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Adjusted Count, Complete Count, and Straight Count: Does it Matter when Appraising Research Performance? A Case Study of LIS Research in Post-Apartheid South Africa

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Abstract

Counting of publications and citations is the fundamental yet important technique used in bibliometric/informetric measurements of research performance. Informetricians are however divided on the most appropriate method of counting publications and citations as a means of assessing the authors, institutions and countries' research output and citation impact, respectively. This paper reports on the results generated from a case study of the LIS researchers' output using three methods of publications count, namely, adjusted count (A_c), complete count (C_c) and straight count (S_c). Using data extracted from the Library, Information Science and Technology Abstracts (LISTA) database, the study found that there are differences in the number of articles generated in each counting method per author, as well as in the authors' rankings. The study concludes that in informetric studies, the method of counting chosen for purposes of assessing the performance of researchers matters as each method produces different results. The study recommends that the choice of the counting method should largely depend on the purpose for which the informetric study is being conducted.

Keywords

Adjusted Count, Complete Count, Straight Count, Bibliometrics, Informetrics, Research, South Africa, Publications Count

Introduction

Broadly speaking, bibliometric/informetric studies are largely based on the counting of publications and citations as indicators of research production and impact, respectively. Publications count is the most commonly used method to measure or assess individuals', institutions' and/or countries' research output while citations count reflects one's influence within a specific subject field or discipline. Its flaws notwithstanding, publications count is a widely accepted measure of:

- The number of publications, citations, books, patents, etc, that a particular author, group of authors, institutions and/or countries/geographic regions produced.
- How much has been produced on a given topical issue, discipline, country, regional area, etc.
- The number of publications that have each been authored by a given number of authors.
- The number of publications published in a given source (journal, magazine, etc.) (Victoria, n.d.).

Whereas the above mentioned issues may seem easy and straightforward to determine, the reality of the matter is that the current trends in research wherein research collaboration is increasingly becoming popular among researchers thereby leading to increased co-authorship of publications, crediting authors (including institutions

and countries) with a given number of outputs becomes a complex process. Although evaluating research output of single authorship – in which case authorship can be individual or corporate – seems to be straightforward, multiple-authorship of publications poses major challenges. For instance, who among the multiple authors should be credited with what share of contribution to the authorship of a given publication? Does a co-authored paper (or co-published research) imply equal participation of the authors (or researchers)? As early as 1982, Long and McGinnis, too, wondered thus: "if more than one scientist contributes to the authorship of a single paper, should each author be allocated full credit for the paper or should the credit be distributed among the co-authors in some fashion (Long and McGinnis, 1982)"? Which counting method is the most suitable for crediting authors with specific number of publications? Who cares or should care if one or the other method of counting is used to measure research productivity of scientists?

According to Borgman & Furner (2002), Diodato (1994) and Holden, Rosenburg & Barker (2005), there are three main approaches that can be used to count an author's publications output, namely: adjusted, complete (or normal) and straight count. As Gauffriau, et.al. (2007) point out, there is close to consensus about the above mentioned three counting methods. Whereas in the adjusted count approach, every author is allotted an equal fraction of a unit, a complete count approach ensures that each author is fully counted "whenever he/she appears, whether or not there is multiple authorship" (Diodato, 1994). In the straight count approach, only the first listed author is counted, thereby excluding all the other authors in multiple-authorship. On his part, Larsen (2007) outlines a total of 44 different names for the counting methods. Some of these names are used interchangeably in the literature surveyed by Larsen (2007. In his analysis of the publications output of selected countries, Larsen (2007) adopted five approaches of counting publications, namely complete counting, complete normalised counting, straight counting, whole counting and whole normalised counting. The main difference between counting publications for individual authors, on the one hand, and countries or institutions, on the other hand, according to Larsen, lies in the fact that whereas in the author's affiliation field of a given record, the name of a country or institution can be listed several times; authors are usually listed once thereby necessitating the use of different approaches to counting publications produced by any given country.

It has been argued that different counting methods for publications give different results (Gauffriau, Larsen, Maye, Roulin-Perriard and von Ins, 2007). Perhaps, that is why several writers have written to discredit one or the other of these methods of counting and therefore implying that there is no consensus on what constitutes the best method of gauging a given entity's publications output. Nevertheless, bibliometric/informetric studies that have been conducted to measure publication and/or citation counts of particular authors, institutions, and even countries have used one or more of these methods to assess research output and impact. Although all bibliometric studies employ one or more of the counting methods, it has been observed, sadly, that not all bibliometric studies provide details of the counting method chosen by bibliometric/informetric scholars (Larsen, 2008). In his analysis of the state of the art in publication counting in the ISI (Institute for Scientific Information) proceedings, Larsen (2008) summarises his findings thus:

> The proceedings of the ISSI conferences in Stockholm, 2005, and Madrid, 2007, contain 85 contributions based on publication counting. The methods used in these contributions have been analysed. The counting methods used are stated explicitly in 26 contributions and can be derived implicitly from the discussion of methods in 10 contributions. In only five contributions, there is a justification for the choice of method. Only one contribution gives information about different results obtained by using different methods. The non-additive results from whole counting give problems in the calculation of shares in seven contributions, but these problems are not mentioned. Only 11 contributions give a term (terms) for the counting method(s) used.

Gauffriau & Larsen (2005) underscore the importance of making the right choice of a publications and citations counting method by stating thus: "for all rankings of countries research output based on number of publications or citations compared with population, GDP, R&D and public R&D expenses, and other national characteristics the counting method is decisive". In view of this, the authors recommend that the counting methods employed for purposes of evaluating authors', institutions' and/or countries' research performance should be explicitly stated and explained. Gauffriau & Larsen (2005) underscore the importance of making the right choice of a publications and citations counting method by stating thus: "for all rankings of countries research output based on number of publications or citations compared with population, GDP, R&D and public R&D expenses, and other national characteristics the counting method is decisive". In view of this, the authors recommend that the counting methods employed for purposes of evaluating authors', institutions' and/or countries' research performance should be explicitly stated and explained.

Larsen (2008) summarises the research problem that is being investigated in this study thus:

> "The large increase in publication and citation counting has not resulted in generally accepted methods based on precise definitions. On the contrary, there is a lack of knowledge about the properties of different methods and about the size of the differences in figures obtained by using different methods."

Hence, this study employs an informetric analysis approach to measure selected South African LIS (Library and Information Science Studies) researchers' publications output using the three techniques, i.e. adjusted, complete and straight count in order to find out respective variations in the rankings of the researchers as well as their research outputs based on different counting techniques. Specifically, the study seeks to answer the question: what difference does it make if any of the three methods of publications count was used to measure research output of a given entity, particularly in the case of multiple authors?

Methods and Materials

Data was extracted from the LISTA (Library, Information Science and Technology Abstracts) database. The database is one of the largest bibliographic subject-specific databases, which index the literature on Library and Information Science (LIS). The database covers the literature published on such topics as librarianship, classification, cataloguing, bibliometrics, online information retrieval, and information management, among others.

In order to extract relevant data for the current study, a uniform search query [AF "South Africa"], where AF refers to the author's address field, was applied. The author's field contains such information as the name of the author, the department or section to which the author is affiliated, as well as the institutional and country of origin. The application of the search query was meant to yield all documents containing the name South Africa in the author's field, thereby yielding all documents published by authors with affiliations in South African institutions. The bibliographic data for all papers published by each author was extracted and saved in Micsoft Excel worksheets for further analysis. The search was limited to 'articles' in 'academic journals' published between 1995 and 2009. A total of 514 records were obtained and analysed. Data was cleaned using Notepad text editor. For instance, variations in author names such as Ocholla, D; Ocholla, DN; and Ocholla, ND were standardised in order to yield accurate results.

Descriptive statistics and correlation tests were conducted in order to compare the results generated using the three approaches of publications count. The Pearson moment correlation value was computed in order to test for any difference between the results of the three methods of publications count. The correlation formula was applied to the data, which was arranged in two arrays (columns) depending on the variable being analysed. For instance, the correlation test between the number of papers yielded in the adjusted and straights counts was done by having two arrays (columns) depicting the two sets of data for each author as shown in table 1 wherein *array 1* represents $\mathbf{A}_c$ and *array 2* represents S_c results

Table 1: Example of how Data was Organised for the Pearson Product-Moment Correlation Test

Name	Array 1	Array 2
Ackermann, MF	0.5	1
Addison, T	1	1
Adera, E	0.33	1
Alexander, H	0.33	1
Altman, RB	0.25	1
April, KA	1	1
Ariunaa, L	0.33	1
Arko-Cobbah, A	2	2
Arnold, AM	1	1
Arsenault, C	0.5	1
Averweg, UR	1.33	2
Baard, R	1	2
Badal, S	1	1
Badawi, G	1	1
Bakker, S	0.5	1

The Microsoft Excel's in-built command [=*Pearson (array 1, array 2)*] was applied to the data to produce the *Pearson Product-Moment Correlation Coefficient* [PPMC] (denoted by *r*). Developed by Karl Pearson in the 1880s, the coefficient, which gives a value between +1 and -1 inclusive, is widely used in the sciences as a measure of the strength of linear dependence between two variables (x and y) (Wikipedia, 2012). The test can be used to examine whether or not changes affecting one variable negatively or positively affect the other. In this study, the test was applied in two instances, namely, the number of articles and rank of authors in the three methods of counting. In the first instance the author sought to examine whether or not the changes in the authors' total number of publications determined using one counting method relates in any way with those counted using the other method of counting. The second instance took into consideration the ranking of authors in the three counting methods according to the number of publications. In order to rank the authors, the Excel ranking procedure was followed wherein the output for each author was arranged in columns and executing the following command:

= RANK(number, ref, [order])

where

number is the number whose rank we wanted to find
ref was an array of, or reference to, a list of numbers and
order was the number specifying how to rank the *number*

Scope of the Study

As mentioned above, the study was limited to articles, published by authors affiliated to institutions in South Africa, between 1995 and 2009 and as indexed in the LISTA database. The study is also limited in its purpose as it did not focus on measuring the authors', institutional or the country's publications output but, instead, focused on the differences and/or similarities between the counting methods as applied to LIS publications using various techniques.

Results and Discussion

The findings of the study are presented and discussed under the following sub-headings:

- Rank of authors per counting method
- Publications output per author per method of count
- Differences in publications output when benchmarked against the complete count
- Sum total of papers in A_c, C_c and S_c

Rank of Authors per Counting Method

Table 2 provides the names of top ranking authors and their different ranks in each method of publications count. Whereas Ocholla DN leads the pack in $\mathbf{A_c}$ and $\mathbf{C_c}$, he is ranked in position 5 in S_c. Ranking first in S_c is Onyancha, O.B. followed by Fourie, I., Ngulube, P. and Lor, P.J. An examination of the composition of the top twenty authors in each category reveals that except for Fourie, I. who maintained her position in all the categories, all the authors ranked variously in each counting method.

Table 2: Rank Comparison of the top 20 authors in A_c, C_c, and S_c

Name	*Rank in A_c*	*Name*	*Rank in C_c*	*Name*	*Rank in S_c*
Ocholla, DN	1	Ocholla, DN	1	Onyancha, OB	1
Fourie, I	2	Fourie, I	2	Fourie, I	2
Onyancha, OB	3	Onyancha, OB	3	Ngulube, P	3
Ngulube, P	4	Britz, JJ	3	Lor, PJ	3
Britz, JJ	5	Ngulube, P	5	Ocholla, DN	5
Lor, PJ	6	Lor, PJ	6	Minishi-Majanja, MK	6
van Brakel, PA	7	Minishi-Majanja, MK	6	Raju, J	6
du Toit, ASA	8	van Brakel, PA	8	Dick, AL	6
Minishi-Majanja, MK	8	du Toit, ASA	8	Mutula, SM	6
Dick, AL	10	Stilwell, C	10	Britz, JJ	10
Raju, J	11	Raju, J	11	Nassimbeni, M	11
Stilwell, C	12	Bothma, TJD	11	de Jager, K	11
Pouris, A	13	Dick, AL	13	Pouris, A	11
Mutula, SM	14	Nassimbeni, M	13	Penzhorn, C	11
Nassimbeni, M	14	Snyman, MMM	13	Raju, R	11
Bothma, TJD	16	Snyman, RMM	16	Okello-Obura, C	11
Theron, JC	17	Ikoja-Odongo, JR	16	Stilwell, C	17
Mostert, BJ	18	Mutula, SM	18	Ikoja-Odongo, JR	17
Snyman, MMM	18	Mostert, BJ	18	Mostert, BJ	17

A Pearson Product-Moment Correlation (PPMC) test yielded the following coefficients: r=0.585259 (between $\mathbf{A_c}$ and $\mathbf{C_c}$); r=0.548593 (between $\mathbf{A_c}$ and S_c); and r=0.356181 (between $\mathbf{C_c}$ and S_c). Although the coefficients indicate some form of correlation between the different counting methods, they nevertheless reveal a weak relationship among the variables. This is further reinforced by the differences witnessed in the rankings of individual authors in each counting category. For instance, some authors who did not make it to the top twenty in the first category of authors (A_c) emerged among the top ranked authors in C_c. These include Snymann, R.M.M., and Ikoja-Odongo, R. This could imply that these authors published most of their papers through co-authorships, which may have reduced their total number of publications/units when adjusted count was used to measure their output.

There were also those authors who featured in the list of top ranking authors in the $\mathbf{A_c}$ but did not feature in the $\mathbf{C_c}$ list. They include Theron, J.C. and Pouris, A. Ordinarily, authors should be highly ranked in the $\mathbf{C_c}$ than in $\mathbf{A_c}$ but these two authors, just as other authors, were not ranked any higher in the $\mathbf{C_c}$. This may be caused by the fact that whereas other authors heavily co-authored their papers, hence their lower ranking in $\mathbf{A_c}$, the same may have performed much better in the $\mathbf{C_c}$ category thereby overshadowing the two authors. Likewise, there were authors who featured among the top twenty in the $\mathbf{C_c}$ list but did not feature in the S_c list. They are van Brakel, P.A., du Toit, A.S.A., Bothma, T.J.D., Snymann, M.M.M. and Snyman, R.M.M. This simply means that the authors' names were not listed the first, among the collaborators, in the papers. Those who featured among the 20 top authors in the S_c list

but not in the $\mathbf{C}_c$ include de Jagger, K., Pouris, A, Penzhorn, C., Raju, R. and Okello-Obura, C. These authors' names were largely listed first in the names of authors.

Publications Output per Author per Method of Count

This section deals with the ranking and comparison of the authors and their publications output using the three methods of counting. Table 3 provides the names of the top ranking 20 authors and their publications output between 1995 and 2009. The pattern depicted in the table reveals that there were glaring differences in the number of papers each author was credited with in each category of publications count. This pattern was witnessed among the majority of authors. In table 3, for example, Ocholla, D.N., who ranked the first in $\mathbf{A}_c$ and $\mathbf{C}_c$, produced 19.66 ($\mathbf{A}_c$), 33 ($\mathbf{C}_c$) and 11 (S_c). An analysis of the publication pattern, according to the counting method, especially in situations where the authors published three or more articles, produced similar results as those recorded by Ocholla, D.N., wherein the complete count yielded the highest number of articles published by the authors.

It was also revealed that authors who collaborated heavily yielded fewer publications in $\mathbf{A}_c$ than in $\mathbf{C}_c$. Furthermore, most authors' output, measured using the S_c method, was much less than their total number of papers in the S_c. For example, out of 33 publications produced by Ocholla, D.N., only 11 contained his name as the first author, accounting for 33.3%. The other authors' publications output in terms of the number of papers containing their names as the first authors, expressed as a percentage of the number of papers in which their names appeared was as follows: Fourie, I. (81%), Onyancha, O.B. (90%), Ngulube, P. (63%), Britz, J.J. (30%), Lor, P.J. (80%), van Brakel, P.A. (21%), du Toit ,A.S.A. (21%), Minishi-Majanja, M.K. (47%), Dick, A.L. (78%), Raju, J. (70%), Stilwell, C. (33%). A further analysis of the results in the three categories of counting through a PPMC yielded the following coefficients: r=0.968581 (between $\mathbf{A}_c$ and $\mathbf{C}_c$); r=0.882788 (between $\mathbf{A}_c$ and S_c); and r=0.818427 (between $\mathbf{C}_c$ and S_c). The high values imply a strong positive relationship between the variables under investigation in this study.

Table 3: Number of Individuals With X Number of Papers in Each Counting Method

	Ranked by A_c				Ranked by C_c				Ranked by S_c		
Name	**A_c**	**C_c**	**S_c**	**Name**	**A_c**	**C_c**	**S_c**	**Name**	**A_c**	**C_c**	**S_c**
Ocholla, DN	19.66	33	11	Ocholla, DN	19.66	33	11	Onyancha, OB	14	20	18
Fourie, I	15.5	21	17	Fourie, I	15.5	21	17	Fourie, I	15.5	21	17
Onyancha, OB	14	20	18	Onyancha, OB	14	20	18	Ngulube, P	12.49	19	12
Ngulube, P	12.49	19	12	Britz, JJ	9.9	20	6	Lor, PJ	9.08	15	12
Britz, JJ	9.9	20	6	Ngulube, P	12.49	19	12	Ocholla, DN	19.66	33	11
Lor, PJ	9.08	15	12	Lor, PJ	9.08	15	12	Minishi-Majanja, MK	7.66	15	7
van Brakel, PA	7.83	14	3	Minishi-Majanja, MK	7.66	15	7	Raju, J	7.42	10	7
du Toit, ASA	7.66	14	3	van Brakel, PA	7.83	14	3	Dick, AL	7.5	9	7
Minishi-Majanja, MK	7.66	15	7	du Toit, ASA	7.66	14	3	Mutula, SM	5	7	7
Dick, AL	7.5	9	7	Stilwell, C	7.24	12	4	Britz, JJ	9.9	20	6
Raju, J	7.42	10	7	Raju, J	7.42	10	7	Nassimbeni, M	5	9	5
Stilwell, C	7.24	12	4	Bothma, TJD	4.99	10	1	de Jager, K	4	7	5
Pouris, A	5.3	6	5	Dick, AL	7.5	9	7	Pouris, A	5.3	6	5
Mutula, SM	5	7	7	Nassimbeni, M	5	9	5	Penzhorn, C	3.16	5	5
Nassimbeni, M	5	9	5	Snyman, MMM	4.16	9	2	Raju, R	2.25	5	5
Bothma, TJD	4.99	10	1	Snyman, RMM	4.16	8	1	Okello-Obura, C	1.33	5	5
Theron, JC	4.5	5	4	Ikoja-Odongo, JR	3.5	8	4	Stilwell, C	7.24	12	4
Mostert, BJ	4.16	7	4	Mutula, SM	5	7	7	Ikoja-Odongo, JR	3.5	8	4
Snyman, MMM	4.16	9	2	Mostert, BJ	4.16	7	4	Mostert, BJ	4.16	7	4

Authors' Publications Difference Benchmarked against the Complete Count

This section attempts to offer an alternative approach to answer the study's broad question: does it matter which method of counting the publications is used to measure researchers' output? Specifically, the approach seeks to answer the question: by how much is the total number of publications per author affected (i.e. reduced)? The emphasis is to benchmark the other counting methods ($\mathbf{A_c}$ and S_c) against the complete count, which often yields the most number of publications for any given unit of analysis, i.e. author, institution, or country.

Taking the complete count, therefore, as the benchmark or point of reference (i.e. the total number of publications output per individual), the biggest difference between $\mathbf{C_c}$ and S_c in terms of the percentage reduction was recorded by Bothma, T.JD. (900%), followed by Snyman, R.M.M. (700%), van Brakel, P.A. (366.67%), du Toit, A.S.A. (366.7%), Snyman, M.M.M. (350%), van der Walt, T.B. (300%), Britz, JJ (233.33%), and Ocholla, DN (200%). In terms of the difference between the $\mathbf{C_c}$ and the $\mathbf{A_c}$ for each author, the number of publications for Cuyers L, de Pesmacker, P., Jegers, M., Viviers, W., Saayman, A., declined by 600% each while 500% was forfeited by Chetty S and Shongwe B. The following authors' number of publications declined by 400% each in the S_c category: Ncayiyana D, Packer, A., Pakenham-Walsh, N., Cohen, B. and Godlee, F. Table 4 reveals this pattern for the 40 top ranking authors.

Triangulating the findings in table 4 by assessing the number of authors whose output was reduced by x number and/or percentage of publications when the $\mathbf{A_c}$ and S_c methods were applied resulted in figures 1 and 2, respectively. Fig 1 reveals that 88 and 248 authors' total publications in the $\mathbf{C_c}$ reduced by nil (0) publications in $\mathbf{A_c}$ and S_c respectively. Simply put, irrespective of the method used, 88 and 248 authors' output will not be affected if the $\mathbf{A_c}$ and/or S_c method was used, respectively. However, a closer examination, of these authors revealed that they singly produced between 1 and 3 papers each; majority of them singly produced 1 paper each. The percentage reduction of publications per a given number of authors in $\mathbf{A_c}$ and S_c respectively was as follows: between 1% and 100% (60, 20); between 100% and 200% (196, 22); between 200% and 300% (70, 8); and between 300% and 400% (29, 4). There were a total of 153 authors who lost all their publications when the straight count was used to measure their output. Simply put, the 153 authors' names were not listed as the first author in the papers wherein their names appeared as authors.

Table 4: Reduction of authors' publications when benchmarked against the C_c total

Name	C_c minus A_c		C_c minus S_c		Name	C_c minus A_c		C_c minus S_c	
	Count	*%*	*Count*	*%*		*Count*	*%*	*Count*	*%*
Ocholla, DN	13.34	67.85	22	200.00	Cloete, LM	5.01	251.76	7	-
Fourie, I	5.5	35.48	4	23.53	Pouris, A	0.7	13.21	1	20.00
Onyancha, OB	6	42.86	2	11.11	Penzhorn, C	1.84	58.23	0	0.00
Britz, JJ	10.1	102.02	14	233.33	Raju, R	2.75	122.22	0	0.00
Ngulube, P	6.51	52.12	7	58.33	Okello-Obura, C	3.67	275.94	0	0.00
Lor, PJ	5.92	65.20	3	25.00	Theron, JC	0.5	11.11	1	25.00
Minishi-Majanja, MK	7.34	95.82	8	114.29	Jacobs, D	1.67	50.15	2	66.67
van Brakel, PA	6.17	78.80	11	366.67	Weideman, M	2	66.67	2	66.67
du Toit, ASA	6.34	82.77	11	366.67	Eloff, JHP	2.67	114.59	5	-
Stilwell, C	4.76	65.75	8	200.00	Leach, A	3.18	174.73	5	-
Raju, J	2.58	34.77	3	42.86	Swanepoel, A	0	0.00	0	0.00
Bothma, TJD	5.01	100.40	9	900.00	Meyer, HWJ	0.5	14.29	0	0.00
Dick, AL	1.5	20.00	2	28.57	Steyn, C	0.5	14.29	0	0.00
Nassimbeni, M	4	80.00	4	80.00	Fairer-Wessels, FA	1	33.33	0	0.00
Snyman, MMM	4.84	116.35	7	350.00	Thomas, GG	1	33.33	0	0.00
Ikoja-Odongo, JR	4.5	128.57	4	100.00	Ondari-Okemwa,E	1.5	60.00	1	33.33
Snyman, RMM	3.84	92.31	7	700.00	du Plessis, T	2	100.00	1	33.33
Mutula, SM	2	40.00	0	0.00	Kiplang'at, J	2.17	118.58	1	33.33
de Jager, K	3	75.00	2	40.00	Machet, MP	0.5	14.29	2	100.00
Mostert, BJ	2.84	68.27	3	75.00	Underwood, PG	1	33.33	2	100.00

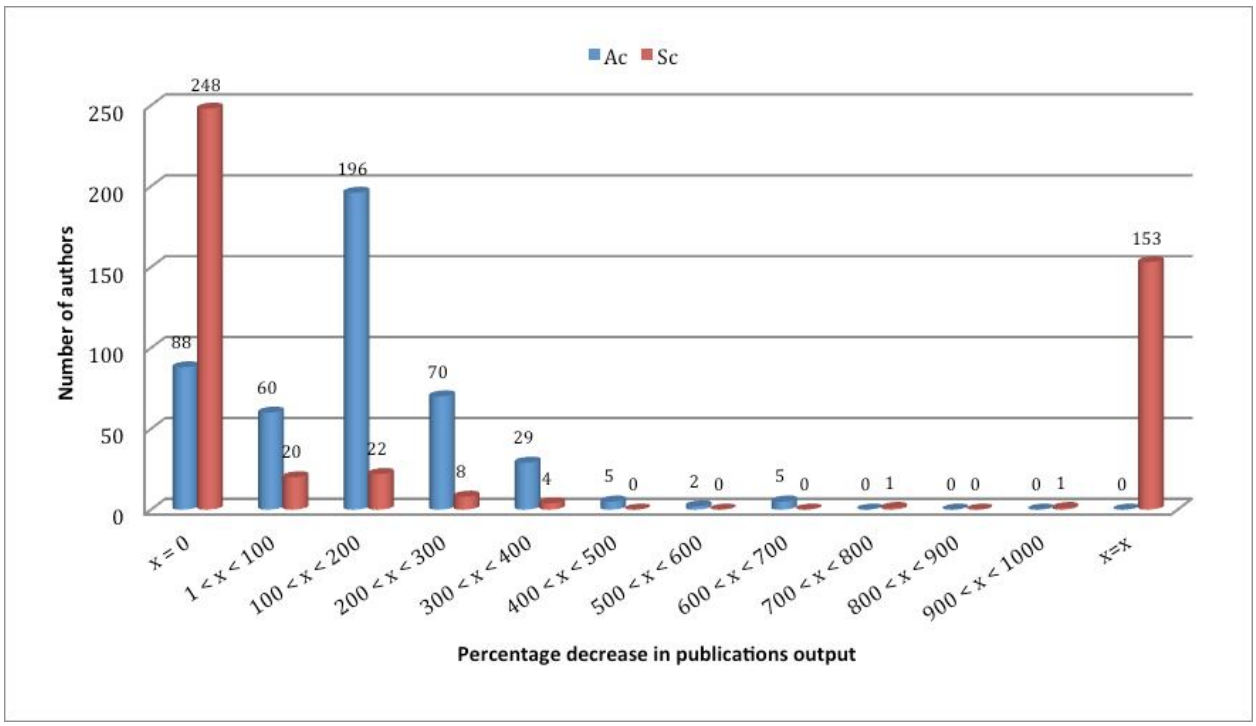

Fig 1: The number of authors with x percentage reduction of publications

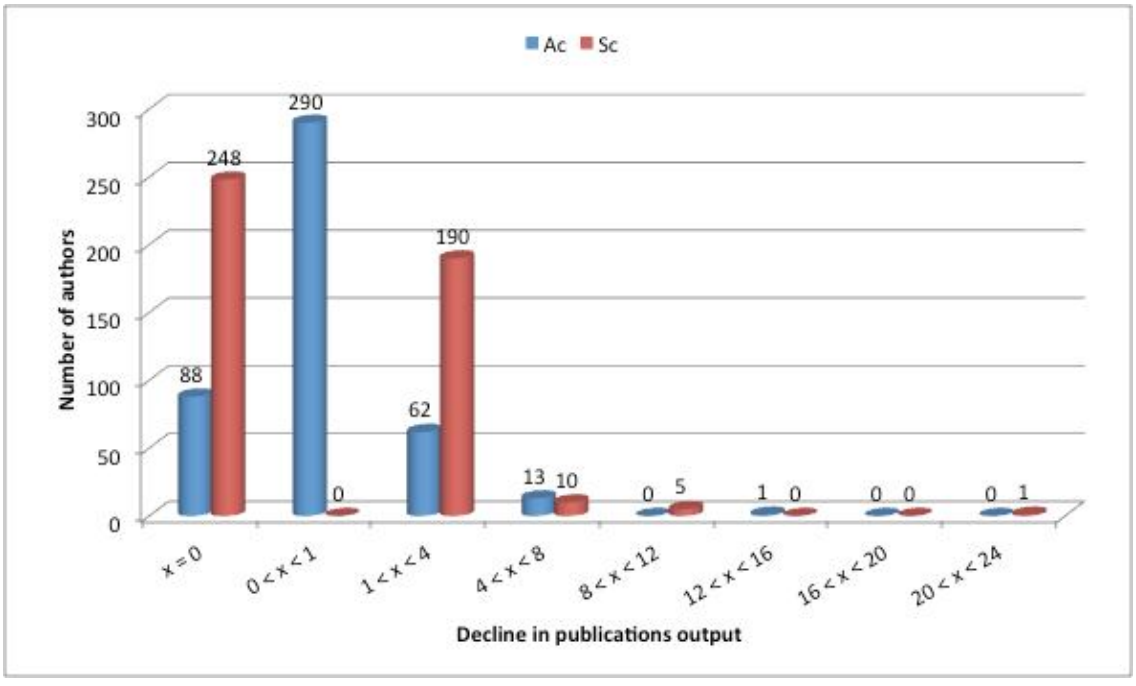

Fig 2: The number of authors with decline in x number of publications

As regards the number of papers that the x number of authors lost when $\mathbf{A_c}$ and S_c were respectively applied, it was as follows: between 0 and 1 publications (290, 0); between 1 and 4 (62, 190); between 4 and 8 (13, 10); between 8 and 12 (0, 5); between 12 and 16 (1, 0); and between 20 and 24 publications (0, 1). The highest number of papers (i.e. 22 papers) lost by a single author was recorded in the straight counting method.

Aggregation of Papers in $\mathbf{A_c}$, $\mathbf{C_c}$ And $\mathbf{S_c}$

Supposing the counting of papers using the three methods as applied to the single unit of analysis (i.e. the author) was aggregated to measure a corporate unit's (e.g. institution or country) output, what would be the difference? In other words, what if the author wanted to sum up all papers produced by the total number of authors in each method of counting publications in order to measure a country's total publications output? Using the data obtained for study adjusted count would yield a sum total of 517.8 publications in LIS research output in South Africa between 1995 and 2009 while the total number of publications produced using complete count and straight count would be 878 and 514 respectively. Ordinarily, $\mathbf{A_c}$ and S_c should yield an equal number of publications for a corporate unit of measurement (i.e. institution or country) but given that the values generated in $\mathbf{A_c}$ are often expressed in fractions (in this case expressed as a two-decimal point value), some units are lost in the process. For example, in the case where three authors have published an article, their individual contribution (output) is 0.33. If we reverse these individual contributions to the whole unit by multiplying the 0.33 of a unit that is contributed by each author by 3 authors, we will arrive at 0.99 of a whole unit that was initially split among the three authors.

This result does not represent the whole unit, which was shared among the three authors. Nevertheless, it can be deduced that whereas the complete count will exaggerate the total number of publications by country or institution when using the authors' total publications, the adjusted count and straight count methods will produce a near perfect (if not perfect) reflection of the unit's research output. However, one does not have to assess a country's or institution's research output by summing up the individual author's publications counts. There are different techniques that have been proposed for purposes of crediting countries with publications (see Gauffriau, Larsen, Maye, Roulin-Perriard & Ins, 2008). Olesen (2007), too, outlines several techniques for counting the publications according to the country of origin, namely: *absolute country counting, first country counting, normal country counting, standard country counting and total country counting*. The same techniques can be used to measure institutional research output.

Conclusions and Recommendations

This article's main focus was to compare the results generated by different publication counting methods, taking the LIS sector in South Africa as a case study. The research question that guided the study was: does it matter which of the three widely used counting methods one uses to count publications? Indeed, the study has revealed and therefore concurs with previously published studies (e.g. Gauffriau, Larsen, Maye, Roulin-Perriard & Ins, 2008) that it matters. However, the main difference is in the amount of research (number of publications – articles or papers) that one would be credited with when each of the counting methods is applied. Whereas the correlation test, as applied to the ranking of authors, yielded low coefficients implying weak correlation between the results of the three counting methods, the correlation test, based on the number of publications, yielded high values indicating a strong relationship. This means therefore that the method of counting matters most when authors are given ranks/positions based on their standing in the three methods. But if the authors' publications are considered to assess their performance in research output, it may not matter which method is applied, as the application of any of the methods would almost equally affect each individual's output, most probably because the pattern of publication (i.e. collaborative or individual-based research) is similar for majority of the authors.

Worth noting, too, was the manner in which majority of the authors' total publications output (based on complete count) was greatly affected when the other two methods (adjusted count and complete count) were applied. It was noted that the number of publications for the majority of the authors were greatly reduced when the $\mathbf{A_c}$ and S_c methods were

used. Some authors' number of publications was reduced as much as by over 500% especially when the S_c method was applied. Whereas the S_c yielded the lowest number of articles for the majority of the authors, the method can nevertheless be applied in informetric studies in such fields as pure sciences, e.g. Biology. As Herbertz and Muller-Hill (cited in Moed 2000) claim, in molecular biology research, the first author's position is given to the scientist who did the main work, and therefore, "when two groups collaborate, the group delivering the first author collects two thirds of the citations, and the second group, one third and in the case of three collaborating groups, the group presenting the first author receives a portion of 0.5, and the other groups, 0.25 each". However, as informetricians may not be privy to the basis upon which authors' names are arranged in a paper, it becomes difficult to credit the first author only for a publication that has been jointly published by more than one author.

Aggregating the results in each method of counting revealed a huge difference between the complete count results, on the one hand, and the straight and adjusted count, on the other hand. As already discussed under aggregation of papers, there were 878 publications in $\mathbf{C_c}$, 517.8 in $\mathbf{A_c}$ and 514 in S_c produced by a total of 455 authors. Therefore, the study found that on average, each author's publications count would be reduced by a margin of 0.79 and 0.80 units when the adjusted and straight count are applied, respectively. This pattern may vary from one study to another depending on the intensity of collaboration (i.e. the number of authors engaged in the publication of an article).

It is in such like circumstances that one could conclude that qualitative approaches, combined with quantitative approaches, may be used to measure each author's contribution to a given paper. For instance, authors may be asked to indicate the percentage of their input into the particular research or co-authorship of publications. The National Research Foundation (NRF) of South Africa uses this approach when rating researchers besides using several other criteria.

An examination of the results also revealed that whereas some authors are not often the first authors, implying that the authors may not be the main researchers, they nevertheless have performed well in their individual capacity, as well as favourably contributed towards the country's research output. It follows that a researcher's output is enhanced not only through the research where he/she is the main researcher but also through collaborative research. Although these authors' publications are greatly reduced when $\mathbf{A_c}$ and S_c methods of counting are applied in the measurement of their research output, the fact that they are among the top producers gives credence to the fact that research collaboration can enhance one's research output and therefore should be encouraged.

In conclusion, the choice of one method or the other for purposes of research performance appraisal of authors should be done based on the objectives of such an appraisal. For instance, if the appraisal is meant to gauge the suitability of a candidate for employment or promotion, the $\mathbf{C_c}$ and $\mathbf{A_c}$ can apply. However, if it is for purposes of rewarding or rating the authors involved in the publication of the papers or conducting the research, then $\mathbf{A_c}$ may be the best-suited method.

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Note: A complete list of the Adjusted, Complete and Straight Counts of Publications Output of LIS Researchers in South Africa is available on request.

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