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## Method Article

# More than just a number of publications: Unity Index, an alternative “ranking” for bibliometric analyses



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## A B S T R A C T

This paper presents the unity index- an index designed in response to the call to find a more holistic way to assess scientific production. In this case, the scientific production is understood from a multivariate perspective using existing measurements, such as the number of publications, the number of, and the H-Index. It can be used especially when generating or assessing production in bibliometric studies. The index consists of a 3-part point system where points are assigned to the authors based on their position in the rank of the 3 traditional indicators for production, acceptance and impact. The index is calculated by attributing 1 point to the author with most published articles and increasing the number of points attributed by 1 to all the subsequent authors. The same point attribution is done to the remaining 2 indicators, acceptance -citations- and impact -h-index-. In the presented method, 3 different means of calculation are shared. Finally, the method is validated and different ways to analyze the results and generate insights are suggested.

- *The Unity Index offers a new way to assess scientific production from a multivariate perspective.*
- *The index can be calculated easily using MS Excel formulas, but automatic ways of calculation are also easily available.*
- *Bibliometric studies can profit from a less linear way to analyze the information and generate more insightful information and guide the research.*

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## A R T I C L E I N F O

*Method name:* Unity Index

*Keywords:* Bibliometric studies, Bibliometrix, Python, Scientometrics, Measure, Ranking, Scientific production, Quantitative research

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## Specifications table

Subject area:	Economics and Finance
More specific subject area:	<i>Bibliometric Studies in Management</i>
Name of your method:	<i>Unity Index</i>
Name and reference of original method:	<i>Non-applicable</i>
Resource availability:	<b>Mandatory software:</b> MS Office, R. <b>Optional Software:</b> Jupyter Notebook/Python

## Method details

A bibliometric study is part of the scientometrics field and is known for using statistical methods to analyze bibliographical data from a quantitative perspective [1,2]. It is mostly based on how authors cite and get cited, and on scientific production based on the number of publications. Therefore, it provides important criteria to select, evaluate, and monitor published research [3]. While these methods are not new, they have gained popularity among scholars with the rise of comprehensive bibliographic databases such as Clarivate Analytics' WoS database and Elsevier's Scopus database. In addition to the development open software tools [4], software tools for analyzing, such as Bibliometrix [5] or VOSviewer [6,7] were also developed.

Traditionally, the indicators to rank and position authors within bibliometric analyses are linear and show a lack of interaction between them. The standard way to assess the production is the number of publications, while acceptance is by the number of citations, and the impact measurement is by the H-Index [8]. When studied, these linear indicators can be merely informative and might present an incomplete picture of the authors, adding little value to the results and the understanding of the field.

Assessing researchers based on their production or linear indicators has created a publish or perish culture, where authors are pushed to publish in quantity and not in quality [9,10]. This is counterproductive for research development due to the increase in the number of available papers, which can negatively affect the quality of the scientific production [11]. This culture is not new, and existing proposals have attempted to change it. The Leiden Manifesto is one of the most prominent initiatives and promises a revised assessment of the scientific production based on the utility and the push of scientific cooperation [12]. Yet, this and other similar initiatives look for a systematic change.

A change proposed by initiatives like the Leiden Manifesto is desired, but a change of that magnitude will take generations to happen. As a short-term response, I propose a new way to assess scientific production using the existing indicators for production, acceptance, and impact, but breaking the aforementioned linearity and generating relationships between them.

This response is called the unity index and is a 3-part point system in which the authors are assigned points based on their position in the rank on the 3 traditional indicators for production. The index is calculated by attributing 1 point to the author with most published articles and increasing the number of points attributed by 1 to all the following authors according to their rank. As such, the author with the second highest number of publications gets 2 points, the author with the third highest number of publications gets 3 points, etc. The same point attribution is done for the remaining 2 indicators: acceptance -citations- and impact -h-index-. After the point attribution, the unity index is calculated by adding the 3 components, as shown in equation 1.

Equation 1: Unity index

$$\uparrow \text{Unity Index} = \downarrow \text{PointsPublication} + \downarrow \text{PointsCitations} + \downarrow \text{PointsH}_{\text{Index}}$$

It is important to note that the Unity Index is initially designed with bibliometrics studies in mind. By that, the position of a specific author depends on the data set, and not on the overall production, which means that a specific author can lose or gain notoriety depending on the field or query used to retrieve the data set. This variability is a strength of the index because it gives the researcher the possibility to assess the authors based on specific cases, and gives the opportunity for niche authors to find their way up in terms of assessment. An example of this change of position is shown in the method validation section, along with an example of the different types of analysis that this type of relationship can bring.

The process of calculating the Unity index consists of 2 major parts: the generation of the input and the calculation of the Index. The first part, which is also the standard for all bibliometric analyses, is the search and the compilation of the bibliometric data. In this step, the researcher can choose any bibliometric database available, two of which are Clarivate Analytics' WoS database and Elsevier's Scopus. After choosing the fitting database, the researcher will have to run and define a search query that satisfies the needs of the study. While there is no good or bad query, it is crucial that the query responds to the needs of the project in terms of limitations and expansion in order to ensure the quality of the input.

Once the data is retrieved, a database including all the bibliometric data is downloaded. For the unity index, the basic information required is the name of the author and the citation map, which is usually downloaded by default from any of the major databases. After downloading the data, the researcher will treat the data using a bibliometric tool- in this case, I recommend Biblioshiny, a web service from the Bibliometrix<sup>1</sup> library running in R [5], because of its user-friendly scheme for non-coder researchers. In Fig. 1, the basic script to access Biblioshiny in R is displayed. These 2 lines of code are sufficient to access the platform and explore it at its full potential.

```
> library(bibliometrix)
To cite bibliometrix in publications, please use:

Aria, M. & Cuccurullo, C. (2017) bibliometrix: An R-tool for comprehensive science mapping analysis,
Journal of Informetrics, 11(4), pp 959-975, Elsevier.

https://www.bibliometrix.org

For information and bug reports:
- Send an email to info@bibliometrix.org
- Write a post on https://github.com/massimoaria/bibliometrix/issues

Help us to keep Bibliometrix free to download and use by contributing with a small donation to support our

To start with the shiny web-interface, please digit:
biblioshiny()

> biblioshiny()
```

Fig. 1. biblioshiny Basic Script in R.

Once Biblioshiny is loaded, a web browser tab will open, and the researcher can upload the database downloaded from the bibliometric software. With this step, shown in Fig. 2, the researcher will be able to manipulate the data and generate multiple classic bibliometric analyses.

After the dataset is properly loaded onto the tool, the generation of the dataset commences by downloading 3 documents: most relevant authors, most locally cited authors, and author impact. In order to do that, it is important that the researcher makes sure that all the authors of the database are selected, the number of documents (Authors > Most Relevant Authors), the number of local citations (Authors>Most Local Cited Authors), and the H-index (Authors > Authors Impact). In Fig. 3, the sequence of clicks to access and download the data is shown.

After downloading these 3 documents, the researcher will create a newly compiled document in which all the information will be available comprehensively. A suggested method to compile this document is using MS Excel function VLOOKUP<sup>2</sup>, with the author's name as the lookup value. After the compilation of the information, the researcher will have a 4-column matrix including Authors, Articles, LocalCitations, and h\_index. Here, it is important to respect the names and order of columns if the researcher is planning to calculate the index automatically using the python repository or the MS Excel macro available in GitHub<sup>3</sup>.

<sup>1</sup> <https://www.bibliometrix.org/home/>.

<sup>2</sup> <https://support.microsoft.com/en-us/office/vlookup-function-0bbc8083-26fe-4963-8ab8-93a18ad188a1>.

<sup>3</sup> <https://github.com/cplata21210/UnityIndex>.

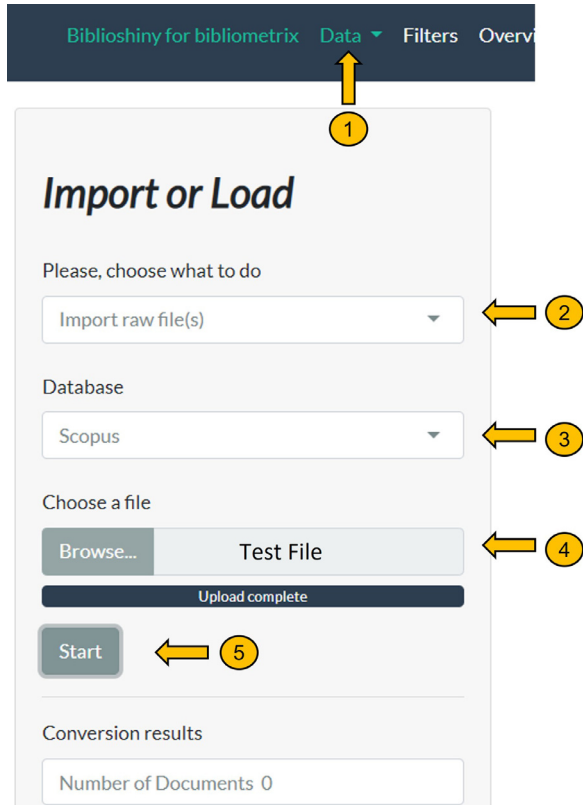


Fig. 2. Upload The Bibliometric Dataset.

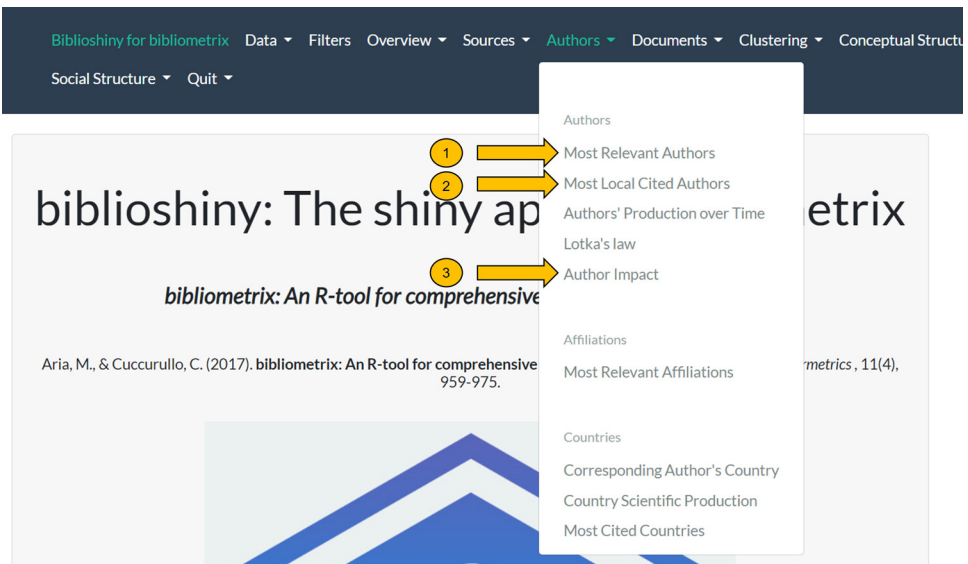


Fig. 3. Generating Input Dataset.

The previous steps conclude the first part, by the end of which the data set would be ready to use. Now, the calculation of the index begins, following either of the three methods mentioned next. The first, is using MS Excel functions, the second using an MS Excel macro, and the third using a Python script running in a Jupyter Notebook.

*Calculation of the Unity Index using MS Excel functions*

To calculate the Unity Index using MS Excel function, the input needed is the dataset retrieved before, and the correct use of the functions RANK.EQ<sup>4</sup>, and SUM. Assuming that columns A, B, C, and D are labeled, Authors, Articles, LocalCitations, and h\_index respectively, the researcher should then label the columns E to J as follows: PointsPublication, PointsCitations, PointsH-Index, UnityIndex, UnityRank, and RaiseInRank (Fig. 4).

	A	B	C	D	E	F	G	H	I	J
1	Authors	Articles	LocalCitations	h_index	PointsPublication	PointsCitations	PointsH-Index	UnityIndex	UnityRank	RaiseInRank
2	Author 1	21	9	14						
3	Author 2	11	5	10						
4	Author 3	8	9	4						
5	Author 4	7	2	6						
6	Author 5	7	1	6						
7	Author 6	6	1	4						
8	Author 7	6	36	5						
9	Author 8	6	3	3						
10	Author 9	6	0	5						
11	Author 10	5	2	4						
12	Author 11	5	1	3						
13	Author 12	5	5	4						
14	Author 13	5	32	4						
15	Author 14	5	0	5						
16	Author 15	5	0	3						
17	Author 16	5	3	2						
18	Author 17	4	0	4						
19	Author 18	4	10	2						
20	Author 19	4	4	2						
21	Author 20	4	8	3						

Fig. 4. Columns Set Up.

In column E (PointsPublication), the point awarding function will be generated using the MS Excel function RANK.EQ. This function will give the author with the most published articles a total point of 1 and will add 1 point to each subsequent author. In the case that multiple authors share the same amount of publications, the function will attribute the same amount of points to all these authors. For columns F (PointsCitations) and G (PointsH-Index), the researcher will use the same function RANK.EQ and change the input values for the corresponding column.

The UnityIndex is calculated in column H by adding the points gained by each author in columns E, F, and G, which will give the researcher a combined view of the author's production, acceptance by the community, and impact. Hereby, it is important to note that, counterintuitively, the author with the best performance is the author with the least points in the Unity Index. Additionally, in column I, the rank based on the Unity Index will be calculated by using again the function RANK.EQ. However, unlike columns E through G where the points are attributed in a descending order -the author with the most publications will get the least number of points- here, the researcher will change the parameters to organize the data in ascending order, giving the highest rank position (1) to the author with the lowest Unity Index.

Additionally, and to understand the rise in rank or the change of the positions when compared linearly from publication output and the unity index, a subtraction between the column E -

<sup>4</sup> <https://support.microsoft.com/en-us/office/rank-eq-function-284858ce-8ef6-450e-b662-26245be04a40>.

PointsPublications- and column I -UnityRank- is done in the column J -RaiseInRank-. As a final step to present the data in a more aesthetic way, column J can be formatted to graphically show the rise in rank, and a bubble chart as well as a bar chart can be plotted. It is recommended to choose the first 25 authors with the best performance in the Unity Index and plot a bubble chart with the x-axis showing the number of publications and the y-axis showing the number of local citations, with the size of the bubble representing the H-Index. As for the bar chart, the same 25 authors will be plotted, but in this case, the Raise in Rank column will be the input, as shown in the example used in Fig. 5.

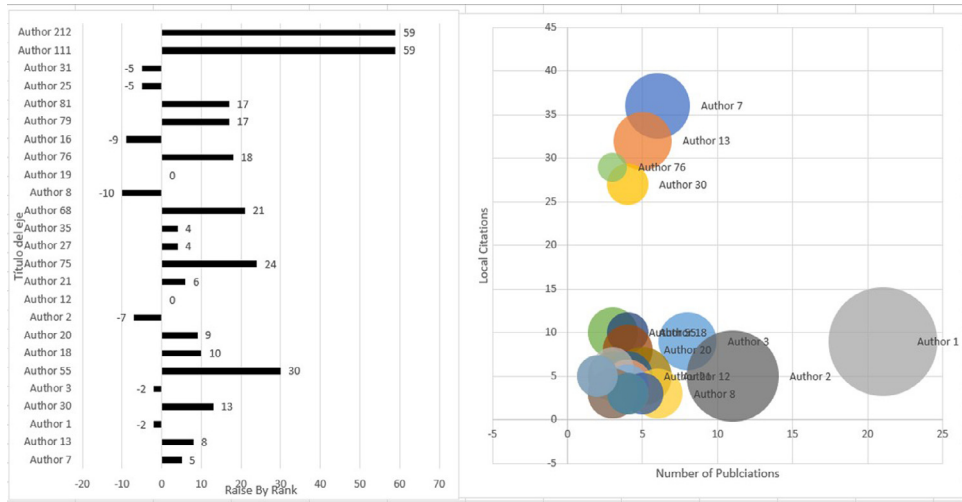


Fig. 5. Example of Plotting.

#### Calculation of the Unity Index using MS Excel macro

Another way to more automatically calculate the index is using the excel macro, Macro\_Unity\_Index, available on the Github repository. When downloading the macro, the researcher will find 3 sheets: the read-me sheet with some basic information and instructions, the Unity Index sheet where all the calculations are done, and the graph sheet where some key information gets plotted automatically.

After reading the information in the read me sheet, the researcher will proceed by pasting the information of the authors in the first 4 columns, as shown in Fig. 6.

After all the information is pasted on the correct columns, the researcher will proceed to run the macro by pressing *CTRL+h*, or by the route View > Macro > See Macro > Execute. Afterwards, the macro does the necessary calculations and displays the compiled information when done, as presented in Fig. 7.

On the Graphs sheet, a graphical representation of the information displayed in the matrix is delivered. This representation is set for the first 25 authors, yet it can be easily changed by adding or subtracting of the number of authors the researcher would like to present (Fig. 8).

#### Calculation of the Unity Index using python script

An additional automatic way to calculate the index while reducing the human error to a minimum is using the Python Script, Unity\_Index\_Github, available on the Github repository. It is important to note that for this method to be successful, the dataset file must respect the titles of the columns expressed earlier and should be saved as a TopUnity\_Data.CSV.

A	B	C	D	E	F	G	H	I	J
Authors	Articles	LocalCitation	h_index	PointsPublic	PointsCitatic	PointsH-Inde	UnityIndex	UnityRank	RaiseInRank
Author 1	21	9	14						
Author 2	11	5	10						
Author 3	8	9	4						
Author 4	7	2	6						
Author 5	7	1	6						
Author 6	6	1	4						
Author 7	6	36	5						
Author 8	6	3	3						
Author 9	6	0	5						
Author 10	5	2	4						
Author 11	5	1	3						
Author 12	5	5	4						
Author 13	5	32	4						
Author 14	5	0	5						
Author 15	5	0	3						
Author 16	5	3	2						
Author 17	4	0	4						
Author 18	4	10	2						
Author 19	4	4	2						
Author 20	4	8	3						

Fig. 6. Unity Index Macro Set-up.

A	B	C	D	E	F	G	H	I	J
Authors	Articles	LocalCitation	h_index	PointsPub	PointsCita	PointsH-Ir	UnityInde	UnityRan	RaiseInRa
Author 7	6	36	5	6	5	5	16	1	5
Author 13	5	32	4	10	6	8	24	2	8
Author 1	21	9	14	1	64	1	66	3	-2
Author 30	4	27	2	17	8	42	67	4	13
Author 3	8	9	4	3	64	8	75	5	-2
Author 55	3	10	3	36	33	16	85	6	30
Author 18	4	10	2	17	33	42	92	7	10
Author 20	4	8	3	17	74	16	107	8	9
Author 2	11	5	10	2	104	2	108	9	-7
Author 12	5	5	4	10	104	8	122	10	0
Author 21	4	5	3	17	104	16	137	11	6
Author 75	3	5	3	36	104	16	156	12	24
Author 27	4	4	3	17	126	16	159	13	4
Author 35	4	4	3	17	126	16	159	13	4
Author 68	3	6	2	36	90	42	168	15	21
Author 8	6	3	3	6	162	16	184	16	-10
Author 19	4	4	2	17	126	42	185	17	0
Author 76	3	29	1	36	7	156	199	18	18
Author 16	5	3	2	10	162	42	214	19	-9
Author 79	3	3	3	36	162	16	214	19	17

Fig. 7. Output of the Unity Index Macro.

When downloading the python script, the researcher will open it using Jupyter Notebook, which is easily available via Anaconda Navigator <sup>5</sup>. For a less experienced researcher in terms of coding, it is recommended that all the files (dataset, python script) be saved in the same folder. With this, the probability of encountering an error from the code is reduced.

<sup>5</sup> <https://www.anaconda.com/>.

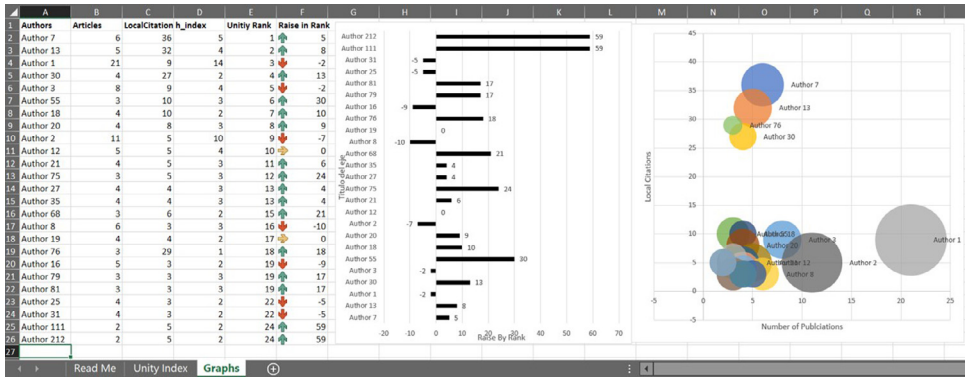


Fig. 8. Graphical representation of the Unity Index.

After opening the Jupyter notebook, the only action needed to run the code is clicking the run button at the top of the page, as shown in Fig. 9. The run button should be clicked once for every cell. It is important to note that the code is very efficiently crafted, and does not necessarily need high-end hardware, but can run on almost every system in a very efficient way and without having any compatibility problems.

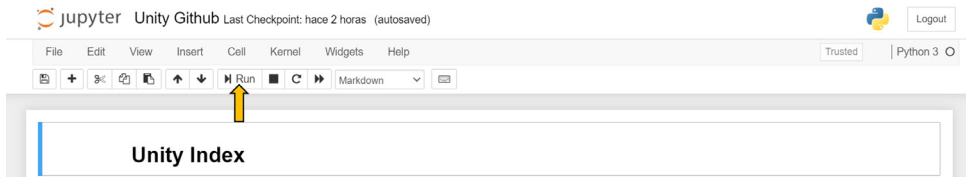
The script used to calculate Unity in an automatic way is found below. It is important to note that in the available GitHub<sup>6</sup> there is no need to write any code, since this is already parametered correctly

```
def TopUnity(df, cr_file):
    top = np.ones([len(df.columns), len(df)])
    for i, col in enumerate(df.columns[1:]):
        top[i, :] = df[col].rank(method='min', ascending = False)
    unity = top[0, :] + top[1, :] + top[2, :]
    TopU = pd.DataFrame(np.column_stack((df['Authors'], unity)), columns =
    ['Authors', 'Unity'])
    uni_sort = TopU['Unity'].rank(method='min', ascending = True)
    TopUni =
    pd.DataFrame(np.column_stack((df['Authors'], df['Articles'], df['LocalCitation
    ns'], df['h_index'], top[0, :], top[1, :], top[2, :], unity, uni_sort, top[0, :]-
    uni_sort)),
    columns =
    ['Authors', 'Articles', 'LocalCitations', 'h_index',
    'PointsPublications', 'PointsCitations', 'PointsH-
    Index', 'UnityIndex', 'UnityRank', 'RaiseInRank'])
    TopUni = TopUni.sort_values(by=['UnityRank'], ascending=True)
    if cr_file == True:
        TopUni.to_csv('TopUnity_file.csv', index=False)
    return(TopUni)
```

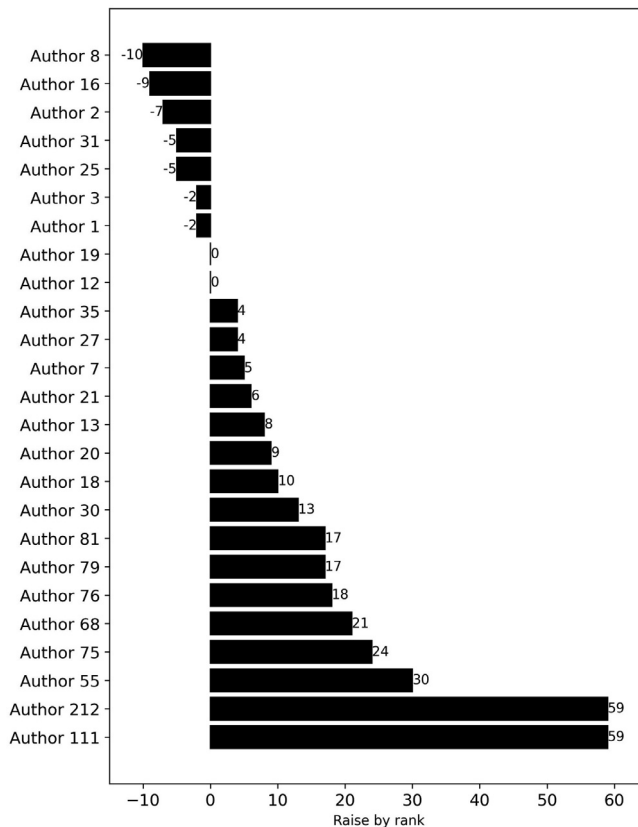
When the running process is finished, the researcher will find that the code generates and saves 3 files: the TopUnity\_file, where all the results of the calculations are compiled, the cross analysis file (Fig. 10), and the raise by rank graph file (Fig. 11).

<sup>6</sup> GitHub repository available: <https://github.com/cplata21210/UnityIndex>.





**Fig. 9.** Running the python script.



**Fig. 10.** Raised by rank Python Output.

Finally, as already mentioned, the code is set to plot the first 25 authors, yet, this could be changed. However, it is recommended that it is only changed by researchers that have some experience with python scripts, and if this is not the case, the researcher can contact the corresponding author via mail.

## Method Validation

To validate the mentioned model, the first step is to retrieve the information as shown in Fig. 12. The information retrieval section starts by choosing the information source. In this case, Elsevier's Scopus database was chosen based on the broad inclusion of journals and the detailed information it provides. After searching the abstract, title, and keywords of the Boolean words Mergers AND

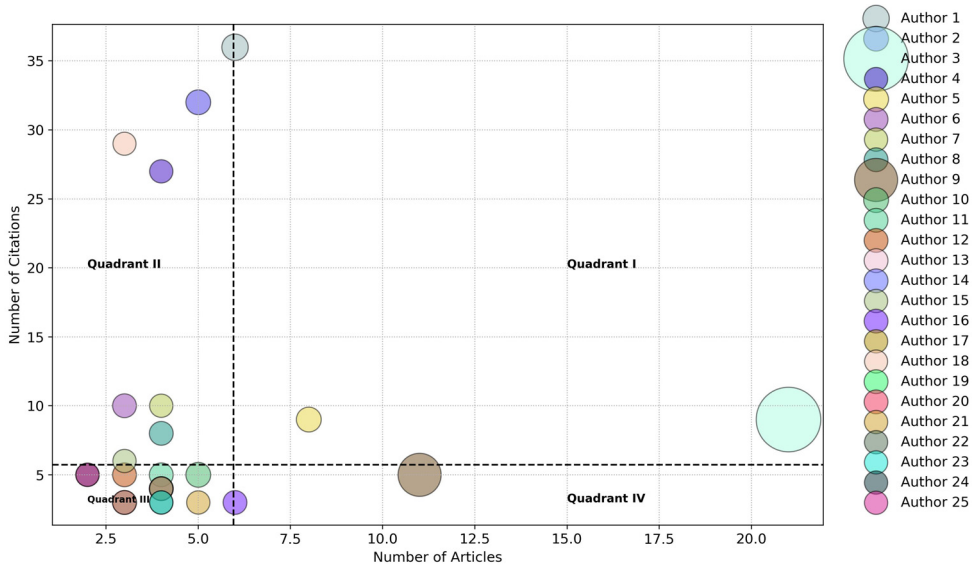


Fig. 11. Multivariable Analysis Python Output.

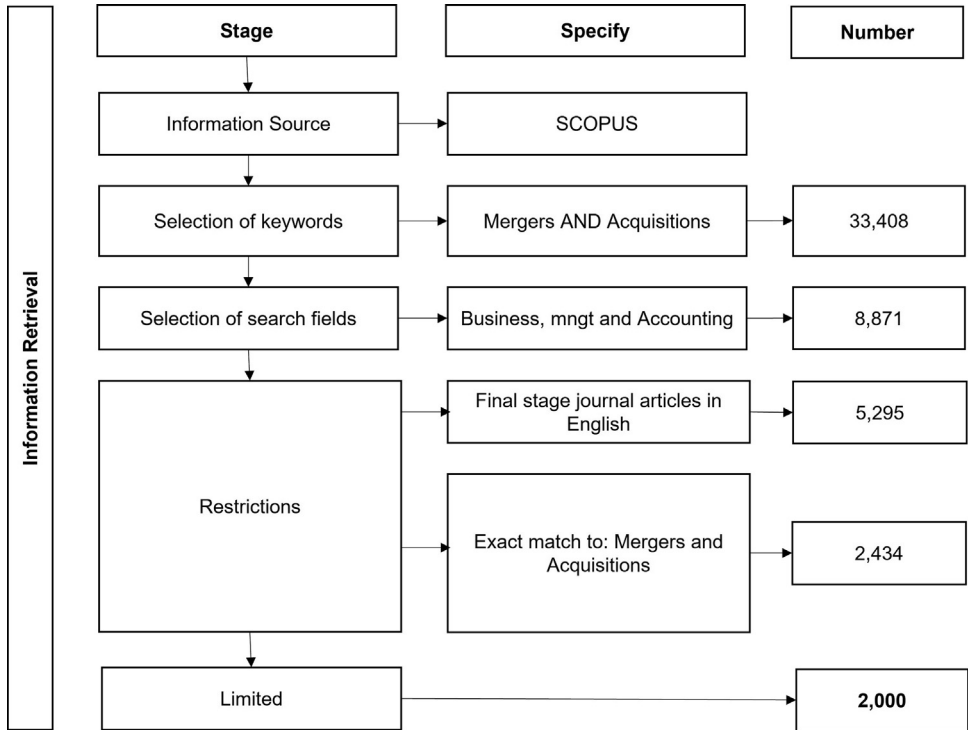


Fig. 12. Bibliometric Flow.

Acquisitions, a preliminary number of 33.408 hits was obtained. To limit the search, only articles inside the business, management, and accounting fields were considered, resulting in 8.871 hits.

To further refine the search, only journal articles written in English and in their final stage of the publication process were taken into account, which also lowered the number to 5.295. Furthermore, in order to focus the search, only articles with an exact match of the keywords Mergers and Acquisitions were considered, which brought down the count to 2.434<sup>7</sup> articles. Since this is a method validation, the final dataset was limited to 2.000 entries.

To begin, the software tools used to perform the analysis are the Bibliometrix pack [5] running in the R 4.2.2 version, and the Unity\_Index\_Github script, explained in the *Calculation of the Unity Index Python script* section, including the use of the matplotlib libraries in the version 3.5.2 python for the correct plotting of the information.

The first analysis, displayed in Fig. 13 shows how the different authors shift positions in the “ranking” when the position in the Unity index and the publications are compared.

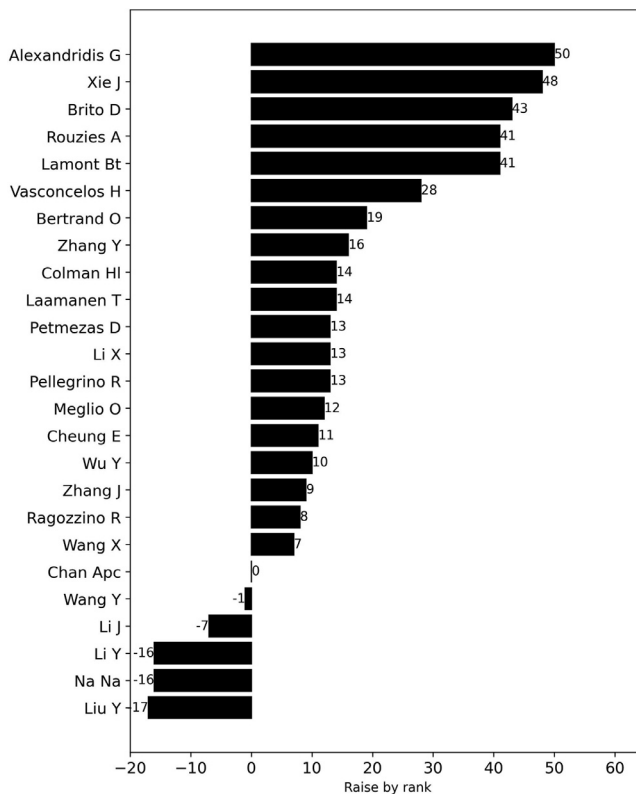


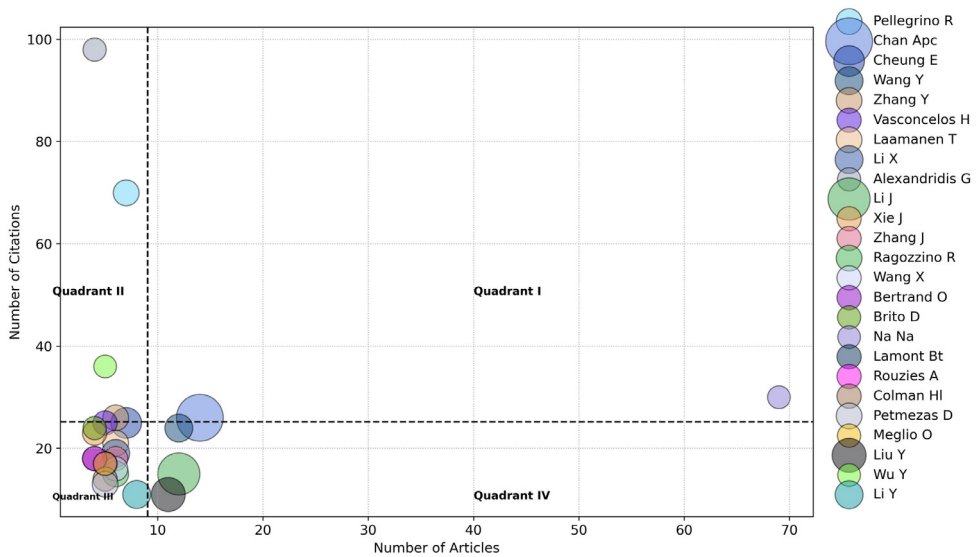
Fig. 13. Raise by Rank Validation.

Comparing the first 25 authors with the best Unity Indexes shows that, on average, each author gained 15 positions. Only 4 authors lost positions, while 19 authors gained positions, with Alexandridis G, Xie J, Brito D, Lamont Bt, and Rouzies A being the authors with most positions

<sup>7</sup> Elsevier's Scopus database final query: TITLE-ABS-KEY (mergers AND acquisitions) AND (LIMIT-TO (SUBJAREA , "BUSI")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (EXACTKEYWORD , "Mergers And Acquisitions")).

gained. This could be attributed to the fact that position-gaining authors are not as consistent in their productivity, so their position in the publication rank is not secure; however, their publications are quite accepted and have a higher impact, as measured by the number of publications and the H-Index—a trend in line with the Leiden Manifesto proposals [12]. This shows that the Unity Index is complying with its purpose to serve as a normalizing measure when compared to the linear traditional measures, and to give the opportunity of having a more complete view when assessing scientific production.

In Fig. 14, the unity index multivariable analysis is presented. Following the method explained before, the x-axis shows the number of publications, whereas the y-axis represents the number of local citations followed by the size of the bubble representing the H-Index. Additionally, the average line for each axis was presented to create 4 quadrants that will help understand how the pool of authors can be characterized.



**Fig. 14.** unity index multivariable analysis.

An example of how productivity does not necessarily translate to impact or acceptance within a specific part of a field is the case of Na Na. With 69 publications, more than double the average publications of the 25 authors with a better position in the Unity Index Ranking, Na Na falls behind the average in terms of the number of citations and the H-Index. In a traditional bibliometric analysis, this author would have been given the most credit, leaving behind authors like Rouzies A, who has a modest number of publications, right at the average, and yet, her publications are consistently being cited and have an impact.

Another example is Lui Y, an author with both the production and citations right above the average, yet with an under-average H-Index. This results in a position sharing with Alexandridis G, an author that has a low number of publications compared to the average yet has a number of citations 4 times above average. Both examples show how the Unity Index allows consistent authors to gain notoriety, and especially in bibliometric studies where the quantity measured is important to have alternative measures to unveil gem authors.

Additionally, the graph shows 4 quadrants which are based on the average citations and publications of the studied authors. In quadrant I, authors like Na Na, with publications and citations over the average, can be characterized as authors with a consistent publication rate and publication acceptance in the field. In quadrant II, authors like Pellegrino R have a high number of citations but an under-the-average productivity yet are authors that have well-accepted research.

Furthermore, in quadrant IV, authors like Li J, with over the average publications yet under the average citations are ones that still lack some acceptance from the community. This is not a weakness from the author's point of view, because not all the scientific production of the authors is assessed, just the portion that fits inside the query. It can be the case that the author is more prominent in other fields. Additionally, a deeper understanding of the literature using other types of research approaches such as Systematic Literature Reviews could help to understand these phenomena.

In the quadrant III, homogenous authors are found. There are authors that do not necessarily stand out in terms of production or acceptance, yet their contributions to the field is not assessed with the unity index. As the index is a calculated amount, this data closes the door to have external comparison. However, with that being said, it can be the case that an author with a low Unity Index in a certain dataset can be a top ranked author in a different data set.

Finally, the Unity Index could serve as a response to the publish or perish culture in the short term by using the available indicators to assess the researcher's productivity from a multivariate point of view, especially in highly quantitative studies such as the bibliometric studies.

## Conclusion

The motivation of this paper stems from the need to answer past calls for action such as the Leiden manifesto, that request the finding of easily implemented alternatives to measure and assess scientific production [12]. With this motivation in mind, the objective of this paper was to present an alternative approach, Unity, combining the three more traditional scientific production measures such as production, acceptance, and impact measured by the number of publications, citations, and the h-Index respectively.

Unity is calculated by adding the points assigned to each of the variables. The points are attributed by giving 1 point to the author with the most published articles and increasing the number of points attributed by 1 to all the subsequent authors. The same point attribution is done to the remaining 2 indicators acceptance -citations- and impact -h-index-.

This paper does not aim to add a new measurement of the researcher's work which would feed the publish or perish culture, but rather, to create a leeway measurement that could be useful while desired structural changes that are expected to take more time and require more extended discussions take place. In the meantime, the evolution of the linear measurements to a multivariate measure can serve a temporary solution.

With regards to policy, an index such as unity can serve as a "middle" man for extended structural changes, by giving the opportunity to slowly evolve the mindset of linear measures. The calculation of unity was thought of as a simple option that could be applied using one of the several previously mentioned techniques, and with this, it extends the opportunity to perform more robust bibliometric analyses.

## Declaration of Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

## Data Availability

Data will be made available on request.

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