

# A question of impact: is citations per paper a reliable measure of impact?

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## Introduction

Invariably an international comparison of national science systems includes bibliometric measures of publishing size (papers) and impact (citations/paper). For example, Robert May (e.g. 1997) used the relative citation impact (RCI) to support his argument that better value for money might be associated with performing basic research in universities rather than in research institutions. The RCI for a scientific field in a country is determined by taking the ratio between the impact of the publications that involve authors from that country in the field and the impact of all publications in the field. The RCI is used only to compare the impact in a given field across science systems but it is never used to compare the impact across fields within a science system. The reason for this is that it is believed that the citation patterns and culture vary from field to field thus making them incomparable. This assumption may be incorrect.

## Citations and papers

In a recent paper (Katz, 1999) the author showed that a power law relationship exists between citations and papers for scientific communities of different publishing sizes within a science system. Figure 1 illustrates this relationship for the world science using refereed papers<sup>1</sup> indexed in the SCI between 1981 and 1992 and the citations received by those papers between 1981 and 1994 counted using a 3-year citation window<sup>2</sup>. The relationship observed between citations,  $c$ , and papers,  $p$ , is given in equation 1

$$c = k p^{1.27 \pm 0.03} \quad (1)$$

where  $k$  is a constant.

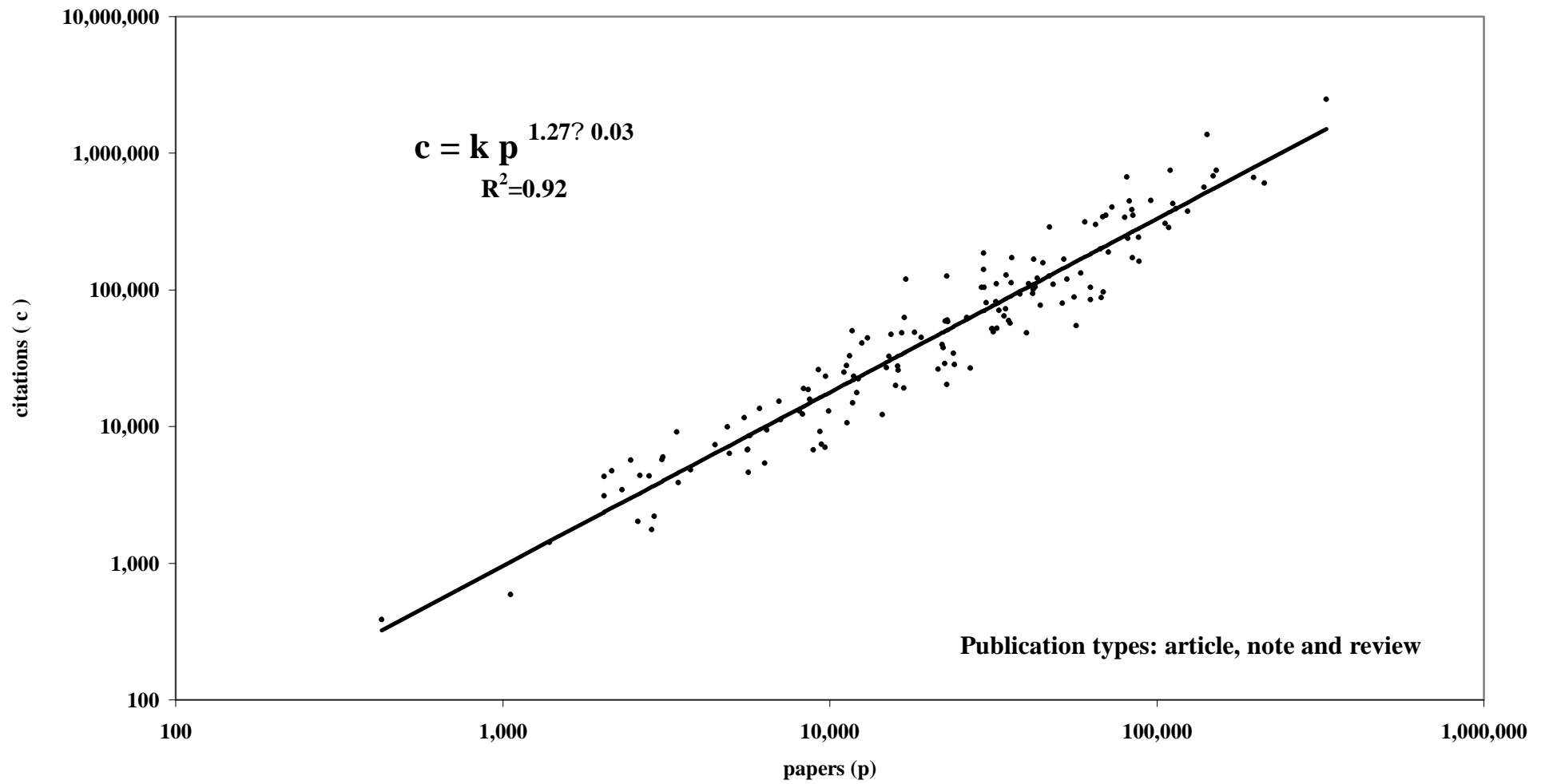
The paper also demonstrated that the exponent of the power law relationship has been relatively constant over the time interval (Table 2) and it is reasonably constant across a number of OECD science systems and institutional sectors within the UK science system (Table 2). Although not identical the national exponents were similar to the world exponent and had  $R^2$  values between 0.89 and 0.94. This result is interpreted as indicating that there is no characteristic publishing size for a scientific community that will produce an optimum number of citations and the relationship between citations and papers is scale-independent suggesting that science is a self-similar system (fractal). Furthermore if citations is used as a proxy measure for recognition then it also suggest that the “Matthew effect in science” is strong (Merton, 1968) since the number of citation or recognition increases in a non-linear manner with the number of published papers.

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<sup>1</sup> Article, note or review publication types

<sup>2</sup> Year of publication plus the subsequent two years

# World Science



**Figure 1 - Science Citation Index (1981-1992)**

(data source: Institute for Scientific Information)

Table 1 - Exponent stability over time for the world system

<b>Year</b>	<b>Exponent</b>	<b>R<sup>2</sup></b>
1981	1.25 ± 0.02	0.92
1982	1.26 ± 0.03	0.92
1983	1.26 ± 0.03	0.92
1984	1.24 ± 0.03	0.91
1985	1.26 ± 0.03	0.92
1986	1.26 ± 0.03	0.91
1987	1.27 ± 0.03	0.91
1988	1.27 ± 0.03	0.91
1989	1.27 ± 0.03	0.91
1990	1.28 ± 0.03	0.91
1991	1.24 ± 0.03	0.91
1992	1.26 ± 0.03	0.91

Table 2 - Power law exponent for various OECD countries

<b>Country</b>	<b>Exponent</b>	<b>R<sup>2</sup></b>
World	1.27 ± 0.03	0.92
EU	1.25 ± 0.02	0.94
US	1.34 ± 0.04	0.89
UK	1.27 ± 0.03	0.93
France	1.22 ± 0.02	0.95
Germany	1.23 ± 0.03	0.93
Canada	1.25 ± 0.03	0.90
Australia	1.20 ± 0.03	0.91
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UK		
Education	1.23 ± 0.03	0.93
Medical	1.23 ± 0.03	0.95
Industry	1.16 ± 0.05	0.81
Other	1.28 ± 0.03	0.90

Traditionally impact is used as a basic comparative indicator. An international bibliometric comparison in a given field usually involves comparing the Relative Citation Impact (RCI) for the various countries. The RCI is computed using equation 2 where impact  $I = \text{citations/paper}$

$$RCI_i = \text{country}_i \text{ impact/world impact} = I_i/I_w \quad (2)$$

It is assumed that papers and citations are independent variables and that the resulting impact measure and therefore the RCI is normalised. In other words the effect of the publishing size on citations counts has been eliminated. However, equation 1 suggests that papers and citations are not independent variables and it can be used to derive equation 3

$$c/p = kp^{0.27 \pm 0.03} \quad (3)$$

Equation 3 indicates that the impact increases in a power law relationship to the number of published papers. Impact may not be normalised for size.

We might ask what governs the magnitude of the exponent in the power law relationship between citations and papers?

### The exponent

The exponent of the power law relationship for a national science system is governed by a number of things. For example, the number of papers published by scientists in a system and indexed in a database like the SCI can be influenced by such things as the national funding priority for science, size of the skilled work force and the language of publication. Similarly, the impact of a nation's research is not only related to the talents of its scientists and engineers but other factors including the access to state-of-the-art research equipment and amount of international collaboration. In fact, the exponent of the power law relationship between citations and papers for a national science system *emerges* from the complex and dynamic interaction among many internal and external factors that characterise the system.

### The Relative National Citation Impact indicator

The power relationship between citations and papers gives us a tool for developing a new bibliometric indicator, *the relative national citation impact* indicator (RNCI). This indicator is calculated as follows. First the exponent for a specific national science system is used to calculate the number of citations a given field might be field might expected to receive,  $c_e$ , given its publishing size. The power law relationship between citations,  $c$ , and papers,  $p$ , is given by the general equation

$$c = kp^n \quad (3)$$

where  $n$  is the slope of the log-log regression line and  $k$  is a constant. This relationship can be used to calculate an impact measure that is adjusted for the effect of publishing size. Using the power law we can compute the number of citations,  $c_e$ , a field of a given publishing size should *expect* to receive. Then we can calculate the expected impact,  $I_e$ , as follows

$$I_e = c_e/p = kp^{n-1} \quad (4)$$

where  $p$  is the number of papers published in the field. Next we calculate the conventional or *actual* impact,  $I_o$ , given by

$$I_o = c_o/p \quad (5)$$

The ratio between the observed impact and the expected impact gives us a measure of how much impact a field is actually in its country compared to the amount of impact it is expected to have given its publishing size. This indicator is called the *relative national citation impact* (RNCI) indicator and is given by the following equation

$$RNCI = I_o/I_e = c_o/c_e \quad (6)$$

Since the RCNI is adjusted for publishing size by using the power law relationship between citations and papers and the exponent of the power law relationship that characterises this relationship in a specific system we can

- compare fields of different sizes with in the same science system

- compare similar fields across science systems taking into account the nature of the system in scientists in that field work

Table 3 gives the RCI values and a new indicator, the *relative national citation impact* (RNCI), for the top twenty high impact ISI science fields<sup>3</sup>. There are 152 fields in total. The RNCI is the ratio between the actual number of citations received by papers in a field and the average expected number of citations calculated using the power law relationship for that country. Because we are simply comparing actual to expected citations for a field of a given size we can now make comparisons among fields within and between systems.

The picture that is portrayed using this new indicator is different from the one we are used to seeing using only the RCI<sup>4</sup>. According to the RCI indicator the US dominates world science; it has the highest RCI in 70 of the 152 fields. However, according to the RNCI the US ranks highest in only 16 fields while Germany and France rank highest in 35 fields. Interestingly, the highest RNCI in the table belongs to Germany in *multidisciplinary sciences*. In comparison to the RCI indicator, the RNCI indicator shows the UK maintained its lead in *biophysics*, shared its high rank in *neurosciences* with France, lost its highest rank in *oncology* to Australia but gained the highest rank in *developmental biology* from the US.

The existence of power law distributions, in particular Lotka's and Zipf's laws, in the scientific publishing has been recognised for nearly a century. However, the use of power laws to quantify structure in human activity is a recent phenomena<sup>5</sup>. The data presented here illustrate that citations can be dependent on publishing size and therefore impact can depend on publishing size; the RCI that is based on citations/paper may be an inappropriate metric for international bibliometric comparisons.

1. May R.M., The scientific wealth of nations, *Science*, 275, 793-796 (1997)
2. Katz J.S., The self-similar science system, *Research Policy*, 28, 501-517 (1999)
3. Merton R.K., The Matthew Effect in Science, *Science*, 159, 3810, 56-63 (1968)
4. Katz J.S. and Katz L., Power laws and athletic performance, *J. Sport Sciences*, 17, 467-476 (1999)

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<sup>3</sup> The values for all 152 fields arranged in alphabetical order are given in the appendix I

<sup>4</sup> It is important to note that since the data that was available for this study does cover all countries a comparison could only be made between those countries for which data was available. If Japan, other European and Eastern European countries are included the number of fields in which France and Germany lead according to the RNCI values will probably decrease significantly.

**Table 1 RCI and RNCI for top twenty impact fields**

Field	World (c/p)	RCI							RNCI							
		US	EU	UK	Fra	Ger	Can	Aus	Wld	US	EU	UK	Fra	Ger	Can	Aus
Multidisciplinary Sciences	9.61	<b>1.85</b>	1.14	1.34	0.85	1.41	1.29	1.00	2.63	3.51	3.30	3.33	0.84	<b>4.53</b>	3.95	3.18
Cytology & Histology	8.27	<b>1.58</b>	0.84	1.10	0.81	1.03	0.76	0.70	2.64	<b>3.13</b>	2.08	2.59	0.76	2.64	1.98	1.95
Biochemistry & Molecular Biology	7.51	<b>1.31</b>	0.96	1.19	0.86	1.14	0.85	0.84	1.64	1.43	1.55	1.74	0.85	<b>2.01</b>	1.37	1.70
Developmental Biology	7.00	<b>1.30</b>	0.91	1.29	0.66	1.09	0.85	0.61	3.40	3.55	2.82	<b>3.65</b>	0.52	3.52	2.71	1.90
Immunology	6.83	<b>1.30</b>	0.93	1.10	0.90	0.97	0.85	0.96	2.01	1.85	1.78	1.94	0.85	<b>2.16</b>	1.68	1.98
Virology	6.28	<b>1.34</b>	0.98	1.21	0.87	0.85	0.93	0.96	2.63	<b>2.79</b>	2.39	2.64	0.79	2.06	2.43	2.44
Hematology	6.11	<b>1.32</b>	0.80	0.90	0.80	0.91	1.09	1.14	2.26	2.26	1.63	1.73	0.72	2.10	2.49	<b>2.67</b>
Infectious Diseases	5.55	1.14	0.89	0.87	<b>1.34</b>	0.81	1.12	1.31	2.50	2.10	2.07	1.84	1.40	1.99	2.79	<b>3.33</b>
Genetics & Heredity	5.51	<b>1.35</b>	1.03	1.20	1.14	1.16	1.02	0.93	1.81	1.86	1.74	1.82	1.08	<b>2.17</b>	1.72	1.67
Biophysics	5.42	1.10	1.05	<b>1.27</b>	0.91	1.14	1.02	1.04	1.72	1.46	1.71	<b>2.01</b>	0.82	1.94	1.74	2.00
Medicine Research & Experimental	5.22	<b>1.66</b>	0.90	1.15	0.96	1.03	1.22	1.02	1.81	2.30	1.63	2.03	0.99	2.15	<b>2.36</b>	2.03
Endocrinology & Metabolism	5.04	<b>1.29</b>	0.88	1.05	0.80	0.79	1.14	1.20	1.68	1.63	1.37	1.47	0.74	1.46	1.79	<b>2.01</b>
Physics, Atomic Molecular & Chemical	5.00	<b>1.31</b>	0.96	0.98	0.88	1.08	0.94	0.97	1.67	1.71	1.47	1.37	0.80	1.65	1.44	<b>1.75</b>
Neurosciences	4.94	1.16	1.00	<b>1.19</b>	1.03	0.92	1.01	0.92	1.33	1.06	1.28	<b>1.38</b>	1.04	1.30	1.23	1.37
Physics, Nuclear	4.78	<b>1.45</b>	1.12	1.15	1.31	1.08	0.91	0.75	1.90	<b>2.36</b>	1.94	2.10	1.14	1.69	1.77	1.56
Clinical Neurology	4.77	<b>1.24</b>	0.82	0.94	0.68	1.02	1.00	1.07	2.00	1.87	1.52	1.62	0.62	<b>2.19</b>	1.75	2.13
Oncology	4.71	1.21	1.00	<b>1.24</b>	1.04	0.92	1.17	1.12	1.44	1.24	1.38	1.60	1.03	1.41	1.74	<b>1.86</b>
Astronomy & Astrophysics	4.61	<b>1.39</b>	1.00	1.21	0.99	1.01	1.18	1.15	1.56	1.57	1.46	1.57	0.92	1.49	1.76	<b>1.76</b>
Physiology	4.59	<b>1.27</b>	0.98	1.15	0.91	1.20	0.94	0.83	1.45	1.32	1.42	1.53	0.94	<b>1.91</b>	1.14	1.20
Physics	4.55	<b>1.85</b>	1.17	1.20	1.44	1.37	1.00	0.74	1.23	<b>1.88</b>	1.40	1.43	1.36	1.67	1.30	1.14
Number of highest values (out of 152 fields)		<b>70</b>	<b>0</b>	<b>26</b>	<b>12</b>	<b>10</b>	<b>15</b>	<b>24</b>	n/a	<b>16</b>	<b>4</b>	<b>20</b>	<b>35</b>	<b>35</b>	<b>14</b>	<b>33</b>

Note: highest RCI and RNCI values in a field are bold

# Appendix I - Comparison of RCI and RNCI

(alphabetic order)

Field	World Impact	RCI							RNCI							
		US	EU	UK	France	Germany	Canada	Australia	World	US	EU	UK	France	Germany	Canada	Australia
Acoustics	1.79	1.25	1.04	1.17	1.02	0.91	1.09	1.41	0.81	0.80	0.84	0.86	0.83	0.75	0.84	1.10
Aerospace Engineering & Technology	0.76	1.13	0.65	0.93	0.35	0.82	0.73	0.79	0.44	0.36	0.32	0.47	0.13	0.42	0.34	0.39
Agriculture	1.41	1.05	1.07	1.14	1.30	0.86	0.91	1.04	0.47	0.38	0.54	0.48	0.78	0.48	0.38	0.41
Agriculture Economics & Policy	0.76	1.21	0.92	0.93	0.75	0.70	0.82	0.98	0.60	0.60	0.57	0.43	0.65	0.65	0.34	0.45
Agriculture, Dairy & Animal Science	1.62	1.20	0.97	1.16	0.97	0.66	1.07	0.81	0.66	0.63	0.64	0.65	0.67	0.45	0.57	0.41
Agriculture, Soil Science	1.44	0.98	1.16	1.57	1.13	0.79	1.13	1.50	0.64	0.49	0.76	1.01	0.78	0.48	0.59	0.76
Allergy	2.86	1.08	1.00	1.21	1.14	0.91	1.41	1.41	1.55	1.56	1.29	1.52	1.67	1.52	2.08	1.96
Anatomy & Morphology	2.14	1.24	1.04	1.53	0.77	0.99	1.23	1.01	1.08	1.31	0.97	1.40	0.73	0.89	1.16	0.99
Andrology	1.87	1.38	1.01	2.03	0.96	0.69	1.42	1.67	1.44	2.23	1.25	3.07	1.17	0.80	2.10	1.97
Anesthesiology	2.91	1.27	0.93	1.08	1.24	0.49	0.94	0.72	1.42	1.62	1.11	1.07	1.91	0.63	1.15	0.83
Astronomy & Astrophysics	4.61	1.39	1.00	1.21	0.99	1.01	1.18	1.15	1.56	1.57	1.46	1.57	1.43	1.49	1.76	1.76
Behavioral Sciences	2.56	1.04	1.01	1.11	0.82	0.97	1.08	0.90	1.15	0.87	1.15	1.05	0.91	1.27	1.00	1.02
Biochemistry & Molecular Biology	7.51	1.31	0.96	1.19	0.86	1.14	0.85	0.84	1.64	1.43	1.55	1.74	1.39	2.01	1.37	1.70
Biology	4.00	1.39	0.98	1.02	0.79	1.12	1.18	0.87	1.52	1.68	1.41	1.21	1.11	1.85	1.75	1.25
Biology, Miscellaneous	2.25	1.15	1.04	1.20	0.94	1.31	0.94	0.78	1.23	1.20	1.17	1.18	1.03	1.51	1.01	0.81
Biometrics	4.27	1.11	1.00	0.96	0.84	1.12	0.79	0.85	2.30	1.99	2.14	2.02	1.79	2.37	1.76	1.81
Biophysics	5.42	1.10	1.05	1.27	0.91	1.14	1.02	1.04	1.72	1.46	1.71	2.01	1.42	1.94	1.74	2.00
Biotechnology & Applied Microbiology	3.14	1.30	1.04	0.97	0.97	1.12	1.03	0.94	1.25	1.38	1.25	1.03	1.20	1.42	1.07	1.18
Cardiovascular System	4.25	1.34	0.85	1.03	0.57	0.85	1.17	1.16	1.36	1.35	1.10	1.26	0.74	1.19	1.65	1.80
Chemistry	2.83	1.95	1.13	1.43	1.20	1.12	1.37	1.03	0.70	1.20	0.80	1.05	0.94	0.74	1.01	0.87
Chemistry, Analytical	2.75	1.45	1.03	1.27	1.03	0.87	1.25	1.17	0.86	1.07	0.87	1.09	0.87	0.79	1.13	1.13
Chemistry, Applied	1.22	1.56	1.16	0.81	1.67	1.27	1.95	1.38	0.56	0.79	0.67	0.40	1.06	0.75	1.05	0.82
Chemistry, Clinical & Medicinal	3.70	1.21	0.91	0.96	0.77	0.95	0.93	0.94	1.81	1.87	1.43	1.31	1.15	1.85	1.64	1.52
Chemistry, Inorganic & Nuclear	2.91	1.53	1.10	1.24	1.10	1.07	1.51	1.30	0.93	1.32	0.92	0.98	0.96	0.85	1.50	1.29
Chemistry, Organic	3.02	1.33	1.05	1.08	0.99	1.14	1.37	1.27	0.86	1.00	0.84	0.81	0.78	0.96	1.29	1.34
Chemistry, Physical	2.88	1.60	1.11	1.14	1.06	1.17	1.16	1.23	0.85	1.19	0.90	0.88	0.84	0.97	1.05	1.23
Clinical Neurology	4.77	1.24	0.82	0.94	0.68	1.02	1.00	1.07	2.00	1.87	1.52	1.62	1.23	2.19	1.75	2.13
Computer Applications & Cybernetics	1.49	0.86	1.58	1.84	0.90	1.68	1.19	4.15	1.24	0.87	2.07	2.56	1.13	2.05	1.26	5.04
Computer Science, Artificial Intelligences	2.67	1.14	0.96	0.78	0.98	0.99	0.91	0.70	2.01	1.93	1.96	1.42	1.81	2.24	1.54	1.28
Computer Science, Cybernetics	2.12	1.02	1.21	1.17	1.20	1.40	0.79	0.95	1.83	1.66	2.07	2.54	2.20	1.93	1.25	1.54
Computer Science, Hardware & Architecture	1.81	1.01	1.13	1.48	1.13	1.10	0.97	0.98	1.06	0.75	1.45	1.96	1.34	1.37	0.95	1.19
Computer Science, Information Systems	1.67	1.10	1.03	1.25	1.17	0.98	0.90	0.86	1.35	1.36	1.23	1.58	1.30	1.04	1.05	1.06
Computer Science, Interdisciplinary Applicati	1.82	1.10	1.15	1.30	1.01	1.65	0.77	0.76	0.97	0.90	1.03	1.04	0.91	1.61	0.67	0.70
Computer Science, Software, Graphics, Progr	1.47	1.01	1.05	1.09	1.18	1.06	0.97	1.29	0.93	0.69	1.08	1.00	1.15	1.12	0.80	1.27
Computer Science, Theory & Methods	1.50	1.18	0.95	0.98	0.93	0.93	1.08	0.70	0.89	0.88	0.77	0.86	0.72	0.71	0.85	0.62
Construction & Building Technology	0.85	1.17	1.00	0.97	0.93	1.11	0.87	1.05	0.54	0.55	0.53	0.41	0.53	0.71	0.36	0.44
Critical Care	2.21	1.13	1.08	1.08	1.04	1.23	0.99	0.68	1.42	1.33	1.52	1.50	1.41	1.94	1.40	0.62
Crystallography	1.88	1.33	1.15	1.30	1.12	1.08	1.00	1.17	0.76	1.08	0.78	0.84	0.73	0.72	0.82	0.90
Cytology & Histology	8.27	1.58	0.84	1.10	0.81	1.03	0.76	0.70	2.64	3.13	2.08	2.59	2.01	2.64	1.98	1.95
Dentistry & Odontology	1.56	1.02	1.11	0.94	0.86	0.94	1.34	1.05	0.64	0.50	0.65	0.46	0.71	0.82	0.90	0.70
Dermatology & Venereal Diseases	2.10	1.38	1.04	1.26	0.79	0.94	1.15	1.36	0.84	1.00	0.77	0.89	0.59	0.77	1.24	1.41
Developmental Biology	7.00	1.30	0.91	1.29	0.66	1.09	0.85	0.61	3.40	3.55	2.82	3.65	1.75	3.52	2.71	1.90
Ecology	2.72	1.13	1.00	1.13	0.58	1.08	1.08	1.03	1.05	0.86	1.06	1.02	0.60	1.37	0.97	0.91
Education, Scientific Disciplines	0.73	0.98	1.16	1.28	0.63	0.44	1.52	1.26	0.41	0.29	0.59	0.53	0.34	0.31	0.59	0.47
Electrochemistry	2.62	1.36	1.34	1.52	1.49	1.29	1.16	1.05	1.18	1.48	1.57	1.79	1.49	1.63	1.40	1.35
Endocrinology & Metabolism	5.04	1.29	0.88	1.05	0.80	0.79	1.14	1.20	1.68	1.63	1.37	1.47	1.24	1.46	1.79	2.01
Energy & Fuels	1.28	1.13	0.98	1.09	1.00	0.89	1.15	1.49	0.58	0.53	0.56	0.59	0.54	0.49	0.60	0.75
Engineering	0.89	1.33	1.34	1.34	1.61	1.17	0.93	1.61	0.40	0.43	0.58	0.48	0.74	0.57	0.32	0.67
Engineering, Biomedical	1.71	1.21	0.88	0.81	0.97	0.68	1.06	0.96	0.85	0.84	0.67	0.56	0.81	0.57	0.77	0.82
Engineering, Chemical	1.55	1.21	0.94	0.97	1.16	0.68	0.98	1.17	0.56	0.53	0.52	0.54	0.68	0.34	0.51	0.68
Engineering, Civil	1.18	1.00	1.18	1.15	1.24	1.14	0.86	1.28	0.52	0.40	0.65	0.51	0.75	0.80	0.33	0.59
Engineering, Electrical & Electronic	1.84	1.23	1.04	1.03	1.25	1.10	0.80	0.93	0.57	0.52	0.63	0.51	0.80	0.73	0.44	0.62
Engineering, Industrial	0.62	1.20	0.90	1.03	0.88	0.78	0.93	0.81	0.49	0.50	0.50	0.52	0.46	0.47	0.44	0.42
Engineering, Manufacturing	0.91	1.09	0.90	0.47	0.66	1.65	0.66	1.10	1.20	1.28	1.25	0.57	0.86	2.34	0.85	1.50
Engineering, Mechanical	0.99	1.33	1.07	1.01	1.20	1.10	0.88	1.14	0.43	0.47	0.49	0.40	0.57	0.51	0.37	0.51
Engineering, Petroleum	0.82	1.17	1.08	1.48	1.04	0.96	1.87	1.46	0.54	0.53	0.54	0.83	0.42	0.42	0.98	0.78
Entomology	1.65	1.04	1.18	1.41	0.99	1.15	0.95	0.71	0.68	0.51	0.89	0.92	0.72	0.91	0.54	0.42
Environmental Sciences	2.24	1.14	1.00	1.03	0.84	1.00	1.08	0.92	0.80	0.65	0.83	0.77	0.76	0.92	0.74	0.76
Ergonomics	1.93	1.17	1.01	0.75	0.95	0.84	0.92	0.61	1.49	1.62	1.30	0.90	1.37	1.35	1.18	0.75
Fisheries	1.80	1.07	1.07	1.03	0.99	0.72	1.78	1.01	0.91	0.89	1.18	1.02	1.02	0.86	1.12	0.72
Food Science & Technology	1.74	1.18	0.96	1.11	1.17	0.75	1.21	1.00	0.66	0.62	0.61	0.66	0.82	0.46	0.69	0.65
Forestry	1.27	1.01	1.07	1.20	0.96	1.00	1.18	1.09	0.68	0.55	0.75	0.85	0.58	0.75	0.59	0.57
Gastroenterology & Hepatology	3.68	1.14	1.01	1.39	0.82	0.91	1.20	1.23	1.48	1.43	1.29	1.71	1.06	1.28	1.90	1.86
Genetics & Heredity	5.51	1.35	1.03	1.20	1.14	1.16	1.02	0.93	1.81	1.86	1.74	1.82	1.95	2.17	1.72	1.67
Geography	1.28	1.22	1.22	1.27	0.98	0.81	1.20	1.48	0.94	1.10	1.16	1.02	0.78	0.96	0.75	1.05
Geology	2.68	1.24	0.92	1.16	0.91	0.80	1.20	1.29	1.12	1.08	0.98	1.11	0.88	0.90	1.11	1.19
Geosciences	2.97	1.45	1.11	1.13	1.29	1.36	0.88	1.03	1.00	1.07	1.14	0.99	1.24	1.54	0.71	0.97
Geriatrics & Gerontology	2.29	1.08	0.87	0.87	0.98	0.85	1.05	1.14	1.35	1.12	1.16	0.99	1.49	1.44	1.35	1.56
Hematology	6.11	1.32	0.80	0.90	0.80	0.91	1.09	1.14	2.26	2.26	1.63	1.73	1.63	2.10	2.49	2.67
History & Philosophy of Science	1.02	0.98	1.07	1.17	1.30	0.62	1.03	1.16	0.97	0.90	0.92	0.76	1.25	0.63	0.86	0.77
Horticulture	0.94	1.12	0.95	1.16	1.00	0.65	1.09	1.21	0.51	0.44	0.54	0.59	0.78	0.34	0.53	0.55
Immunology	6.83	1.30	0.93	1.10	0.90	0.97	0.85	0.96	2.01	1.85	1.78	1.94	1.72	2.16	1.68	1.98
Infectious Diseases	5.55	1.14	0.89	0.87	1.34	0.81	1.12	1.31	2.50	2.10	2.07	1.84	3.49	1.99	2.79	3.33
Instruments & Instrumentation	1.69	1.28	1.29	1.14	1.51	1.56	1.29	0.95	0.68	0.70	0.87	0.70	1.03	1.06	0.85	0.68
Limnology	2.83	1.14	0.84	0.69	0.99	0.67	1.24	0.80	1.63	1.44	1.49	1.14	1.82	1.17	1.61	0.87
Marine & Freshwater Biology	2.25	1.14	1.02	1.05	0.81	1.00	1.29	1.05	0.86	0.83	0.83	0.72	0.70	0.96	0.85	0.74

# Appendix I - Comparison of RCI and RNCI

(alphabetic order)

Field	World Impact	RCI							RNCI							
		US	EU	UK	France	Germany	Canada	Australia	World	US	EU	UK	France	Germany	Canada	Australia
Materials Science	1.66	1.56	1.21	1.09	1.26	1.34	1.06	1.18	0.57	0.80	0.69	0.55	0.67	0.82	0.65	0.79
Materials Science, Biomaterials	2.31	1.17	0.87	0.66	1.08	0.51	1.15	0.84	1.90	2.18	1.46	1.01	1.65	1.04	1.79	1.33
Materials Science, Ceramics	2.39	1.24	0.90	0.73	1.15	0.86	0.93	1.36	1.35	1.40	1.19	0.87	1.45	1.07	1.48	1.84
Materials Science, Characterization & Testing	0.56	0.99	1.07	1.10	1.14	0.72	0.85	0.51	0.58	0.56	0.56	0.48	0.65	0.43	0.40	0.24
Materials Science, Coatings & Films	2.04	0.97	1.33	1.16	1.17	1.52	0.88	1.82	1.39	1.16	1.82	1.69	1.41	1.98	1.28	2.48
Materials Science, Composites	1.51	1.12	0.94	0.96	0.80	0.96	1.04	1.58	1.31	1.31	1.16	1.00	0.95	1.34	1.27	1.82
Materials Science, Paper & Wood	0.78	0.89	1.22	1.16	2.37	1.08	1.35	1.26	0.45	0.34	0.54	0.80	1.18	0.46	0.49	0.55
Materials Science, Textiles	0.78	1.04	1.03	1.05	0.86	0.79	0.92	1.22	0.63	0.64	0.63	0.48	0.78	0.63	0.62	0.46
Mathematics	0.97	1.22	1.15	1.24	1.24	1.17	0.93	0.93	0.34	0.32	0.37	0.39	0.36	0.38	0.30	0.33
Mathematics, Applied	1.22	1.17	1.06	1.13	1.09	1.03	0.99	1.05	0.47	0.41	0.47	0.49	0.47	0.49	0.41	0.48
Mathematics, Miscellaneous	1.55	1.17	1.08	1.13	1.09	1.05	1.07	0.77	1.23	1.28	1.23	1.22	1.21	1.20	1.04	0.67
Mechanics	1.65	1.36	1.07	1.21	1.16	1.03	0.87	1.27	0.68	0.75	0.71	0.70	0.73	0.74	0.58	0.82
Medical Laboratory Technology	2.12	1.04	0.96	0.74	1.41	1.54	1.24	1.02	1.40	1.11	1.39	0.83	2.29	2.85	1.68	1.54
Medicine Legal	1.29	1.14	0.94	1.03	1.77	0.85	1.20	1.05	0.88	0.94	0.72	0.65	2.03	0.62	1.13	0.79
Medicine Miscellaneous	1.20	1.03	1.06	0.96	1.30	0.98	1.36	0.71	0.79	0.59	0.98	0.80	1.10	0.90	0.99	0.58
Medicine Research & Experimental	5.22	1.66	0.90	1.15	0.96	1.03	1.22	1.02	1.81	2.30	1.63	2.03	1.78	2.15	2.36	2.03
Medicine, General & Internal	4.02	1.89	0.99	1.27	0.83	0.58	1.37	0.81	1.11	1.67	1.04	1.05	1.00	0.70	1.68	0.90
Metallurgy & Mining	1.35	1.70	1.35	1.50	1.35	1.25	1.00	1.12	0.46	0.76	0.64	0.69	0.62	0.55	0.44	0.59
Meteorology & Atmospheric Sciences	3.51	1.26	1.00	1.19	1.12	1.17	0.91	0.87	1.47	1.31	1.54	1.63	1.67	1.77	1.27	1.17
Microbiology	4.14	1.39	1.02	1.05	1.17	1.03	1.09	1.08	1.31	1.43	1.24	1.15	1.51	1.32	1.36	1.50
Microscopy	2.17	0.96	1.14	1.20	0.84	1.36	0.99	1.15	1.27	1.11	1.27	1.23	0.86	1.51	1.13	1.34
Mineralogy	2.48	1.42	0.86	1.04	0.94	0.91	0.97	1.09	1.35	1.77	1.00	1.14	1.00	1.08	1.03	1.09
Multidisciplinary Sciences	9.61	1.85	1.14	1.34	0.85	1.41	1.29	1.00	2.63	3.51	3.30	3.33	2.21	4.53	3.95	3.18
Mycology	1.31	1.34	1.16	1.31	1.23	1.01	1.28	1.39	0.74	0.95	0.80	0.73	0.99	0.80	0.91	0.82
Neurosciences	4.94	1.16	1.00	1.19	1.03	0.92	1.01	0.92	1.33	1.06	1.28	1.38	1.38	1.30	1.23	1.37
Nuclear Science & Technology	1.60	1.24	1.18	1.56	1.39	1.03	1.32	1.49	0.64	0.74	0.69	0.95	0.87	0.54	0.88	1.11
Nutrition & Dietetics	2.38	1.17	1.00	1.24	0.79	0.71	1.17	1.18	1.03	0.93	1.01	1.13	0.72	0.90	1.10	1.20
Obstetrics & Gynecology	2.41	1.16	0.93	1.27	1.37	0.54	1.21	1.61	0.92	0.80	0.79	0.99	1.53	0.49	1.19	1.55
Oceanography	2.61	1.40	1.03	1.05	0.92	1.17	1.23	0.88	1.18	1.31	1.27	1.18	1.00	1.49	1.27	0.82
Oncology	4.71	1.21	1.00	1.24	1.04	0.92	1.17	1.12	1.44	1.24	1.38	1.60	1.48	1.41	1.74	1.86
Operations Research & Management	0.98	1.15	0.93	1.00	1.03	0.91	0.95	0.77	0.56	0.51	0.52	0.48	0.59	0.59	0.44	0.43
Ophthalmology	2.15	1.33	0.81	1.08	1.07	0.62	0.96	0.80	0.88	0.87	0.69	0.83	1.24	0.52	0.88	0.68
Optics	2.83	1.22	1.08	1.15	1.14	1.10	0.98	0.98	1.07	1.05	1.09	1.05	1.11	1.14	1.08	1.07
Ornithology	1.58	0.98	1.07	1.05	1.04	0.65	1.25	0.82	0.98	0.79	1.03	0.85	1.26	0.65	0.93	0.59
Orthopedics	0.84	0.79	1.49	1.78	1.31	0.76	1.01	1.17	0.43	0.26	0.59	0.63	0.74	0.40	0.41	0.50
Otorhinolaryngology	1.26	1.15	0.95	0.73	1.40	0.82	1.15	1.45	0.62	0.57	0.54	0.36	1.05	0.58	0.82	1.01
Paleontology	1.51	1.22	1.00	1.07	0.85	1.25	1.04	0.81	0.99	1.04	0.94	0.89	0.71	1.33	0.86	0.57
Parasitology	2.35	1.26	1.15	1.43	0.82	0.94	0.99	1.47	1.11	1.35	1.15	1.16	0.81	0.98	1.13	1.29
Pathology	3.21	1.28	0.99	1.20	0.58	1.01	1.04	0.82	1.15	1.16	1.03	1.08	0.62	1.19	1.21	0.92
Pediatrics	2.27	1.26	0.86	1.17	0.64	0.56	1.23	0.83	0.84	0.79	0.67	0.82	0.51	0.48	1.00	0.68
Pharmacology & Pharmacy	3.34	1.27	1.06	1.38	1.06	0.99	1.13	1.10	0.84	0.80	0.85	1.01	0.92	0.88	0.96	1.09
Photographic Technology	1.20	1.52	1.21	1.21	1.63	1.19	1.10	1.03	0.79	1.12	1.00	0.84	1.29	1.05	0.82	0.71
Physics	4.55	1.85	1.17	1.20	1.44	1.37	1.00	0.74	1.23	1.88	1.40	1.43	1.67	1.67	1.30	1.14
Physics, Applied	3.44	1.44	1.05	1.02	1.00	1.19	0.91	0.97	1.00	1.14	1.13	1.05	1.00	1.31	1.06	1.25
Physics, Atomic Molecular & Chemical	5.00	1.31	0.96	0.98	0.88	1.08	0.94	0.97	1.67	1.71	1.47	1.37	1.35	1.65	1.44	1.75
Physics, Condensed Matter	3.82	1.76	1.10	1.06	1.12	1.19	1.20	0.73	1.12	1.68	1.18	1.18	1.15	1.21	1.49	1.11
Physics, Fluids & Plasma	3.05	1.17	0.99	1.17	1.00	0.93	0.94	1.09	1.53	1.38	1.45	1.49	1.40	1.36	1.52	1.48
Physics, Mathematical	2.67	1.33	1.18	1.25	1.45	1.23	0.98	0.93	1.28	1.49	1.40	1.52	1.57	1.46	1.21	1.18
Physics, Nuclear	4.78	1.45	1.12	1.15	1.31	1.08	0.91	0.75	1.90	2.36	1.94	2.10	2.17	1.69	1.77	1.56
Physics, Particles & Fields	3.42	1.60	1.13	1.44	1.27	1.33	1.24	0.88	1.40	1.97	1.46	1.93	1.63	1.58	1.74	1.44
Physiology	4.59	1.27	0.98	1.15	0.91	1.20	0.94	0.83	1.45	1.32	1.42	1.53	1.37	1.91	1.14	1.20
Plant Sciences	2.63	1.21	1.08	1.19	1.04	1.18	0.90	1.26	0.77	0.74	0.79	0.79	0.83	0.91	0.60	0.92
Polymer Science	2.26	1.46	1.13	1.12	1.17	1.14	1.29	1.18	0.79	1.05	0.88	0.86	0.87	0.88	1.10	1.15
Psychiatry	3.50	1.19	0.90	1.11	0.97	0.58	0.76	0.76	1.31	1.12	1.11	1.12	1.64	0.76	0.87	0.94
Public Health	2.46	1.25	1.07	1.15	1.15	0.73	1.14	1.16	0.93	0.87	1.00	0.92	1.27	0.80	1.06	1.14
Radiology & Nuclear Medicine	2.66	1.24	0.82	1.00	0.90	0.69	0.95	0.80	0.88	0.76	0.70	0.77	0.90	0.57	0.80	0.84
Rehabilitation	1.13	1.00	1.36	1.82	0.89	0.89	1.03	0.75	0.85	0.61	1.79	2.40	1.32	1.63	0.72	0.62
Remote Sensing	1.64	1.37	1.09	1.15	1.35	1.09	0.90	0.88	1.15	1.33	1.27	1.18	1.41	1.38	0.89	0.81
Reproductive Systems	3.24	1.32	0.81	1.15	0.67	0.85	1.33	1.23	1.71	2.03	1.24	1.63	0.88	1.64	2.10	1.60
Respiratory Systems	3.59	1.15	0.88	1.08	1.01	0.59	1.32	1.16	1.51	1.36	1.22	1.28	1.47	0.90	1.73	1.75
Rheumatology	3.41	1.33	0.86	1.05	0.49	0.60	1.15	1.05	1.78	2.20	1.29	1.35	0.71	1.12	1.78	1.62
Robotics & Automatic control	1.60	1.20	1.22	1.26	1.15	1.12	1.29	1.43	0.95	1.01	1.16	1.05	1.07	1.26	1.15	1.10
Spectroscopy	2.43	1.03	1.14	1.23	1.00	1.33	1.56	1.24	0.95	0.78	1.02	1.05	0.84	1.22	1.36	1.27
Sport Sciences	2.20	1.09	0.89	0.65	0.57	1.03	0.93	1.11	1.87	1.79	1.54	1.66	1.05	1.78	1.34	1.89
Statistics & Probability	1.60	1.16	1.02	1.28	1.04	0.85	1.06	0.80	0.79	0.71	0.78	0.85	0.81	0.68	0.72	0.49
Substance Abuse	2.17	1.07	1.03	1.15	0.87	0.71	1.02	0.90	1.34	1.15	1.36	1.27	1.28	1.25	1.18	1.01
Surgery	2.04	1.13	1.00	1.27	1.12	0.76	1.06	0.78	0.64	0.51	0.62	0.69	0.86	0.54	0.67	0.51
Telecommunications	1.13	1.13	0.84	0.87	0.61	0.79	0.98	0.95	0.55	0.48	0.48	0.40	0.33	0.52	0.50	0.56
Thermodynamics	1.47	1.34	1.00	1.06	1.01	0.98	0.99	1.30	0.78	0.90	0.79	0.81	0.76	0.70	0.82	0.99
Toxicology	2.67	1.18	1.04	1.17	0.90	1.09	1.05	0.98	0.99	0.89	1.01	1.05	0.98	1.16	0.99	1.09
Tropical Medicine	1.97	1.61	1.23	1.31	1.20	1.20	1.12	1.79	1.06	1.80	1.25	1.05	1.19	1.39	1.71	1.83
Urology & Nephrology	2.54	1.19	0.92	0.87	1.39	1.02	1.09	1.12	1.04	0.95	0.89	0.78	1.60	1.05	1.20	1.27
Veterinary Science	1.30	1.11	1.03	1.45	0.90	0.68	1.10	1.05	0.44	0.38	0.42	0.52	0.43	0.26	0.45	0.40
Virology	6.28	1.34	0.98	1.21	0.87	0.85	0.93	0.96	2.63	2.79	2.39	2.64	2.09	2.06	2.43	2.44
Water Resources	1.70	1.06	1.03	1.04	0.99	0.88	1.26	1.27	0.77	0.60	0.86	0.77	0.86	0.87	0.82	0.88
Zoology	1.58	1.21	1.06	1.26	0.73	0.92	1.24	1.03	0.56	0.54	0.59	0.61	0.40	0.57	0.55	0.51
Number of highest values (out of 152 fields)		<b>70</b>	<b>0</b>	<b>26</b>	<b>12</b>											