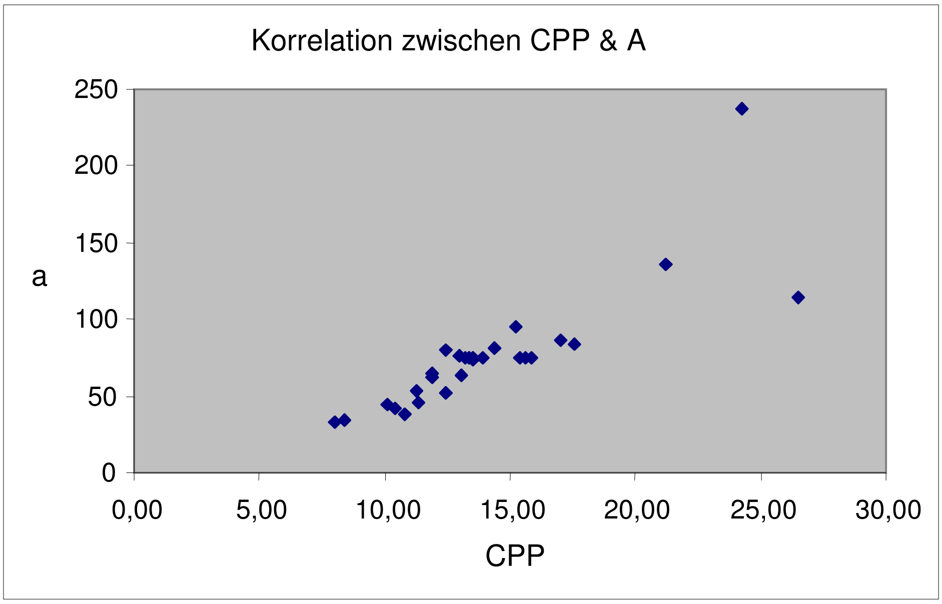

Figure 8. Correlation between CPP and A (particle physics).

As a result of the different determination coefficients in both disciplines, we assume that in contrast to the previous results, there is generally no correlation between CPP and A.

Conclusion

The foregoing discussions on the different correlations revealed that the form and degree of correlation do not just vary considerably between the individual comparisons but also amongst the disciplines.

In both of the disciplines studied, the correlation between the citation rate CPP and the H-Index was relatively low. The relation between CPP and the H-Index is very clearly influenced by other factors. We therefore performed a more detailed examination of existing formulas that also incorporate the number of publications. We also found varying degrees of correlation here. Although the average deviations lay below the level of direct correlation, the values were not satisfactory. From this we can infer that varying degrees of correlations exist between CPP and the H-Index depending on the object being studied, and that no universal rule can be derived.

No direct correlation could be determined between N_p and h. However, the relation between h and N_p can deliver information on the relative proportion of articles. A high number of publications do not automatically mean a high value for h as a proportion of N_p.

The relation between $N_{c,h}$ and $N_{c,tot}$ also gives us information on the distribution of citations received. Since the issues regarding the distribution are a heavily discussed topic, further studies are required to analyse this correlation in more details.

When analysing the relation between $N_{c,h}$ and $N_{c,tot}$, we determined that a potential correlation between the two indicators exists for both disciplines. In order to be able to make a statement that would hold for all disciplines, further research is necessary.

We did not determine any correlation between CPP and the A-Index. Our investigations did not reveal any other relations that would have provided information for a bibliometric analysis.

We do not expect to obtain any more relevant results in this context from studies using other correlations.

References

Ball, P. (2005). Index aims for fair ranking of scientists. *Nature*, *436*, 900.

Ball, R. (2006). Der Hirschfaktor. Ein neuer "Stern" am bibliometrischen Indikator-enhimmel. *B.I.T. Online*, *9*, 309-312.

Banks, M. G. (2006). An extension of the Hirsch index: Indexing scientific topics and compounds. *Scientometrics*, *69*, 161-168.

Bornmann, L. & Daniel, H. (2005). Does the H-Index for ranking of scientist really work?. *Scientometrics, 65*, 391-392.

Bornmann, L. & Daniel, H. (2007). What do we know about the h index?. *Journal of the American Society for Information Science and Technology*, *58*, 1381-1385.

Burrell, Q. (2007). Hirsch's H-index. A sochastic model. *Journal of Informetrics*, *1*, 16-25.

Csajbók, E., Berhidi. A., Vasas, L., & Schubert, A. (2007). Hirsc H-index for countries based on essential science indicators data. *Scientometrics*, (to be published), 1-27.

Egghe, L. (2006). An improvement of the H-index: The g-index. *ISSI Newsletter*, *2*, 8-9.

Garfield, E. (2006). Is citation analysis a legitimate evaluation tool?. In Braun, T. (Ed.), *Evaluations of Individual Scientists and Research Institutions.* A selection of papers reprinted from the journal Scientometrics. Akadémiai Kiadó Zrt (Scientometrics Guidebooks Series, 1), 955-971.

Glänzel, W. (2006). On the H-index: A mathematical approach to a new measure of publication activity and citation impact. *Scientometrics*, *67*, 315-321.

Hirsch, J. E. (2005). An index to quantify an individual's scientific research output. *Proceedings of the National Academy of Sciences of the United States of America*, *102*, 16569-16572.

Imperial, J. & Rodriguez-Navarro, A. (2007). Usefulness of Hirsch's H-index to evaluate scientific research in Spain. *Scientometrics*, *71*, 271-282.

Jin, B., Liang, L. Rousseau, R., & Egghe, L. (2007). The R- and AR-indices: Complementing the H-Index, *Chinese Science Bulletin, 52*, 855-863.

Kaube, J. (2006). Forscher, was ist dein Wert. *Frankfurter Allgemeine Sonntagszeitung, 39*, 82.

Kelly, C. & Jennions, M. (2006). The H-index and career assessment by numbers. *Trends in Ecology & Evolution, 21* (4), 167-170.

Liang, L. (2006). H-index sequence and H-Index matrix: Constructions and applications. *Scientometrics*, *69*, 153-159.

Mittermaier, B., Plott, C., Tunger, D., Bukard, U. & Lexis, H. (2006). Wissdex Neurologie. *Wissen Schaft, 9*, 30-31.

Mittermaier, B., Plott, C., Tunger, D., Bukard, U. & Lexis, H. (2007). Wissdex Teilchenphysik. *Wissenschaft*, *2*, 56-57.

Rousseau, R. (2006). *Evolution of JASIS's Hirsch index.* Available at: *http://eprints.rclis.org/archive/00005430/*

Seglen, P. O. (1992). The Skewness of Science. *Journal of the American Society for Information Science*, *43*, 628-638.

Sidiropoulus, A.; Katsaros, D. & Manolopoulos, Y. (2007). Generalized H-Index for disclosing Latent Facts in Citation Networks. *Scientometrics, 72*, 253-280.

Ursprung, H. & Zimmer, M. (2007). *Who is the "Platz-Hirsch" of the German econozmics profession? A citation analyses*. Konstanz: Universität Konstanz.

Van Raan, A. F. J. (2005). Fatal attraction: Conceptual and methodological problems in the ranking of universities by bibliometric methods. *Scientometrics*, *62*, 133-143.

Van Raan, A. F. J. (2006). Comparison of the HirscH-Index with standard bibliometric indicators and with peer judgment for 147 chemistry research group. *Scientometrics*, *67*, 491-502.