

The *Contribution Score* Project

Introducing an alternative to full or fractional counting

Gunnar Sivertsen

Nordic Institute for Studies in Innovation, Research and Education, Oslo, Norway

NIFU

Lin Zhang

School of Information Management, Wuhan University, China



Outline

1. Background
2. The merits of and problems with fractional counting
3. Balancing scientific production across different areas of research and co-authorship practices
4. The *Contribution Score* project
5. Conclusion and further research

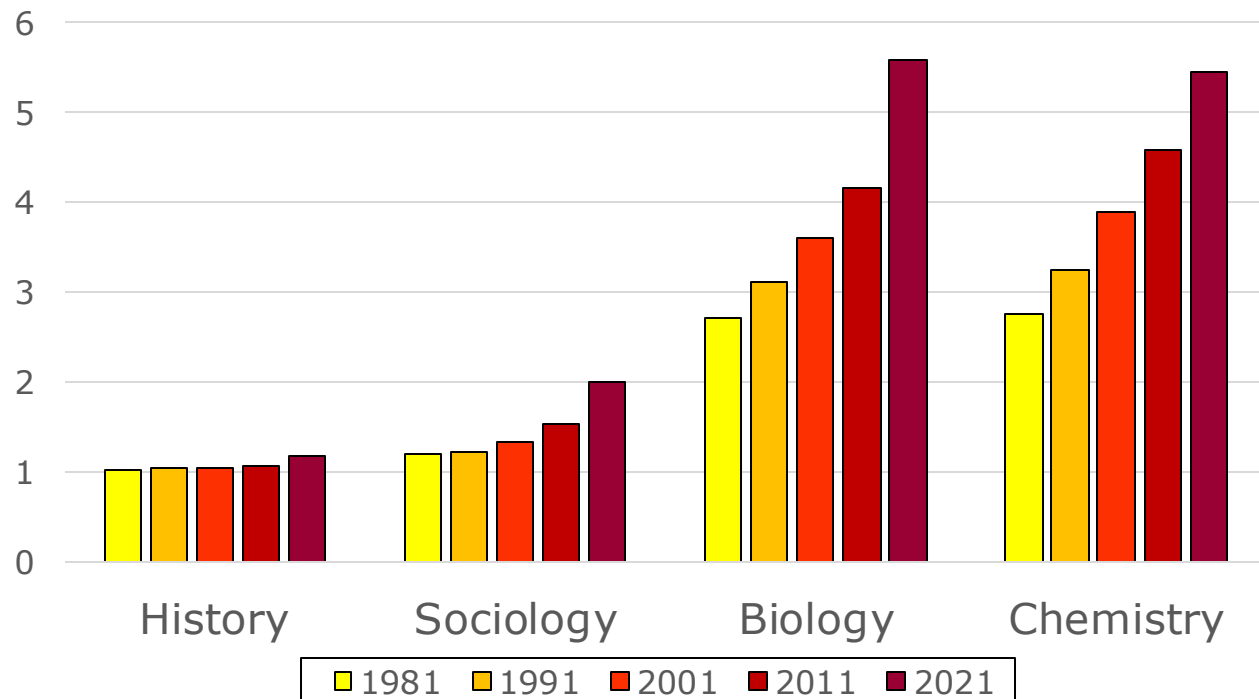
Outline

1. Background: Why is University of Waterloo losing impact?
2. The merits of and problems with fractional counting
3. Balancing scientific production across different areas of research and co-authorship practices
4. The *Contribution Score* project
5. Conclusion and further research: How can University of Waterloo reclaim her impact?

Collaboration is increasing



Authors per paper in Web of Science



Productivity seems to decrease

“The trend is for authors to produce more publications per year (increased fractionalization) but for the overall number of publications per author to decrease. We suggest that the effort required to participate in research collaborations is a factor in the decrease in publications per author.”

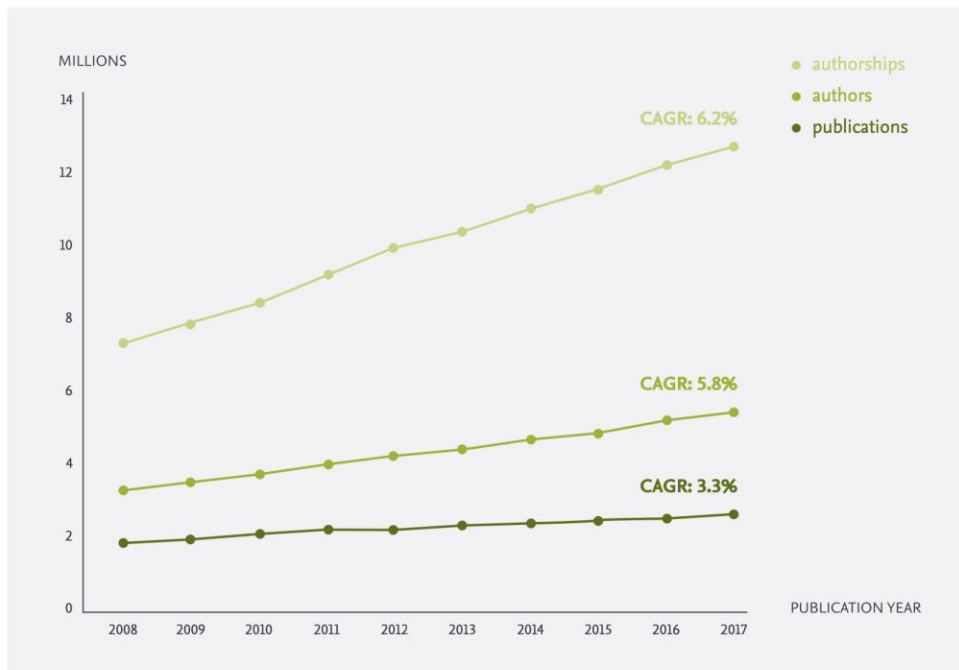



Figure 1: Trends of publications, unique authors, and authorships per publication year 2008–17 (millions). Compound Annual Growth Rate (CAGR) is shown for the same period.



Fractional Authorship & Publication Productivity

Highlights

- Authors divide their research output across publications, contributing via research collaborations
- The trend is for authors to produce more publications per year (increased fractionalization) but for the overall number of publications per author to decrease
- We suggest that the effort required to participate in research collaborations is a factor in the decrease in publications per author

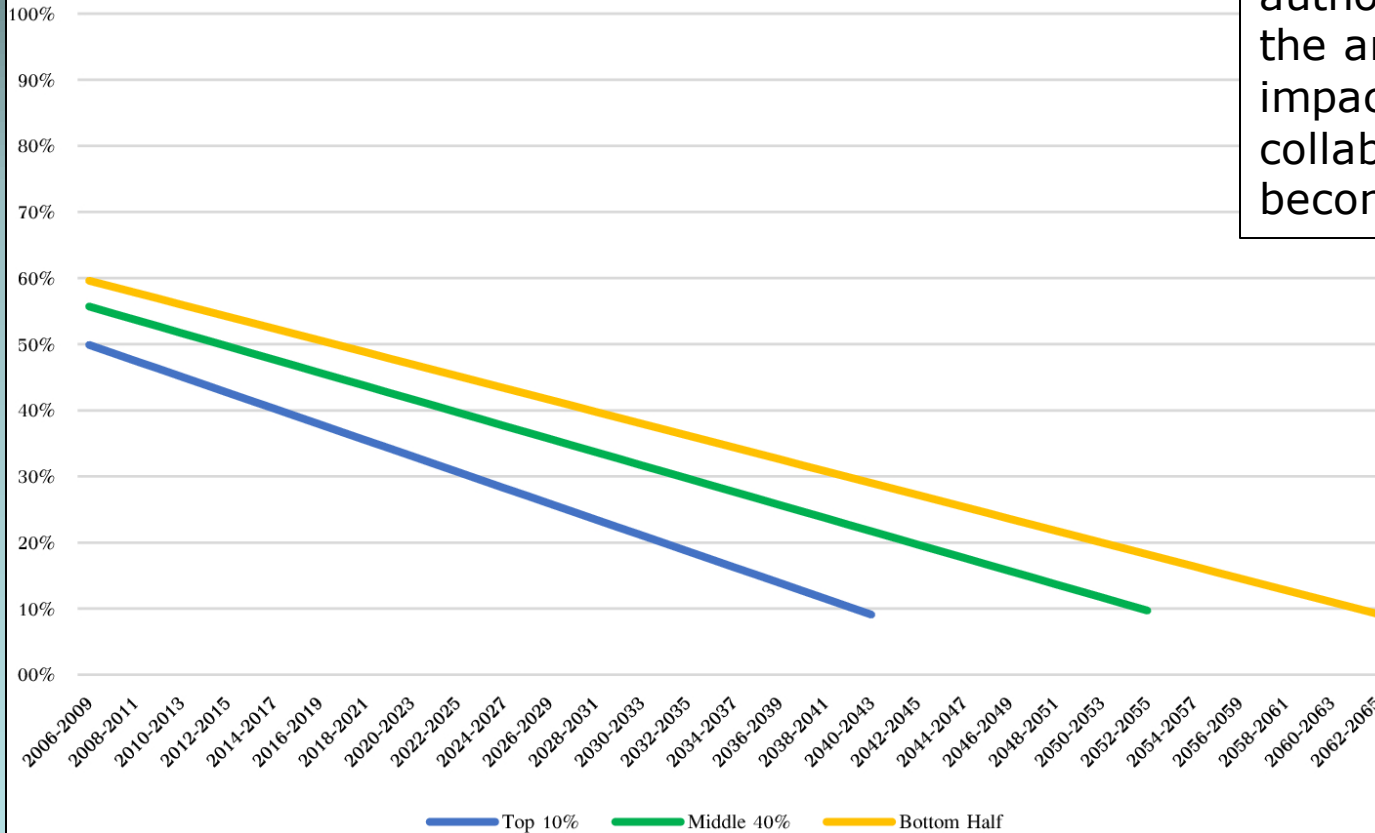
International Center for the Study of Research

© ICSR 2019

Gasson. K., Herbert. R. & Ponsford. A. (2019). Fractional Authorship & Publication Productivity. ICSR Perspectives. <https://dx.doi.org/10.2139/ssrn.3392302>

Citation impact seems to decrease

Trend in fractionalization by level of citation impact
(All universities, All Science)



“While the number of publications is rising along with the number of inter-university collaborations, the resulting division of authorship means that the amount of citation impact retained by each collaborating university becomes ever smaller.”

Demaine, J. Fractionalization of research impact reveals global trends in university collaboration. *Scientometrics* (2022).

<https://doi.org/10.1007/s11192-021-04246-w>

The example of University of Waterloo

The *Fractionalization* of impact

- As collaboration *increases*, fractional impact **decreases**
- “**Fractionalization ratio**”:
 - In 2006-2009:
 $4131 \div 6923 = 0.5967$
 - By 2015-2018:
 $5968 \div 11349 = 0.5258$
 - A **decrease** of 0.071 (~**12%**)
- *Collaboration ‘tax’ on impact*

| University | Period | Fractional Counting | Publications | Top 1% most cited |
|------------------------|-----------|---------------------|--------------|-------------------|
| University of Waterloo | 2006–2009 | 0 | 6923 | 76 |
| University of Waterloo | 2007–2010 | 0 | 7378 | 82 |
| University of Waterloo | 2008–2011 | 0 | 7894 | 84 |
| University of Waterloo | 2009–2012 | 0 | 8321 | 93 |
| University of Waterloo | 2010–2013 | 0 | 8864 | 101 |
| University of Waterloo | 2011–2014 | 0 | 9434 | 116 |
| University of Waterloo | 2012–2015 | 0 | 10030 | 131 |
| University of Waterloo | 2013–2016 | 0 | 10514 | 138 |
| University of Waterloo | 2014–2017 | 0 | 10981 | 187 |
| University of Waterloo | 2015–2018 | 0 | 11349 | 197 |
| University of Waterloo | 2006–2009 | 1 | 4131 | 41 |
| University of Waterloo | 2007–2010 | 1 | 4380 | 41 |
| University of Waterloo | 2008–2011 | 1 | 4699 | 38 |
| University of Waterloo | 2009–2012 | 1 | 4924 | 43 |
| University of Waterloo | 2010–2013 | 1 | 5210 | 40 |
| University of Waterloo | 2011–2014 | 1 | 5437 | 46 |
| University of Waterloo | 2012–2015 | 1 | 5679 | 57 |
| University of Waterloo | 2013–2016 | 1 | 5810 | 53 |
| University of Waterloo | 2014–2017 | 1 | 5898 | 80 |
| University of Waterloo | 2015–2018 | 1 | 5968 | 82 |

Jeffrey Demaine: Fractionalization of research impact reveals global trends in university collaboration. *BRIC 2021*, April 27, 2021

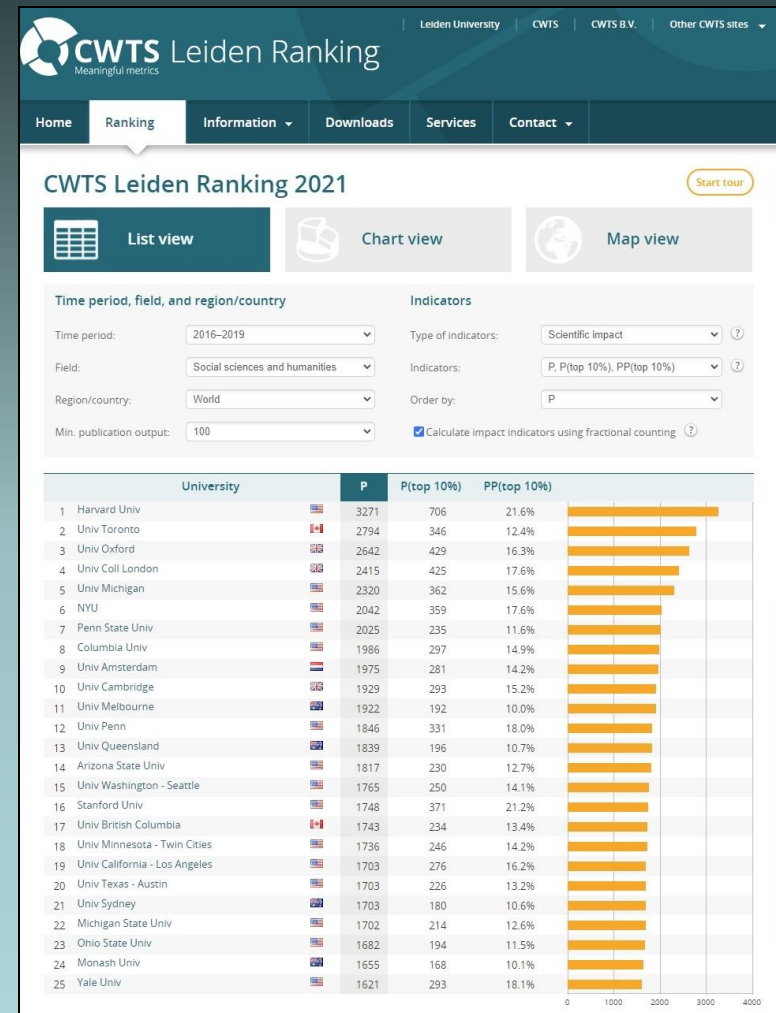
Outline

1. Background
2. The merits of and problems with fractional counting
3. Balancing scientific production across different areas of research and co-authorship practices
4. The *Contribution Score* project
5. Conclusion and further research

The merits of fractional counting

- “The fractional counting method leads to a **more proper field normalization** of scientific impact indicators and therefore to fairer comparisons between universities active in different fields.
- For this reason, fractional counting is the preferred counting method for the scientific impact indicators in the Leiden Ranking.”

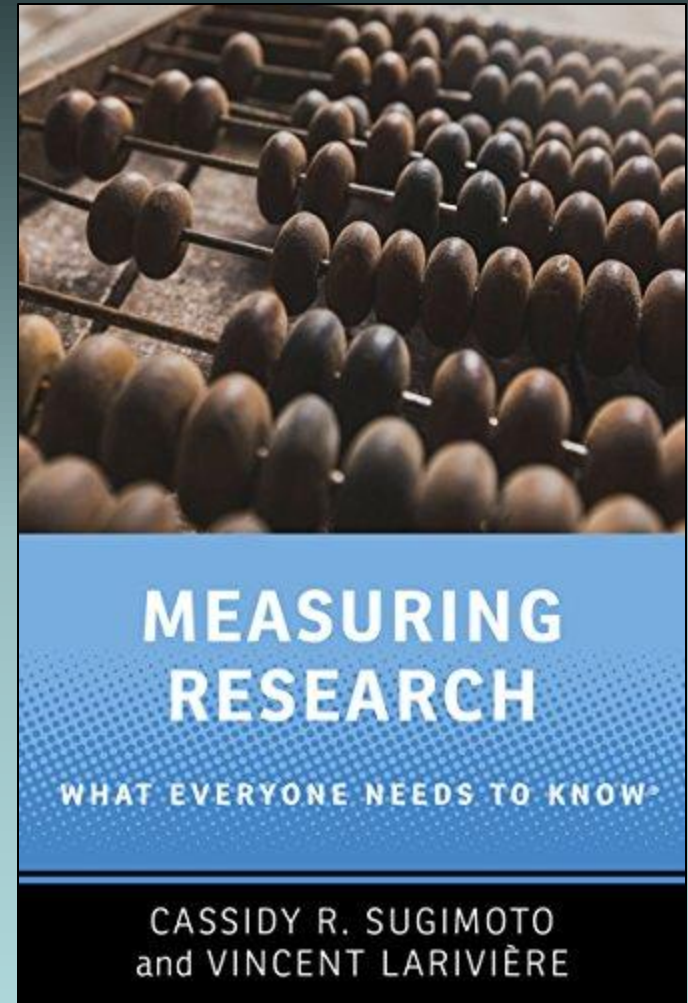
CWTS Leiden Ranking. Information. Indicators.
<https://www.leidenranking.com/information/indicators>



The merits of fractional counting

- When researchers collaborate, “full counting methods lead to an inflated perception of the actual output”.
- “The advantage of fractional counting is that **the sum of articles of all units in the system is equal to the actual output in the system.**”

Sugimoto, C.R. & Larivière, V. (2018). Measuring Research: What Everyone Needs to Know. New York: Oxford University Press, 54-55.



The problems with fractional counting

- Ethics in scientific publishing require that all authors are responsible for the work as a whole.

The screenshot displays the ICMJE website interface. At the top left is the ICMJE logo and the text "INTERNATIONAL COMMITTEE of MEDICAL JOURNAL EDITORS". To the right is a search bar with the placeholder "Enter search terms" and a "SEARCH" button. Below the header is a navigation menu with five items: "Recommendations", "Conflicts of Interest", "Journals" (with a sub-link "Stating That They Follow the ICMJE Recommendations"), "About ICMJE", and "News & Editorials".

The main content area is divided into two columns. The left column is titled "Recommendations" and features a highlighted box for "Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals*". Below this box, there are two sub-sections: "I. About the Recommendations" and "A. Preparing a Manuscript for Submission to a Medical Journal". Below the box is a paragraph: "Read the Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly work in Medical Journals." At the bottom of this column are two buttons: "BROWSE" (with a computer icon) and "DOWNLOAD" (with a download icon).

The right column is titled "Conflicts of Interest" and features a highlighted box for "ICMJE Form for Disclosure of Potential Conflicts of Interest". Below this box is a paragraph: "Use the ICMJE Form for Disclosure of Potential Conflicts of Interest to generate a disclosure statement for your manuscript." At the bottom of this column is a button: "ACCESS THE FORM" (with an information icon).

The problems with fractional counting

- The implementation of CRediT – Contributor Roles Taxonomy – in scientific publishing has confirmed that tasks are overlapping in teamwork



CRediT (Contributor Roles Taxonomy) is high-level taxonomy, including 14 roles, that can be used to represent the roles typically played by contributors to scientific scholarly output. The roles describe each contributor's specific contribution to the scholarly output.

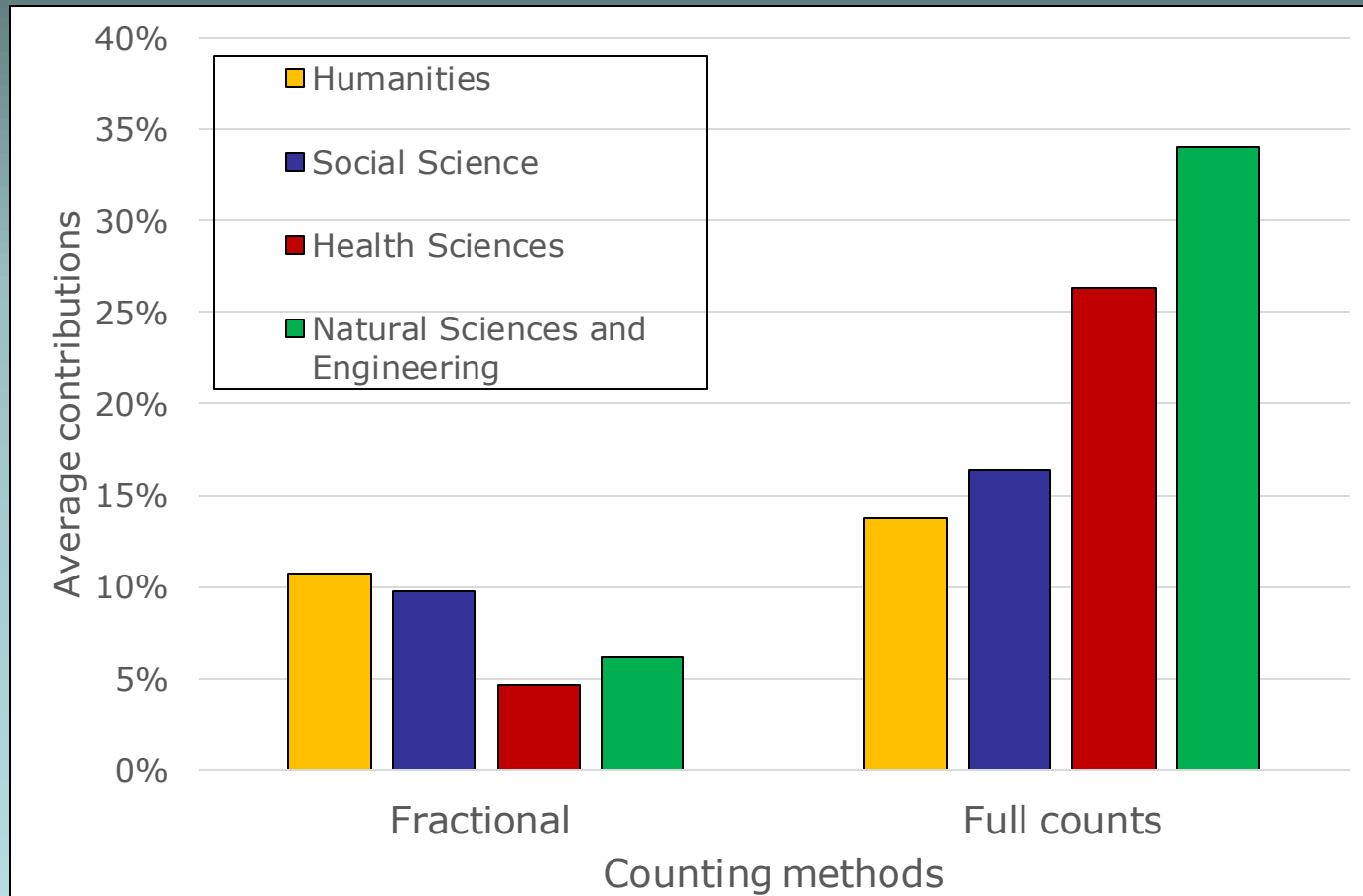
14 Contributor Roles

Conceptualization
Data curation
Formal Analysis
Funding acquisition
Investigation
Methodology
Project administration

Resources
Software
Supervision
Validation
Visualization
Writing – original draft
Writing – review & editing

The problems with fractional counting

- We do not find that fractional counting leads to proper field normalization



The problems with fractional counting

- And why should productivity and citation impact decrease globally as collaboration increases?



Outline

1. Background
2. The merits of and problems with fractional counting
3. Balancing scientific production across different areas of research and co-authorship practices
4. The *Contribution Score* project
5. Conclusion and further research

Modified fractional counting (2019)

- “We propose a new counting method called modified fractional counting (MFC).
- This method is an intermediate counting method between fractional and full counting
- It eliminates differences in contributions that depend on co-authorship practices
- With this method, different areas of research also have a comparable average contribution”

Journal of Informetrics 13 (2019) 679–694

Contents lists available at ScienceDirect

Journal of Informetrics

journal homepage: www.elsevier.com/locate/joi

ELSEVIER

Journal of INFORMETRICS

Regular article

Measuring scientific contributions with modified fractional counting

Gunnar Sivertsen^a, Ronald Rousseau^{b,c}, Lin Zhang^{c,d,*}

^a Nordic Institute for Studies in Innovation, Research and Education, Oslo, Norway
^b University of Antwerp, Faculty of Social Sciences, B-2020 Antwerpen, Belgium
^c Centre for R&D Monitoring (ECOOM) and Dept. MSI, KU Leuven, Belgium
^d School of Information Management, Wuhan University, China

ARTICLE INFO

Article history:
Received 28 August 2018
Received in revised form 20 March 2019
Accepted 20 March 2019

Keywords:
Scientific contributions
Research output
Bibliometrics
Full counting
Fractional counting
Harmonic counting
Modified fractional counting
Sensitivity parameter
Performance indicators
Rankings
Leiden Ranking
Web of Science
Norwegian Science Index

ABSTRACT

We develop and propose a new counting method at the aggregate level for contributions to scientific publications called modified fractional counting (MFC). We show that, compared to traditional complete-normalized fractional counting, it eliminates the extreme differences in contributions over time that otherwise occur between scientists that mainly publish alone or in small groups and those that publish with large groups of co-authors. As an extra benefit we find that scientists in different areas of research turn out to have comparable average contributions to scientific articles. We test the method on scientists at Norway's largest universities and find that, at an aggregate level, it indeed supports comparability across different co-authorship practices as well as between areas of research. MFC is thereby useful whenever the research output from institutions with different research profiles are compared, as e.g., in the Leiden Ranking. Finally, as MFC is actually a family of indicators, depending on a sensitivity parameter, it can be adapted to the circumstances.

© 2019 Elsevier Ltd. All rights reserved.

1. Introduction

The statistics, evaluation, and funding of research is often based on a bibliometric quantification of the contributions of different actors (authors, institutions, countries). Yet, counting methods not only represent purely bibliometric or mathematical problems; they can, moreover, strongly affect decision making and resource allocation in research. Our study focuses on one of the most widespread applications of bibliometrics: methods for counting scientific articles. On an empirical basis, we ask how well the traditional counting methods represent the reality of scientific contributions and we offer a new solution, called modified fractional counting (MFC).

The most well known and widespread counting methods based on article data, are full counting and fractionalized counting. Full counting gives each contributing author one credit, i.e., five authors equals five credits. Fractional counting assigns a fraction of one credit to each author (Egghe, Rousseau, & Van Hooydonk, 2000; Ostroń, 2018; Waltman & van Eck,

* Corresponding author at: Centre for R&D Monitoring (ECOOM) and Dept. MSI, KU Leuven, Belgium.
E-mail address: zhanglin_117@1311.com (L. Zhang).

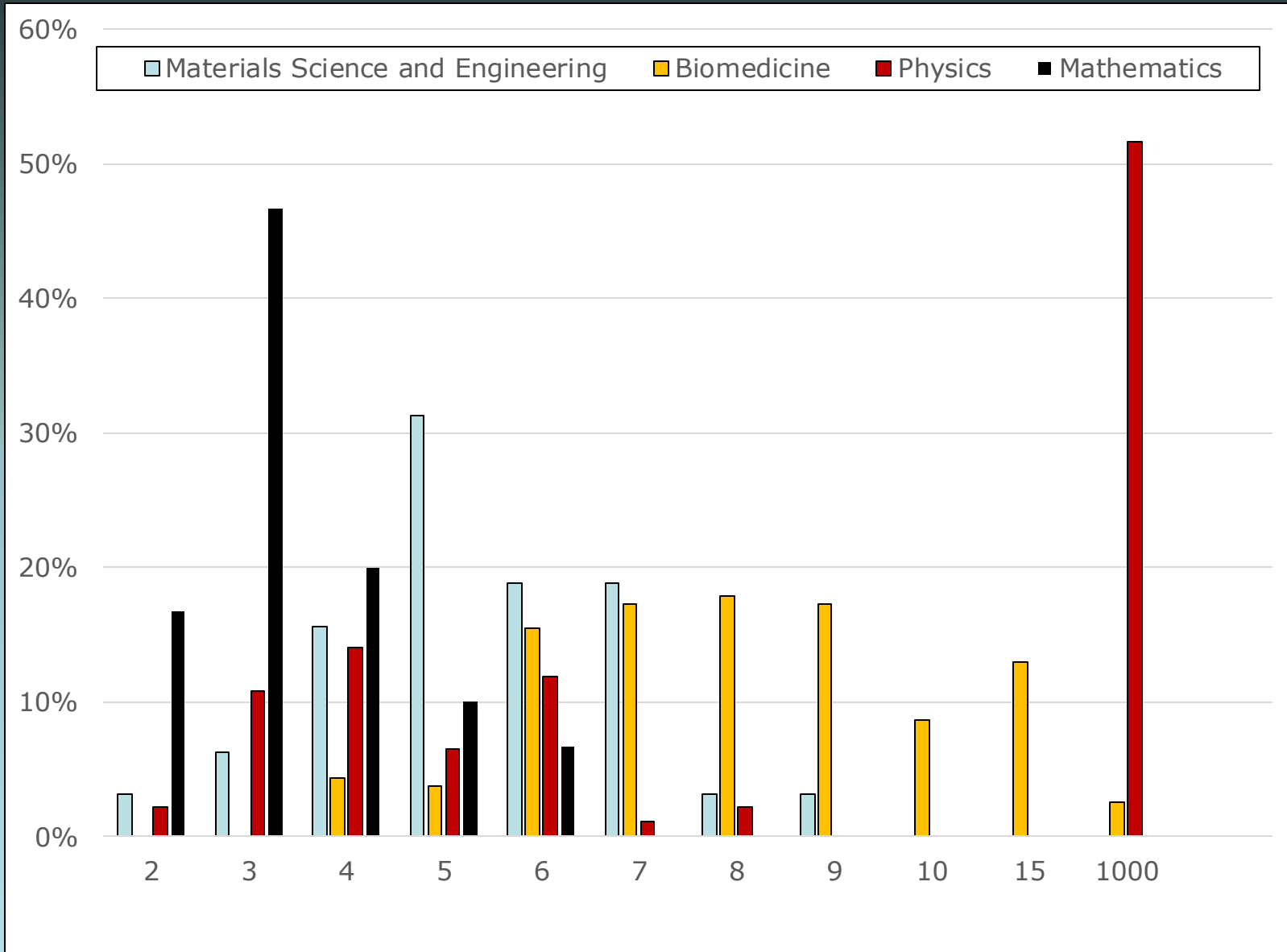
<https://doi.org/10.1016/j.joi.2019.03.010>
1751-1597/© 2019 Elsevier Ltd. All rights reserved.

Sivertsen, G., Rousseau, R., Zhang, L. (2019). Measuring Scientific Production with Modified Fractional Counting. *Journal of Informetrics*, 13(2): 679–694.

The 1,410 scientists in our sample are divided into 12 groups based on the median number of authors in their publications

| Group name | Number of researchers | Median number of authors in publications | Average number of authors in publications |
|-------------------|------------------------------|---|--|
| 1 | 2 | 1 | 1.3 |
| 2 | 26 | 1.5-2 | 2.7 |
| 3 | 99 | 2.5-3 | 3.6 |
| 4 | 154 | 3.5-4 | 4.5 |
| 5 | 216 | 4.5-5 | 6.6 |
| 6 | 273 | 5.5-6 | 8.1 |
| 7 | 197 | 6.5-7 | 8.7 |
| 8 | 143 | 7.5-8 | 10.2 |
| 9 | 93 | 8.5-9 | 11.5 |
| 10 | 54 | 9.5-10 | 14.6 |
| 15 | 89 | 10.5-15 | 19.1 |
| 1000 | 64 | 15.5-3,017 | 1,031.7 |

The distribution of co-authorship groups in four research fields

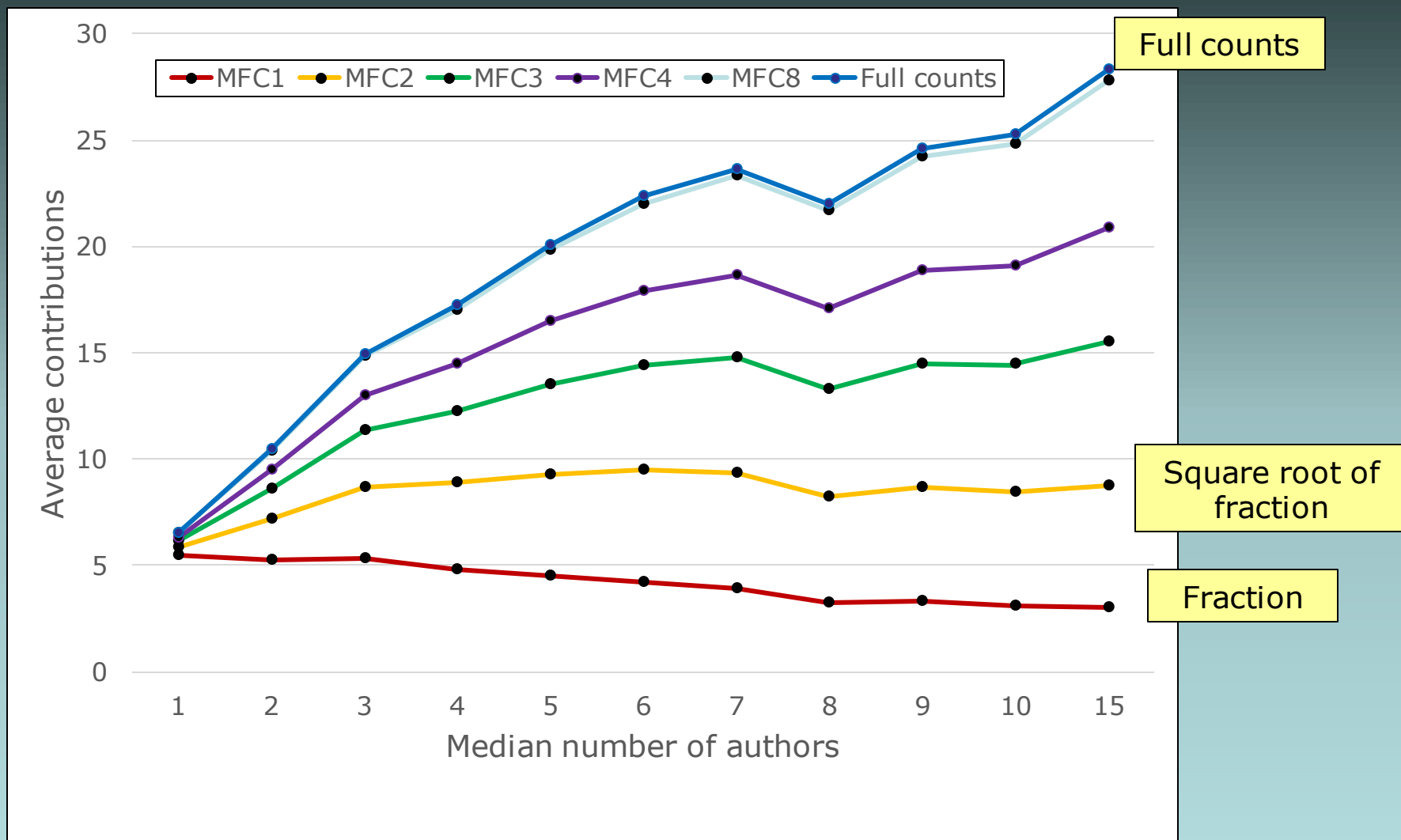


Modified fractional counting (MFC) using a sensitivity parameter that results in a continuum from fractional counting to full counting

- Author's share is $1/\sqrt[k]{N}$ where **N** is the number of authors and **k** is the order of the root

| | MFC1 | MFC2 | MFC3 | MFC4 | MFC8 | Full count |
|---------|------------|-------------|------------|------|------|------------|
| Authors | Fractional | Square root | Cubic root | | | Full count |
| N | k=1 | k=2 | k=3 | k=4 | k=8 | |
| 1 | 1,00 | 1,00 | 1,00 | 1,00 | 1,00 | 1,00 |
| 2 | 0,50 | 0,71 | 0,84 | 0,92 | 0,99 | 1,00 |
| 3 | 0,33 | 0,58 | 0,76 | 0,87 | 0,99 | 1,00 |
| 4 | 0,25 | 0,50 | 0,71 | 0,84 | 0,99 | 1,00 |
| 5 | 0,20 | 0,45 | 0,67 | 0,82 | 0,99 | 1,00 |
| 6 | 0,17 | 0,41 | 0,64 | 0,80 | 0,99 | 1,00 |
| 7 | 0,14 | 0,38 | 0,61 | 0,78 | 0,98 | 1,00 |
| 8 | 0,13 | 0,35 | 0,59 | 0,77 | 0,98 | 1,00 |
| 9 | 0,11 | 0,33 | 0,58 | 0,76 | 0,98 | 1,00 |
| 10 | 0,10 | 0,32 | 0,56 | 0,75 | 0,98 | 1,00 |

Modified fractional counting is based on the square root of the fraction

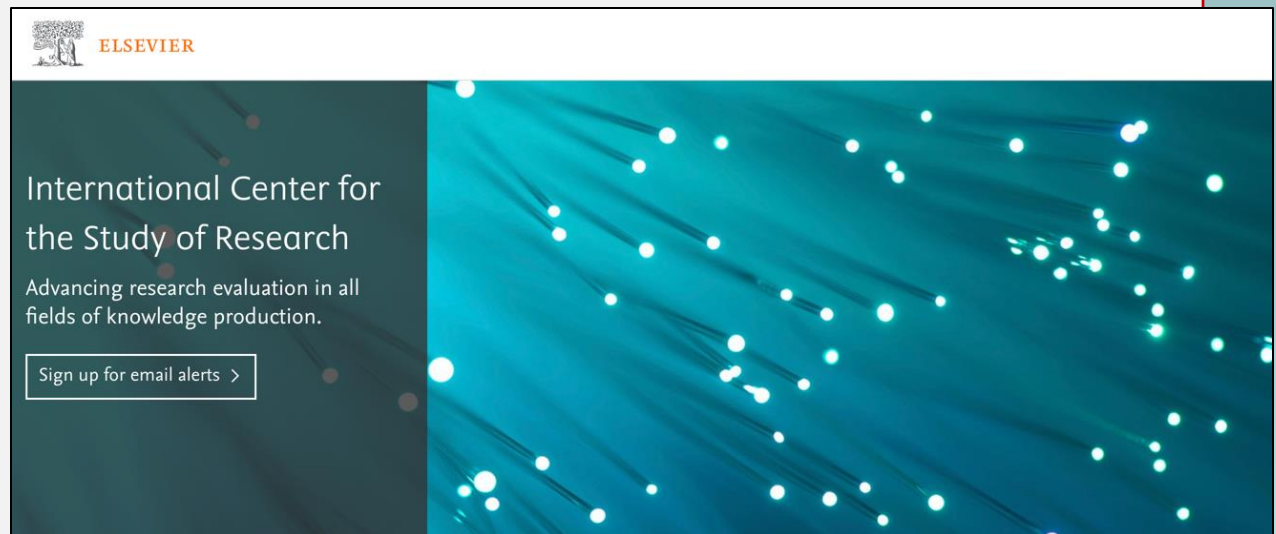


Outline

1. Background
2. The merits of and problems with fractional counting
3. Balancing scientific production across different areas of research and co-authorship practices
4. The *Contribution Score* project
5. Conclusion and further research

Project team

- Gunnar Sivertsen, Nordic Institute for Studies in Innovation, Research and Education (NIFU), Oslo, Norway
- Lin Zhang, School of Information Management, Wuhan University, China
- Alvin Shijie Ding, International Centre for Studies of Research, Beijing, China
- Rachel Herbert, International Centre for Studies of Research, Oxford, United Kingdom
- Andrew M. Plume, International Centre for Studies of Research, Oxford, United Kingdom



Aim

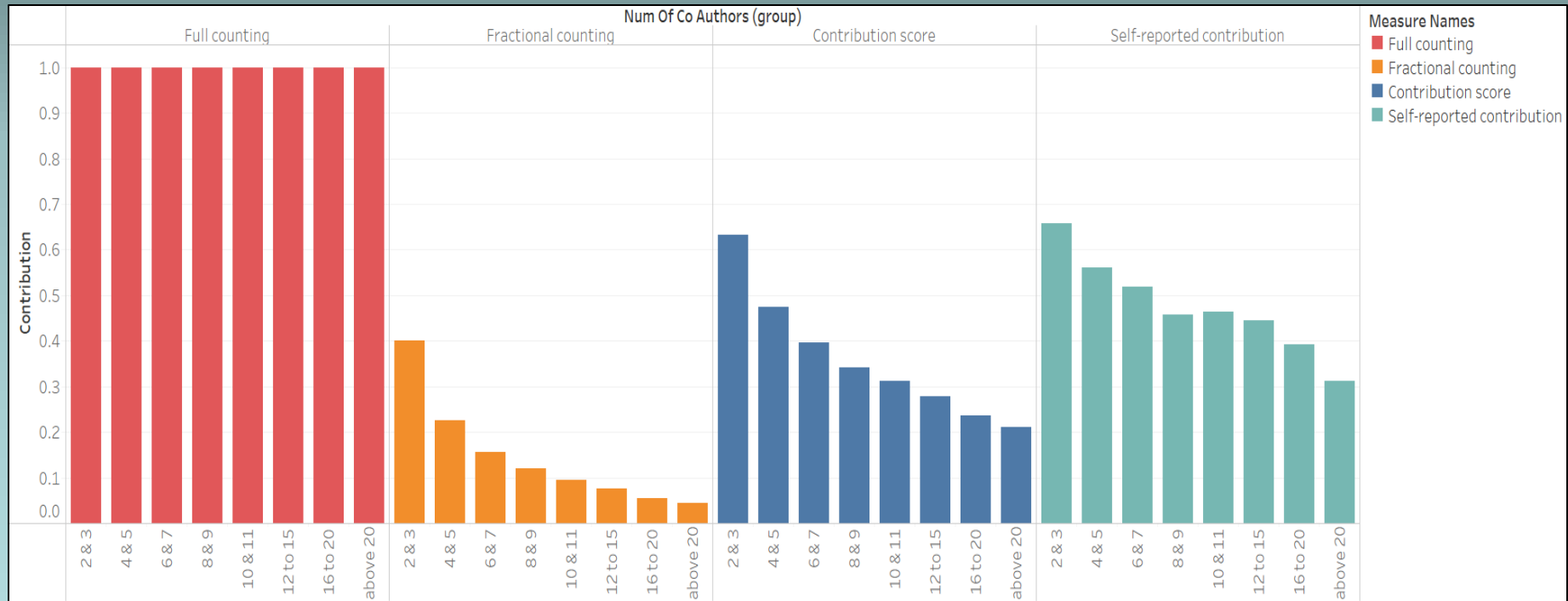
- To develop and validate a fairer indicator of individual contributions to co-authored publications by building on the MFC

Method: Survey

- We selected 49,455 authors worldwide from Scopus by applying four filters:
 1. At least one publication with a CRediT statement (casrai.org/credit) recorded in 2020 or 2021,
 2. variations in the numbers and names of co-authors among their publications,
 3. active with at least one publication each year 2016-2020, and
 4. a recorded email address.
- The authors were asked about their contributions to three recent publications. We asked for the types and degrees of their contributions versus those of their co-authors.
- The 2,812 respondents (5.7%) proved to be unbiased compared to non-respondents regarding gender, world region, research domain, career age, citation impact, and h-index.

Main result

- Self-reported contributions come closest to be simulated by Contribution Scores based on MFC
- The match is more perfect when publications by 1st authors are excluded.



Outline

1. Background
2. The merits of and problems with fractional counting
3. Balancing scientific production across different areas of research and co-authorship practices
4. The *Contribution Score* project
5. Conclusion and further research

Conclusion and further research

- We conclude that the *Contribution Score* can be validated as more suitable than full or fractional counting to represent individual contributions to teamwork in research.
- As the next step, we will investigate the possible application of *Modified Fractional Counting* to measure citation impact at the level of institutions and countries.
- Our hypothesis will be that the University of Waterloo can reclaim her citation impact.
- Special thanks to Jeff Demaine for inspiring us to contribute to BRIC. We hope to be able to visit Canada next time.