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A scientometrics analysis of Colombian universities applying for patents

Iris Jiménez-Pitre[1], Geomar Molina-Bolívar[2], Rodrigo_Gamez Pitre[3]

[1]*Grupo de Investigación BIEMARC, Colombia*
Universidad de la Guajira
iajimenez@uniguajira.edu.co
https://orcid.org/0000-0002-8109-7013
[2]*Grupo de Investigación BIEMARC, Colombia*
Universidad de la Guajira
gmolina@uniguajira.edu.co
https://orcid.org/0000-0001-6380-379X
[3]*Grupo de Investigación BIEMARC, Colombia*
Universidad de la Guajira
rgamez@uniguajira.edu.co
https://orcid.org/ 0000-0003-1436-0974

Abstract.

Colombia shows important increases in the last two decades in its GDP per capita and in the investment for research and development, occupying in Latin America the fifth place in scientific production and the sixth position in the Global Innovation Index. The scientometric indicators of 28 Colombian universities that file patent applications are analyzed through the analysis of indicators on innovation and scientific production published in the SirIber 2020 report. There is a high correlation between the number of patent applications and the published scientific production, the international collaboration of researchers is between 30 and 50% of the publications, favoring the impact of the publications and the citations in patents. Two university profiles were identified: those with an emphasis on scientific publications and those with an emphasis on innovation.

Keywords: universities, Colombia, patents, innovation.

I Introduction

Colombia is gradually advancing in its economic progress and development. In this sense, we can see some figures that demonstrate the efforts being made in this South American country. According to data published by the World Bank [1] on country profiles, it can be seen that in the last two decades Colombia has shown a 155% increase in its GDP per capita and an 85% increase in investment in research and development (the latter standing at 0.24% by 2019). Although it is significantly lower than the Latin American average of 0.71%, some results regarding scientific production and patent development show that innovation supports its growth, despite having fewer resources for the development of research activity compared to other countries in the region [2].

The relationship between innovation and a country's level of development has been the subject of several studies, with patents being the most widely used indicator [3][4][5]. Thus, an increase in the number of applications for these intellectual property titles has been observed, which supports the fact that patents represent an important factor of innovation in the competition and economy of countries [6].

In the case of Colombia, the World Intellectual Property Organization [7] reports 11198 patent applications (direct and PCT national phase) during the period from 2014 to 2018, representing 3.5% with respect to Latin America in the same period. Moreover, this country ranks 6th among the 19 economies in Latin America and the Caribbean in the Global Innovation Index (GII) 2019, it is a ranking of world economies based on innovation capabilities consisting of roughly 80 indicators [8].

With respect to Latin American universities, they are in a phase of opening up to collaboration with the productive sector. The contribution of research to industrial deve

lopment has resulted in an increased interest in establishing inter-institutional links [9], thus collaborating with innovation and actively participating in technological development and economic growth [10]. This is achieved thanks to strategic alliances with private and public organizations, joining efforts under a University-State-Business approach [11].

By adopting patenting as a strategy to protect and value knowledge, as a result of the investment of resources made in its development, universities have relevant elements that distinguish their academic scientific and technological production. Among the determining characteristics found in Mexican universities that produce patents have been the quality of research and the ability to generate, identify and protect the ideas of research and academic staff [9]. Regarding research quality, translated into terms of scientific production with impact, several scientometric indicators are available from databases, widely used in the literature on scientific productivity. In Latin America, according to Scimago Journals & Rankings (SJR) [12], scientific production during the period 1996 to 2019 amounted to approximately two million published documents. These publications were made mainly by Higher Education Institutions (IES) in Brazil (48%), Mexico (16%), Argentina (11%), Chile (8%) and Colombia (5%), the latter occupying the 5th place in the Latin American region.

With regard to innovation, the Ibero-American Ranking of Higher Education Institutions (SIRIber) [2] presents indicators on research and innovation that measure the performance of these institutions during the previous five years. The 2020 publication evaluates the performance of 1748 Ibero-American institutions that have submitted at least one paper indexed in the Scopus© database in the period 2014-2018.

Considering the situation of Colombia described above, and the importance of innovation in the development of the countries, this paper provides a descriptive analysis of the Colombian higher education institutions that have filed patent applications in the period 2014 to 2018. For this purpose, data is collected from the SIRIber 2020 ranking for Colombian institutions with at least one registered patent, and from the data records on statistical profiles of this country, published by the World Intellectual Property Organization (WIPO).

2 Metodologhy

In order to carry out the descriptive analysis of the Colombian universities that present patent applications, the data on innovation and scientometric indicators described in Table 1 are collected, considering as a source the report of the Ibero-American Ranking of Higher Education Institutions (SIRIber) 2020, which presents the evaluation of the universities in the period 2014-2018. There is a total of 61 Colombian universities, of which 28 are filing at least one patent application. Descriptive statistics and correlation are applied for data analysis.

Table 1. Innovation and scientometric indicators**.**

Tag	Indicator	Description and Source

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IC	International Collaboration	Percentage of the production of an institution where the institutional affiliation of the authors corresponds to different institutions and at least one of them is from a different country. This indicator shows the capacity of an institution to create scientific collaboration networks.
Q1	High Quality Publications	Percentage of an institution's work published in journals that are in the top 25% of each knowledge category. It is considered to reflect the institutional capacity to achieve a high expected level of impact.
Ni	Normalized Impact	This indicator reflects the impact of the knowledge generated by an institution on the international scientific community. It takes as a central point the world average of impact (value 1). Thus, if an institution has an NI of 0.8 it means that its production is cited 20% below the world average.
Output	Published articles	Total number of documents published by the institution in magazines indexed in Scopus. This indicator shows the capacity of an institution to publish in scientific journals.
Patents	Patent applications	Number of patents applied for by an institution (single families) This indicator shows the institution's capacity to appropriate knowledge and generate new technologies or inventions.
TI	Technological Impact	Percentage of publications of an institution cited in patents. This percentage is calculated only considering the total of publications in the areas cited in patents.
PosIBE	Relative position of the University in Ibero-America	
PosLAC	Relative position of the University in Latin America	
PosCOL	Relative position of the University in Colombia	

Source: Scimago, SIRIber Report 2020 [12].

3 Results

As a result of the collection of data from Colombian universities that present patent applicants in the report of the Ibero-American Ranking of Higher Education Institutions (SIRIber) 2020, corresponding to the evaluation of the period 2014 to 2018, a total of 61 Colombian universities were found, of which 28 present at least one patent application. These provide a total of 335 patent applications. Table 2 shows the descriptive statistics catalogued in five clusters according to the range for the number of patent applications per university, which vary from 1 to 45 applications. It can be seen that 55% of the applications were made by 21% of the universities.

Table 2. Descriptive statistics by cluster patents indicator.

Cluster	Mean	Min	Max	Total Patents	Patents %	Standard Deviation	Total Univ	Univ %
1	39	35	45	117	34.9%	5	3	10.7%
2	23	21	25	69	20.6%	2	3	10.7%
3	12	10	16	81	24.2%	2	7	25.0%
4	7	5	9	54	16.1%	1	8	28.6%
5	2	1	4	14	4.2%	1	7	25.0%
Total				335			28	

Table 3 shows the correlation between science and innovation indicators for the 28 universities applying for patents. It is observed that the indicators for these universities present moderate correlations between the number of patent applications and their positions at national (0,421) and regional level (0,525 and 0,553). Likewise, the relation between the indicator Technological Impact (TI) and International Collaboration (IT) is moderate (0,548). The high correlation found between this last indicator and Normalized Impact (Ni)(0.761) and High Quality Publications (Q1) (0.823) is also noteworthy. Therefore, there is evidence of the impact of the participation of researchers from foreign institutions in published research, including those cited in patents.

Table 3. Correlation between scientometric and innovation indicators.

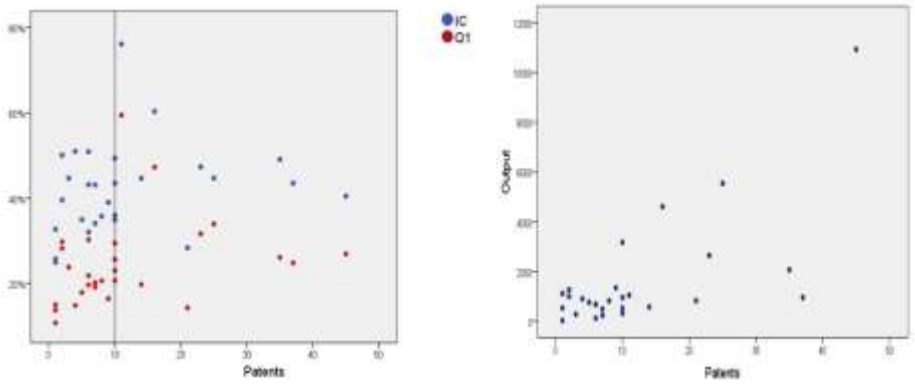
	TI	Patents	Output	IC	Ni	Q1
PosIBE	-0.392	-0.553	-0.699	-0.318	-0.406	-0.424
PosLAC	-0.373	-0.525	-0.650	-0.314	-0.415	-0.412
PosCOL	-0.275	-0.421	-0.476	-0.309	-0.467	-0.357
TI		0.321	0.381	0.548	0.212	0.340
Patents			0.680	0.183	0.059	0.249
Output				0.184	0.157	0.331
IC					0.761	0.823
Ni						0.623

According to Table 2 and Figure 1b, 54% of university applicants file fewer than 10 patents, and fewer than 2000 publications. This group is characterized by less than 30% of Q1

publications, and the presence of International Collaboration in 30 and 50% of its publications (Figure 1a). Table 4 presents three classification clusters considering this group of universities, and shows the averages with respect to the revised indicators. It is observed that universities with a greater number of patents and published documents present more favorable indicators regarding CI, Ni, Q1 and IT.

Table 4. Cluster by range of patent applications and published documents.

Clusters		Total universities	Total patents	--------- Average values per cluster ---------- IC	Ni	Q1	Output	TI	Patents
1	patents >= 10 & outputs > 2000	6	154	52.48	0.56	36.40	4284	0.53	24
2	patents > =10 & outputs < 2000	7	113	43.86	0.50	26.81	734	0.24	16
3	patents < 10	15	68	38.79	0.44	20.15	674	0.22	5



(a) (b)

Fig. 1. Relationship between innovation and scientific production indicators.

Finally, two figures are presented below that describe the performance of universities with respect to patent applications and publication of articles. The first, Figure 2, shows the percentage contributions of the universities with respect to patents and articles. It can be seen that six universities register 60% of the patent applications. These universities are listed below, among which the National University of Colombia stands out for presenting the highest figures in both indicators (Table 5). The list shows that universities such as the Universidad Militar Nueva Granada and the Universidad EAFIT are among the first in terms of patents. However, their scientific production is low, 2.14% and 1.85% respectively, with respect to the total group of universities studied.

Regarding the second figure that describes the performance of universities regarding patent applications and publication of articles (Figure 3), it shows the gap between the percentage

contribution of article publications and patent applications. The result represents the predominant profile of the patent-applicant university with respect to these types of production. Observing the gaps greater than 4%, the scientific profile of the Universidad Nacional de Colombia, the Universidad de Los Andes, the Universidad de Antioquia and the Universidad Javeriana stand out. These four universities occupy the first positions in their country according to the SirIber 2020 Ranking. The innovation profile includes the Universidad EAFIT, the Universidad Industrial de Santander and the Universidad Militar Nueva Granada.

Table 5. Leading Colombian universities in patent applications (60%).

Positions SirIber 2020				Patent	Published
IBE	LAC	COL	University	applications	articles
32	14	1	Universidad Nacional de Colombia	45	10937
241	167	14	Universidad EAFIT	37	947
150	91	6	Universidad Industrial de Santander	35	2064
68	34	2	Universidad de Antioquia	25	5541
130	74	5	Universidad del Valle	23	2638
260	182	17	Universidad Militar Nueva Granada	21	818

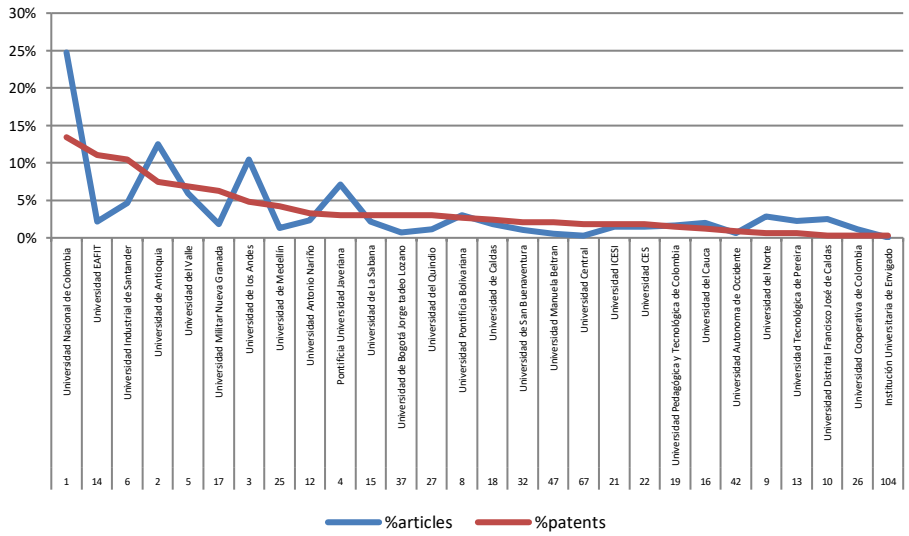


Fig. 2. By university, percentage contribution in publications of articles and patent applications. The position in the national ranking according to SirIber 2020 is indicated by university.

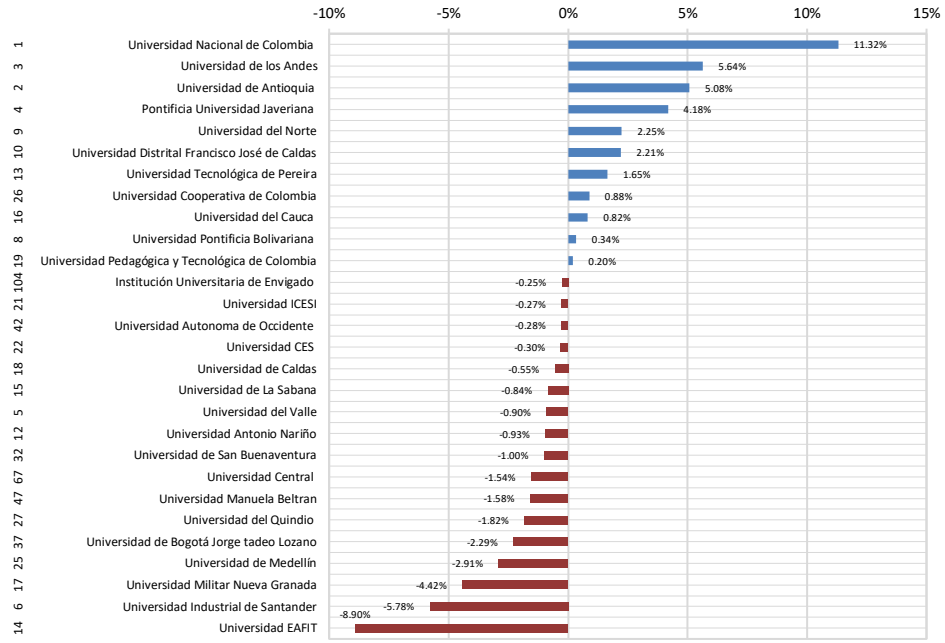


Fig. 3. By university, percentage gap between contribution in article publications and patent applications. Blue bar: scientific profile. Red bar: innovation profile. The position in the national ranking, according to SirIber 2020, is indicated by university.

4 Conclusions

A total of 61 Colombian universities were found to be registered in the Ibero-American Ranking of Higher Education Institutions (SIRIber) 2020 report, of which 28 filed at least one patent application, totaling these 335 applications during the evaluation period of this ranking from 2014 to 2018.

Among the outstanding findings is that 54% of Colombian universities register less than 10 patent applications each, six universities present 60% of them. The Universidad Nacional de Colombia stands out for filing the largest number of patent applications and scientific publications. On the other hand, institutions such as the Universidad EAFIT and the Universidad Militar Nueva Granada are among the first in terms of patents, with low scientific production, compared to other similar ones. These are specific cases, even though the correlation found between patents and scientific publication is high. Regarding the relationship between the indicators, moderate correlations are observed between the patent applications and their positions in the SirIber ranking, both at national and regional level. The relevant association between the International Collaboration indicator and the Technological Impact, Normalized Impact and High-Quality Publications indicators is highlighted. Therefore, the impact of the participation of researchers from foreign institutions in published research, including those cited in patents, is evident. It is observed that the universities with a greater number of patents and published documents present, on average, better values in the scientometric indicators reviewed.

Finally, two profiles of universities applying for patents were identified, regarding the gap between the contribution in scientific production and the development of patent applications. In the scientific profile, Universidad de los Andes, Universidad de Antioquia y Universidad Javeriana stand out. In the innovation profile, we have mainly the Universities: EAFIT, Universidad Industrial de Santander and Universidad Militar Nueva Granada.

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