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Quantity v/s quality of scientific publications: an analysis for main cities of Spain (2001-2007)

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Abstract

This new economic base, located in cities, is based on knowledge and information as sources of production and competitiveness. Therefore, cities are centers of knowledge production and dissemination. This work seeks to highlight the dynamics of scientific production in Spain. Specifically, it aims to analyze the quantity and quality of scientific publications in the period between 2001 and 2010. For this analysis, the quantity is measured by the number of scientific papers published by researchers from a city and the quality by the number of times that works signed by scientists from a city, are cited by researchers around the world. The results suggest a concentration of quantity and quality of the scientific production in the Spanish metropolitan areas. However, we can provide that ranking who have the main cities in the context of national scientific publication is not similar for both parameters.

Keywords: Bibliometrics, scientific publications, scientific quality, Spanish Cities

Introducción

Since the last quarter of the 20th century, much of the world population has been protagonist an important process of globalization, mainly due to; the accelerated knowledge production, the increase of intangible capital on a macroeconomic scale, the increase in levels of innovation, and the ICT revolution that have democratized access to information and knowledge dissemination [1], [2].

By Jafre & al.[3], the availability of personnel highly qualified, the spill overs of knowledge, the generation of localized cooperation links, or the viability of infrastructure-oriented scientific research are favored the spatial concentration of knowledge production in certain areas. However, in spite of the change in the pattern of global division of labor and the dematerialization of the economy, cities, now converted into metropolitan areas, are still the heart of innovation and scientific production on a global scale. Roca (2007) explains that in 1981 the top 75 metropolitan cities in the world produced 32.5 percent of scientific articles indexed by SCI-E of the ISI, while in 2001 their production increased by 42.2 percent [4].

This communication is part of a larger research project whose aim is to determine the impact of social capital in the location of innovation activities, both at the metropolitan area of Barcelona and at the level of regions of the Spanish state. It is therefore essential to establish the variables that allow, to assess and locate the innovation activities. As can be found in the literature, the scientific production is one of those variables. The number of scientific publications on indexed journals is a scale, often used to measure the degree of strength of the scientific sector of a particular place. But this scale ignores the quality of this works, ie the impact they have generated in the scientific world.

The document is organized: 1) first is exposed information obtained from SCI-E and results obtained. Moreover the extent and limitations of the information source, 2) Secondly, is analyzed through static and dynamic analysis, the state of production and productivity of 10 cities with the highest scientific production in the period 2001-2010, 3) and finally presents the preliminary findings and conclusions, in terms of quantity and quality of scientific production in the main cities of Spain.

Positioning of the main cities of Spain according to scientific production registered by the Institute for Scientific Information (ISI)

With the aim of providing a vision of the scientific production in Spain, makes an analysis of the number of publications registered by the ISI¹ during the period 2001-2007. In this first part of the paper, we use data derived from ISI due to the solidity of its information, both in quality (rigor in the selection of publications) and quantity. This database has indexed the publication of 5,900 scientific journals, in a range that covers more than 150 disciplines (according to ISI itself.)

However, it is important to note some limitations of the information.

1. The partiality of the scientific production. That is, the information we use is available at the time of the consultation², in which case any scientific production does not result in scientific publications is excluded as the production published in journals not indexed³ by ISI.
2. The temporal variation of the coverage. Annually, the ISI incorporates between 200 and 240 new journals to their databases, thus the information available varies nonlinearly between the cities studied. Therefore part of the spatial variation of the production is attributable to the progressive expansion of the ISI itself.
3. Spatial distribution. Like the first limitation, there is a partiality of information, although referred to space, because most of publications indexed by ISI are Anglo Saxon.⁴
4. The location of the author. Address information self reported by the authors do not guarantee the city where the publication originated, due to this may be the official or that is most convenient.

¹ Institute for Scientific Information aims to collect and summarize publications produced in different scientific knowledge areas. The information is organized in three areas: Science Citation Index Expanded (SCI-EXPANDED), Social Sciences Citation Index (SSCI) and Arts & Humanities Citation Index (A & HCI).

² Includes all journals indexed in Institute for Scientific Information whose inclusion process is complete.

³ It is important to note that the Institute for Scientific Information indexes only journals that he considers relevant to science and technology

⁴ ISI indexes only journals whose contents are in English, (as a minimum) the title, abstract and key words.

Therefore, the data must be treated cautiously since they are only valid for indicative purposes.

Through the ISI Web of Science ®, we realize the compilation of all available publications of the journals at the time of the query. The unit of study is the contribution to the city, obtained from the address that the author has claimed in the publication. The analysis we did for a total of 239 municipalities, of which, 238 correspond to municipalities with over 25,000 residents and the municipality of Arrasate or Mondragón (23,118 pop.) where is located the University of Mondragón.

Table 1: Positioning of the 10 major cities (2007)

	Science Citation Index Expanded (SCI- EXPANDED)	Social Sciences Citation Index (SSCI)	Arts & Humanities Citation Index (A&HCI)	Total (SCI-EXP) (SSCI) (A&HCI)
Madrid	11.080	787	269	12.136
Barcelona	9.617	831	129	10.577
Valencia	3.582	238	32	3.852
Granada	1.899	230	58	2.187
Sevilla	1.945	120	26	2.091
Zaragoza	1.434	101	25	1.560
Santiago	1.241	73	38	1.352
Murcia	1.132	81	23	1.236
Alicante	1.098	109	17	1.224
Oviedo	997	114	9	1.120

Source: ISI Web of Science

Table 1, shows the ranking of the top 10 positions of the total analyzed⁵ (239 municipalities). Moreover, we observed that the highest concentration of scientific publications is in cities of Madrid and Barcelona. The sum of the production of both cities representing 39% of total production in Spain for 2007

⁵ It is important to mention the case of Bilbao, due it is traditionally considered important in science and technology. However, in analyzing the volume of publications cannot add a sufficient number of scientific publications to be among the top 10 positions. We did the exercise, adding the city of Leioa publications (due the location of the University of the Basque Country), but even so, Bilbao ranks below, even under the municipalities of Pamplona, Salamanca, Córdoba since 2004.

Data & Methodology

Data derived from SciVerse Scopus⁶, because this source of information provides as the quantity of scientific publications as citations received over time. Just as the ISI, there are some limitations like the partiality of scientific production, temporal variation of the coverage and location of the author. However, in terms of spatial distribution SciVerse Scopus is more open and includes publication of around the world.

Through this web, it makes the recovery of all available publications of the journals at the time of the query. The unit of study, like previous analysis made with the ISI, is the contribution to the city, obtained from the address that the author has claimed in the publication. Moreover, it lists the number of times those publications, signed by scientists from a city are cited later by researchers around the world.

With the information obtained, it makes a static analysis (2010) and a dynamic analysis (evolution 2001-2007), for the production and the productivity. The production is measured through the quantity of scientific work and productivity is evaluated through two impact factors: Immediate impact factor (IIF) (1) and Half-life impact factor (HIF) (2).

$$IIF_{(x)} = \frac{C_{(x)} P_{(x-1)(x-2)}}{NP_{(x-1)(x-2)}} \quad (1)$$

Where:

IIF⁷ = Immediate impact factor (2 year), (**x**) = Year, which measures the impact, **C** = Total citations, **P** = Total Articles published in a specific period.

⁶ SciVerse Scopus (2004) is the database of citations and summaries of larger SciVerse de Elsevier, with more than 18,000 journals from more than 5,000 international publishers. The information is organized in four areas: Life Sciences, Health Science, Physical Science and Social Sciences & Humanities.

⁷ Immediate Impact Factor - 2 years (for example 2007) = 2007 citations to articles published in 2006-2005 / n ° of articles published in 2006-2005

$$HIF(x) = \frac{C_{(x)} P_{(x-1)(x-5)}}{NP_{(x-1)(x-5)}} \quad (2)$$

Where:

HIF^8 = Half-life impact factor (5 year), (x) = Year, which measures the impact, $C_{=}$ Total citations, $P_{=}$ Total Articles published in a specific period.

A static view of scientific publications in 2010

In the analysis of production, is observed the large number of scientific publications that accumulates Madrid and Barcelona, with the rest of the cities studied. However, the percentage distribution shows similar values for all cities. The main areas in the percentage of global scientific production are: 1) Life science, 2) Health science and 3) Physical science.

Table 2: Percentage distribution of scientific publications 2010

	Life science	Health science	Physical science	Social science & humanities	Global
Cities	a	b	c	d	e=a+b+c+d
Madrid	0,23	0,30	0,41	0,06	18.175
Barcelona	0,23	0,34	0,37	0,06	15.089
Valencia	0,24	0,29	0,41	0,06	5.758
Granada	0,23	0,23	0,08	0,46	3.113
Zaragoza	0,23	0,25	0,47	0,06	2.598
Sevilla	0,28	0,26	0,40	0,05	2.434
Murcia	0,29	0,32	0,31	0,07	1.887
Santiago	0,29	0,25	0,41	0,06	1.576
Alicante	0,25	0,34	0,35	0,06	1.554
Oviedo	0,22	0,30	0,41	0,06	1.479
Total publications	12.724	16.176	20.336	4.427	53.663

Source: ISI Web of Science

With the aim to synthesize the spatial distribution of scientific production, we calculated the coefficient of specialization. Table 3 shows the degree of specialization that each city presented of different areas of knowledge. The majority of cities surveyed have a

⁸ Half-life impact factor – 5 years (for example 2007) = 2007 citations to articles published between 2002-2005 / n ° of articles published between 2002-2005

specialization in the areas of Health Sciences and Physical science, with the exception of Sevilla, Murcia and Santiago who specialize (mainly) in the area of Life Sciences.

Table 3: Coefficient of specialization and diversity

Cities	Life science	Health science	Physical science	Social science & humanities	Diversity
Madrid	0,973	0,983	1,092	0,718	0,891
Barcelona	0,953	1,128	0,988	0,722	0,869
Valencia	1,026	0,956	1,083	0,701	0,885
Granada	0,988	0,775	0,199	5,537	0,934
Zaragoza	0,955	0,826	1,228	0,719	0,961
Sevilla	1,182	0,878	1,065	0,628	0,881
Murcia	1,236	1,065	0,829	0,867	0,820
Santiago	1,207	0,831	1,075	0,677	0,883
Alicante	1,048	1,131	0,915	0,772	0,846
Oviedo	0,941	1,009	1,079	0,770	0,885

Source: ISI Web of Science

Another important indicator is the index of diversity. When more varied is the scientific production, largest is the value it takes this indicator. Overall, are shown in Table 3, the highest diversity of the group of cities studied, is located in Madrid followed by Barcelona. In this case, the diversity makes it clear his relationship with the volume of publications, therefore, does not provide additional information to all cities, but it does show the behavior of the major cities.

Una visión estática de la producción y de la productividad científica.

In the productivity analysis, is observed the weak relation between the quantity and quality of scientific publications. The table 4 shows Madrid and Barcelona at the top in volume exceeding 28. 000 publications (total of 2 years). When is analyzed the quality of the IIF, Madrid is located in sixth place (IIF = 2,3) below Barcelona (1st position with IIF = 2,9).

Table 4: Production and productivity in 2010 through the IIF

Cities	Global		Ranking Immediate impact factor 2010				
	Publications	Citations	Life science	Health science	Physical science	Social science & humanities	Global
Barcelona	28.276	82.773	3,975	3,252	2,215	1,402	2,927
Santiago	2.951	7.974	3,513	2,681	2,381	1,220	2,702
Oviedo	2.574	6.584	3,706	2,294	2,411	0,842	2,558
Valencia	10.391	26.288	3,351	2,657	2,193	1,238	2,530
Granada	5.466	13.820	2,769	2,462	2,628	1,348	2,528
Madrid	33.340	76.719	3,303	2,449	1,812	0,932	2,301
Alicante	3.123	7.047	3,119	1,946	2,204	0,948	2,256
Zaragoza	4.586	10.111	2,893	2,225	2,006	1,024	2,205
Sevilla	4.429	9.646	3,171	2,279	1,659	0,896	2,178
Murcia	3.345	7.118	2,559	2,050	1,946	1,259	2,128

Source: web sciverse Scopus

Disaggregated data by area of knowledge show a similar behavior to the global situation. Barcelona lost the first position in the area of Physical science versus Granada, Oviedo and Santiago. In the case of Madrid is evident the fall of the IIF, mainly in areas of Physical Science (9th position) and Social science & humanities (8th position).

Table 5 shows again, Madrid and Barcelona at the top in terms of quantity, with more than 60,000 publications (total 5 years). However, the analysis of the quality of publications through the HIF, Madrid is located in seventh place, below cities like Santiago and Oviedo with a lower scientific production (less than 7,000 publications). On the other hand, Barcelona is located in the first position with a factor of 2.8.

Table 5 Production and productivity in 2010 through the HIF

Cities	Global		Ranking Half-life impact factor 2010				
	Publications	Citations	Life science	Health science	Physical science	Social science & humanities	Global
Barcelona	62.051	175.493	3,571	3,133	2,192	1,775	2,828
Santiago	6.699	17.418	3,304	2,467	2,352	1,407	2,600
Oviedo	5.921	14.934	3,309	2,370	2,424	1,123	2,522
Granada	12.601	30.653	2,874	2,482	2,289	1,604	2,433
Valencia	23.036	55.923	3,141	2,328	2,167	1,606	2,428
Alicante	7.152	17.108	3,114	1,977	2,452	1,333	2,392
Madrid	75.449	178.967	3,357	2,366	1,902	1,321	2,372
Zaragoza	10.060	23.391	2,934	2,296	2,133	1,563	2,325
Murcia	7.526	17.148	2,669	2,065	2,175	1,543	2,279
Sevilla	10.322	21.457	2,917	1,915	1,754	1,116	2,079

Source: web sciverse Scopus

Disaggregated data by area of knowledge have a similar behavior to the analysis of the IIF. Barcelona lost positions in the area of Physical Science (5th position), compared to

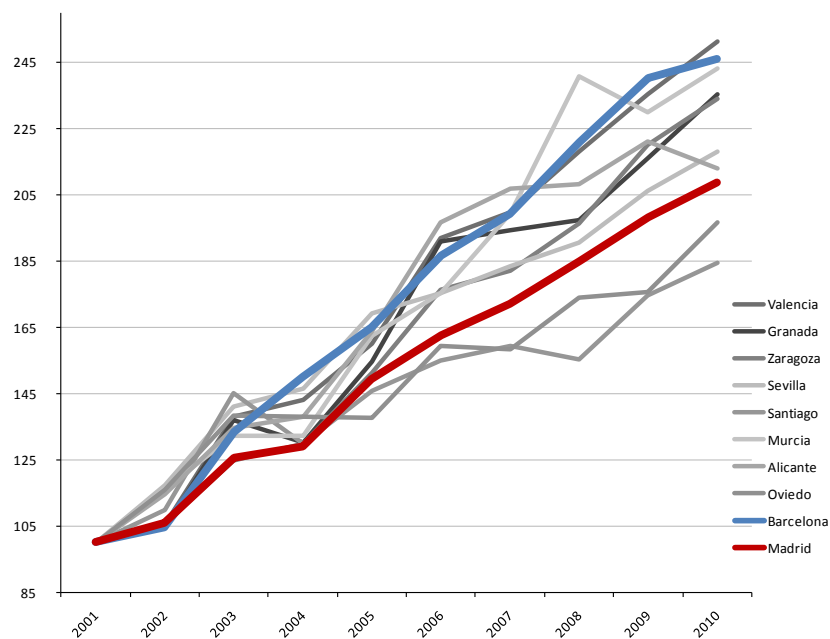
smaller cities such as Alicante, Granada, Oviedo and Santiago. In the case of Madrid is evident the fall of HIF, in almost all areas (Health science, 5th position, Physical science, 9th position and Social science & humanities, 8th position) except in the area of Life Science, where is located the 2nd position.

The other cities, also reveals the lack of relation between the quantity and quality of scientific production. Seville is located in the 6th position in the IIF and 5th position in the HIF, according to the analysis of the volume of scientific publications. But in the analysis of the quality the city falls to 9th and 10th positions, respectively. Moreover, Santiago and Oviedo are cities with the least quantity of publications. However, in the overall analysis of the impact of both factors are located in the top positions under Barcelona.

Results of the global evolution of scientific publications (2001-2010)

In the analysis of production, we see that cities have doubled their scientific production in the period under review, with the exception of Santiago, and Oviedo, as detailed in Table X. The most significant increases are registered in the cities of Barcelona, Valencia and Murcia with values greater than 140%.

Table 6 Index Evolution 100 (2001 = 100)



Cities	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Madrid	100	106	126	129	149	163	172	185	198	209
Barcelona	100	104	133	150	165	187	199	221	240	246
Valencia	100	106	138	143	160	192	200	218	235	251
Granada	100	104	137	130	154	191	194	197	216	235
Zaragoza	100	106	125	130	151	177	182	196	220	234
Sevilla	100	117	141	146	169	175	183	191	206	218
Santiago	100	110	145	130	146	155	159	155	175	184
Murcia	100	116	132	132	163	175	200	241	230	243
Alicante	100	115	135	138	164	197	207	208	221	213
Oviedo	100	116	138	138	138	159	158	174	176	197
Total publicaciones	100	107	132	138	156	176	185	200	216	226

Source: web sciverse Scopus

Finally in dynamic analysis for productivity through IIF shows certain homogeneity in the results. It is noted that at the beginning of the study period is a general fall of IIF, with the exception of cities such as Barcelona, Santiago, Murcia and Seville. In the next period (2007-2009), data indicate a progressive increase in IIF for all cities. Also, is observed a grouping of indices in this period, excluding Barcelona⁹. Distance between the highest factor and the lowest factor is the smaller, not exceeding 1.181 points. This difference, at the beginning of the period in 2006 was 1,247 points and the final in 2010 was 1,403 points. Thus, all cities increased their impact factor, but to different extents.

Table 7 Evolution of productivity, through the IIF.

Cities	2006	2007	2008	2009	2010
Barcelona	2,483	2,539	2,728	2,865	2,927
Santiago	2,091	2,256	2,276	2,538	2,693
Oviedo	2,454	2,193	2,304	2,505	2,545
Valencia	2,384	2,237	2,242	2,401	2,530
Madrid	2,446	2,236	2,361	2,335	2,308
Alicante	2,079	2,056	2,120	2,244	2,215
Zaragoza	2,083	2,022	2,189	2,234	2,190
Sevilla	1,749	1,773	1,846	2,064	2,178
Murcia	1,740	1,855	2,006	1,973	1,864
Granada	1,199	1,192	1,249	1,357	1,289

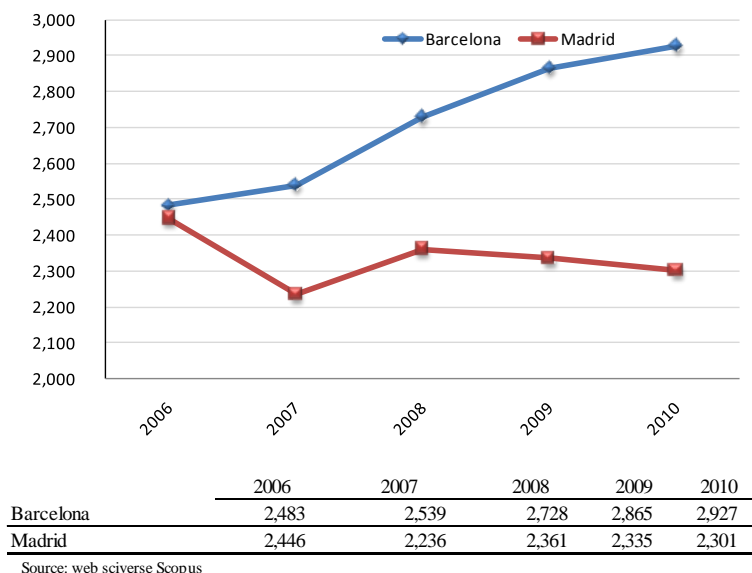
Source: web sciverse Scopus

After the year 2009, is a stagnation of IIF for most cities, with the exception of Barcelona and Santiago to a lesser extent. Figure 1, shows the behavior of Barcelona and Madrid. In 2006, the difference between two cities was small with only 0,037

⁹ Barcelona is excluded from observation because since 2007, her behavior is higher, moving away from other cities, which does not share the phenomenon.

points. However, in 2010 the situation is very different, so much so that Barcelona is located above Madrid by 0,626 points.

Figure 1 Evolution of productivity, through the IIF for Madrid and Barcelona.



When analyzing data of HIF is observed, an increase in all cities studied except for Madrid. Throughout the period analyzed (2006-2010), Madrid is the only city that has a fall of HIF, being located in 2010 with 0,181 points below 2006. Santiago, Zaragoza, Sevilla, Oviedo and Murcia are cities that have the highest growth compared to their initial values in 2006. In a second group, is observed Barcelona, Alicante, Granada and Valencia have a stable growth in the period, not exceeding 0,156 point difference between 2006 and 2010.

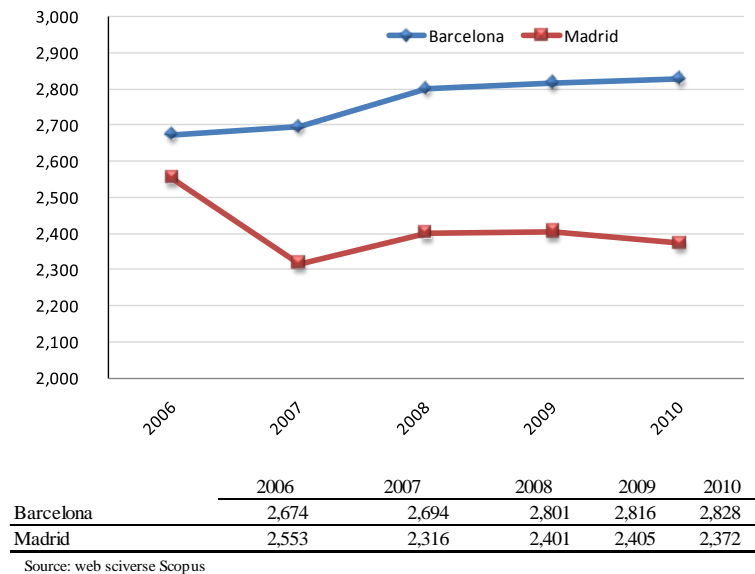
Table 8 Evolution of productivity, through the HIF.

Cities	2006	2007	2008	2009	2010
Barcelona	2,674	2,694	2,801	2,816	2,828
Santiago	2,071	2,213	2,218	2,443	2,503
Oviedo	2,247	2,160	2,393	2,474	2,497
Granada	2,291	2,249	2,300	2,466	2,433
Valencia	2,391	2,369	2,386	2,437	2,428
Alicante	2,175	2,168	2,262	2,267	2,331
Madrid	2,553	2,316	2,401	2,405	2,372
Zaragoza	1,959	2,066	2,215	2,330	2,256
Murcia	1,856	1,980	2,066	2,111	2,093
Sevilla	1,800	1,898	1,944	2,081	2,079

Source: web sciverse Scopus

Like the IIF, there is a grouping of indices, excluding Barcelona¹⁰. So much so, that by 2009, the distance between the highest factor (Oviedo with 2,474) and the lowest factor (Sevilla with 2,081) is the lowest, not exceeding 0,393 points. This difference, at the beginning of the period in 2006 was 1.247 points and the final in 2010 was 1.403 points. Thus, all cities increased their impact factor, but to different extents.

Figure 2 Evolution of productivity, through the IIF for Madrid and Barcelona.



In Figure 2, are analyzed data in detail, by year, for the two major cities, Barcelona is seen with higher factors, well above Madrid, despite having a smaller number of scientific publications. Between the years 2006-2010, Barcelona won a total of 0.154 points, 0.107 of which represent growth over the period 2007-2008. Madrid, meanwhile, with a total loss of 0.181 points, shows that in 2006-2007 showed the biggest fall 0.237 points. In the period under review is observed that Barcelona is more stable and tends to rise. Madrid meanwhile has more contrast, after three years of rises, falls in the last year.

¹⁰ Idem10

Conclusions and future research lines

The main findings in this paper are:

1. - positioning with major cities, in the context of national scientific publication is not similar for both parameters (production v / s productivity), a clear example is the case of Madrid and Barcelona.

2. - You can set that Barcelona has a scientific production of better quality compared to other cities studied. In addition, it is anticipated that the scenario of growth will remain stable in the coming periods.

3. - Madrid is in a stalemate at the quantity level that shows growth and very low in relation to the Spanish context. In terms of quality, the stage is uncertain given the lack of stability presented in the period.

As future research, is to establish the relationship between the quality of scientific output, with the number of authors, in order to find evidence to clarify the independence between the number of citations and the number of scientific articles published.

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