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Comparative analysis on the indicators from Latin American countries with more scientific paper publications in the SIR Iber 2020

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Abstract

The SIR Iber highlights the geographical location of Ibero-American universities by positioning them according to the indicators grouped into three main factors: research, innovation and social impact. The 2020 edition highlights the formation of three groups of countries according to the production capacity of higher education institutions. In group 1 we have: Brazil, Mexico, Chile, Argentina, and Colombia as Latin American countries that managed to publish more than 60,000 papers in the period 2014-2018. This paper analyzes and compares the indicators from the five (05) Latin American countries in group 1 of the SIR Iber 2020 referring to investment in I+S as a percentage of its Gross Domestic Product (PIB), the number of full-time equivalent researchers (Inv JCE), the production (%) of scientific works in the university education sector, to name a few. A conglomerate formed with the Normalized Impact (NI) of public and private IESs is presented, regarding the global average of citation, with the data published in the SIR IBER 2020 Report, and highlights that Chile has a normalized impact above the World average for both public and private IES publications.

Keywords: Clusters University, indicators, SIR IBER, Ibero-American countries.

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1. Introduction

Universities and their academics are ranked based on the ability to publish scientific papers [1] [2] [3] [4]. Subsequently, the SIR IBER ranking performs this classification for higher education institutions located in the countries of Andorra, Spain, Portugal and Latin America, with at least one (1) document published in journals indexed in Scopus in the period analyzed [5] [6]. This is done taking into consideration impact, excellence, leadership, open access, editorial management, and innovation indicators, in order to encourage academic quality, competitiveness, and visibility of universities. [7] [8] [9].

Therefore, the SIR aims to be a framework for the global evaluation of the research activity of university institutions, and; consequently, it weighs its scientific activity based on the bibliometric indicators obtained from scientific documents of any kind indexed in the Scopus database [6]. From 2020, 18 indicators are considered. These indicators are distributed in three (3) main factors: research, innovation and social impact. [5].

Thus, the purpose of this research is to analyze and compare, among the five (05) Latin American countries of group 1 of the SIR Iber 2020, the indicators referring to investment in I+D as a percentage of its Gross Domestic Product (PIB), as well as the number of researchers full-time equivalent (Inv JCE), the production (%) of scientific work in the university education sector, the % of production contributed by the IESs present at the SIR Iber 2020, the% of IES versus the number of IESs included in SIR Iber 2020, the % of IESs that have published more than 100 documents in Open Access (OA), the % of production published by public and private IESs, the NI of both public and private IESs, public-private collaboration, the NI of public-private collaboration, concentration of production by geographical area and by area of knowledge, and; finally, the co-citation indicator. Additionally, in the last section of the paper, a conglomerate formed with the NIs of public and private IESs is presented, regarding the global citation average, with the data published in the SIR IBER 2020 Report.

Nomenclature

SIR	SCimago Institution Ranking
SIR IBER	Iberoamerican Ranking of University Education Institutions
ODS	Sustainable Development Objective
I+D	Research and Development
PIB	Gross Domestic Product
Inv JCE	Number of equivalent full-time researchers
IES	University Education Institution
NI	Normalized Impact
WNC	Weighted Citation Normalized

2. SIR Iber 2020

The SIR Iber 2020 [5] [6] is the twelfth installment of the annual report on the classification of higher education institutions (according to the number of jobs indexed in the Scopus database in the five-year period 2014-2018). In the same way, it is taken into consideration to analyze its performance based on three different sets of indicators (based on the performance of the research, the results of innovation, and the social impact measured by its web visibility).

Moreover, since 2020, the Weighted Citation Normalized indicator has been included in the research factor: as a complement to the traditional Normalized Impact indicator to show the Normalized Impact of each published document based on the number of thematic categories (to which the publication journal belongs), both to calculate the expected citation of each category and to calculate the impact of a given set of documents. A WNC indicator higher than 1 reflects an average impact higher than the category of the magazine, while a WNC indicator below 1 indicates an average impact lower than the category of the magazine. [5] [6] [10].

That is why this edition includes 1,748 from university education institutions belonging to Latin America [5]. According to the ability to publish scientific papers in the region, Brazil, Spain, Portugal, Mexico, Chile, Argentina and Colombia are again ranked as the countries with the largest production capacity: They achieved more than 60,000 scientific papers published in the 2014-2018 period and, therefore, constitute Group 1 analysis for the SIR Iber 2020

report [5], and for this paper, the Latin American countries will be considered: Brazil, Mexico, Chile, Argentina and Colombia.

3. Indicators comparison between Latin American countries from group 1 of the SIR Iber 2020

UNESCO's Sustainable Development Goal (ODS) 9 urges governments to promote sustainable industrialization and innovation, by rapidly increasing spending on Research and Development (I+D) and increasing the number of researchers [5] [11] [12]. Regarding investment in I+D as a percentage of its Gross Domestic Product (PIB), Brazil invests 1.30%, it stands out as the only country in Latin America that invests more than 1% of its PIB in I+D. In second place, it is Argentina with 0.55%. Then, we have Mexico with 0.48%. In fourth place, it is Chile with 0.36%. Finally, we have Colombia with 0.23%. On the other hand, in relation to the number of equivalent full-time researchers (Inv JCE) [5] [12]: Brazil stands out with 179,989 (being the largest number of researchers in the region), surpassing Argentina 3.5 times, which registers 52,383 researchers. Then there is Mexico with 38,882. Next, Chile has 9,111 researchers. Last but not least, Colombia has 4,305 researchers (Table 1).

Table 1.Investment in I+D as a percentage of its Gross Domestic Product (PIB) and number of equivalent full-time researchers (Inv JCE) [5] [12]

	Brazil	Mexico	Chile	Argentina	Colombia
Investment in Research and Development as% of its Gross Domestic Product (PIB)	1.30%	0.48%	0.36%	0.55%	0.23%
Number of equivalent full-time researchers (Inv JCE)	179,989	38,882	9,111	52,383	4,305

This table highlights that Argentina exceeds Mexico and Chile in investment in I+D as a percentage of their PIB and in the Inv JCE indicator, despite the fact that Mexico and Chile achieve higher scientific production in the five-year period 2014-2018.

The university education sector provides a production above 90% in Brazil, Chile (91%), and Colombia, while Mexico and Argentina have close values: 78% and 76.30%, respectively. These numbers consolidate this sector as the main generator of scientific papers regardless of the country. (Table 2) [5].

Table 2. Percentage of production of scientific papers in the university education sector [5]

	Brazil	Mexico	Chile	Argentina	Colombia
% of production of scientific papers in the University Education Sector	>90%	78%	91%	76.30%	>90%

Con respecto a los indicadores % de producción aportada por las IES presentes en el SIR Iber 2020 y % de IES frente al número de IES incluidas en SIR Iber 2020, destaca lo siguiente (Table 3) [5]:

Table 3. Production Percentage contributed by IESs and % of IESs versus the number of IESs included in SIR Iber 2020 [5]

	Brazil	Mexico	Chile	Argentina	Colombia
% of production contributed by the IESs present at the SIR Iber 2020	>40%	9.80%	6.50%	5.40%	4.90%
% of IESs versus the number of IESs present at SIR Iber 2020	6.40%	4.30%	0.98%	1.60%	2.80%

- At regional level, the Brazilian university education institutions (IESs) present at the SIR Iber 2020 constitute 6.40% of the Ibero-American IESs, which contribute more than 40% of the production in the region.
- Mexican IESs represent 4.30% of Ibero-American IESs and provide 9.80% of production to the region, which is equivalent to a quarter of Brazilian IESs.
- The Chilean IESs included in the SIR Iber 2020 represent 0.98% of Ibero-American IESs (it is the lowest value among the five countries considered) and contribute 6.50% of production to the Ibero-American region, which translates into the sixth of Brazilian IESs.
- Regarding Argentinian IESs, they represent 1.60% of the Ibero-American IESs included in the SIR Iber 2020, which provide 5.40% of papers published in Ibero-America.
- Colombia concentrates 2.80% of the Ibero-American IESs, which contribute 4.90% of the publications to Ibero-America (the eighth part of Brazilian IES).

Nevertheless, the % indicator of IESs that have published more than 100 documents in Open Access (OA) highlights that in the five countries (Table 4) [5] IESs publish more than 30%: Chile exceeds 47%. Second is Brazil with 43%. Then there is Colombia with a value above 35%. Fourth, Mexico and Argentina stand out with a value of over 30%.

Table 4. Percentage of IESs that have published more than 100 documents in Open Access (OA) [5]

	Brazil	Mexico	Chile	Argentina	Colombia
% of IESs that have published more than 100 documents in Open Access (OA)	43%	>30%	>47%	>30%	>35%

When comparing the % indicators of the production published by public and private IESs (Table 5) [5] highlights that the greatest production falls on public IESs: 94%, 93% and 95%, accordingly, in Brazil, Mexico, and Argentina. While in Chile and Colombia, both IESs contribute 50% in the development of research in the sector.

However, (Table 5) [5] Chile's private IESs are worth 13% above the global average of NI citations. While public IESs from Mexico and Chile remain above the global average of citations in NI (with the values 6% and 3%). Public and private HEIs in Argentina are 14% below the global citation average. Mexico is 26% below the average of citations in NI in private IESs. Colombian IESs stand out with a value below 30% and below 12% of the world citation average. Lastly, Brazil is below 30% on the global average of citations in NI in both public and private IESs.

Table 5. Percentage of production published by public and private IESs and Normalized Impact (NI) of public and private IESs [5]

	Brazil	Mexico	Chile	Argentina	Colombia
Output (approximate)	320,000	91,000	59,500	52,261	51,000
% of production published by public IESs	94%	93%	50%	95%	50%
% of production published by private IESs	14%	10%	50%	8%	50%
Normalized Impact of public IESs (regarding the global average of citations)	<30%	>6%	>3%	<14%	<30%
Normalized Impact of private IESs (regarding the global average of citations)	<30%	<26%	>13%	<14%	<12%
Public-Private Collaboration	<10%	4%	14%	3%	14%
Normalized Impact Public-Private Collaboration (regarding the world average scale)	<21%	>29%	>3%	>3%	>3%

Furthermore, (Tabla 5) [5] public-private collaboration is greater in Chile and Colombia with 14% of all publications. Brazil follows with less than 10% of all published work. In the last places are Mexico and Argentina with 4% and 3%. The NI of public-private collaboration in Mexico is 29% [5] above the world average scale. The NI

of public-private collaboration in Chile, Argentina, and Colombia has a value above the world average of 3%. Meanwhile, Brazil stands out with a value below the world average of 21%.

Regarding the production concentration by geographic area, it stands out (Table 6) [5]:

- In Brazil: Sao Paulo (40%), Rio de Janeiro, Minas de Gerais, and Rio Grande do Sul concentrate 78% of the national production.
- In Mexico: Mexico City, Nuevo Leon, Mexico, Puebla, and Jalisco account for 81% of the papers published in this country.
- In Chile: The Metropolitan region of Santiago, Valparaiso, and Biobio contribute 89% of the national production.
- In Argentina: Autonomous City of Buenos Aires, Buenos Aires Province, Cordoba, and Santafe concentrate 93% of the published papers.
- In Colombia: Bogota and Antioquia constitute 73% of national production.

Table 6. Production concentration by national region [5]

	Brazil	Mexico	Chile	Argentina	Colombia
Main productive región	Sao Paulo	Mexico City	Metropolitan region of Santiago	Autonomous City of Buenos Aires	Bogota
Main region production	40%	56%	60%	40%	53%
Second productive región	Rio de Janeiro	Nuevo Leon	Valparaiso	Buenos Aires Province	Antioquia
Second region production	15%	9%	15%	30%	20%
Third productive región	Minas Gerais	Mexico	Biobio	Cordoba	
Third region production	12%	6%	14%	13%	
Fourth productive región	Rio Grande do Sul	Puebla and Jalisco		Santafe	
Fourth region production	11%	5% y 5%		10%	

On the other hand, regarding the publication knowledge areas (Table 7) [5], these five countries coincide with medicine with a value of around 25% (with the exception of Brazil with 31%), that is, a quarter of the published papers are located in this knowledge area. Agriculture and biological sciences is the second area of knowledge published for Brazil, Mexico and Argentina, while physics and astronomy is for Chile. Finally, engineering is the area of choice for Colombia.

As a third area of knowledge, engineering for Brazil and Mexico stands out. Agriculture and biological sciences coincide for Chile and Colombia. Finally, biochemistry, genetics and molecular biology stands out in Argentina.

Finally, regarding the co-citation indicator (Table 7) [5], medicine coincides in the five countries. Engineering remains present in Brazil, Chile, and Colombia. Agriculture and biological sciences coincide in Argentina and Colombia.

4. SIR Iber 2020 Report and the Normalized Impact of public and private IESs

Fig. 1 shows the conglomerate that is formed with the NI of public and private IESs, with respect to the global average of citation (with the data published in the SIR IBER 2020 Report respectively), when correlating the NI of public IESs with the NI of private IESs. Last, table 8 [5] shows the characteristics of the NI conglomerate of public and private HEIs for this year for this group of 5 Latin American countries: It highlights that Chile has a normalized impact above the world average for both public and private IES publications.

Table 7. Production concentration by knowledge area [5]

	Brazil	Mexico	Chile	Argentina	Colombia
Main knowledge area published	Medicine	Medicine	Medicine	Medicine	Medicine
% of national production of main knowledge area published	31%	26%	25%	28%	28%
Second knowledge area published	Agriculture and biological sciences	Agriculture and biological sciences	Physics and Astronomy	Agriculture and biological sciences	Engineering
% of national production of second knowledge area published	19%	17%	16%	21%	18%
Third knowledge area published	Engineering	Engineering	Agriculture and biological sciences	Biochemistry, genetics, and molecular biology	Agriculture and biological sciences
% of national production of third knowledge area published	12%	15%	14%	13%	14%
Knowledge areas of the co-citation indicator	Medicine and Engineering	Medicine	Medicine, physics and astronomy, and engineering	Medicine, Agriculture and biological sciences	Medicine, Engineering, Agriculture y biological sciences, and computer's science

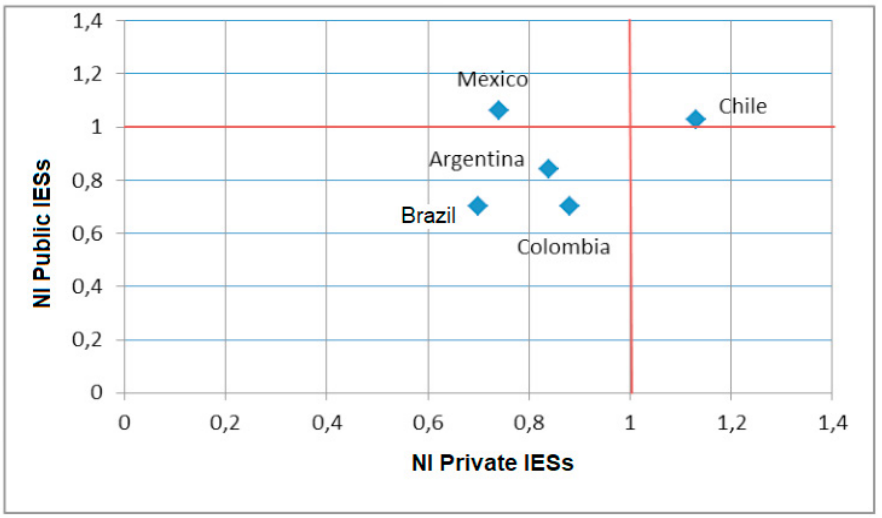

Fig. 1.NI conglomerate of public and private IESs according to the SIR IBER 2020 report [5]

Table 8. Characteristic of the NI conglomerate about public and private IESs (regarding the world citation average), with the data published in the SIR IBER 2020 Report [5]

		SIR Iber 2020	
CLU	Country	NI of public IESs	NI of private IESs
1	Chile	NI>1	NI>1
2	Mexico	NI>1	NI<1
3	Argentina, Colombia, Brazil	NI>1	NI<1

4. Conclusions

To sum up, the SIR IBER ranking positions countries according to the capacity for scientific paper publications by national university education institutions. In the 2020 edition, the first group of countries constituted (in this order) of Ibero-Americans Brazil, Spain, Portugal, Mexico, Chile, Argentina, and Colombia stands out. These countries achieved more than 50,000 publications in the five-year period 2014-2018. Therefore, their contribution exceeds 5% of national production. As a result of the analysis and comparison of the indicators considered in this ranking among these Latin American countries, it highlights:

a) Brazil is considered the only country in Latin America that invests more than 1% of its PIB in I+D (with a value such as 1.30%).
b) Regarding the number of full-time equivalent researchers (Inv JCE), Brazil stands out with 179,989 (being the largest number of researchers in the region), surpassing Argentina 3.5 times (which registers 52,383 researchers). Then there is Mexico with 38,882. Next, Chile with 9,111 researchers, and, last but not least, Colombia with 4,305 researchers.
c) The university education sector provides a production above 90% in Brazil, Chile (91%), and Colombia. While Mexico and Argentina have close values: 78% and 76.30%, mutually.
d) Brazilian university education institutions (IESs) present at SIR Iber 2020 constitute 6.40% of Ibero-American IESs, which contribute more than 40% of production in the region.
e) The % indicator of HEIs that have published more than 100 documents in Open Access (OA) highlights that the IESs of the five countries publish above 30%.
f) When comparing the % indicators of production published by public and private IESs, it is highlighted that the greatest production falls on public IESs: 94%, 93%, and 95% are found in Brazil, Mexico, and Argentina. While in Chile and Colombia both HEIs contribute 50% in the development of research in the sector.
g) Public-private collaboration is greater in Chile and Colombia with 14% of all publications. Brazil follows with less than 10% of the total number of published works. In the last places are Mexico and Argentina with 4% and 3%.
h) The NI of public-private collaboration in Mexico is 29% (above the world average scale). While Chile, Argentina, and Colombia have a value above the world average scale of 3%. Brazil stands out with a value below the world average scale of 21%.
i) As for the production concentration by geographic area, it highlights that it is found in the largest cities in the region.
j) Regarding the knowledge areas of publication, these five countries coincide with medicine with a value around 25% (with the exception of Brazil, which has 31%). In other words, a quarter of the published papers are located in this knowledge area.
k) In the co-citation indicator, medicine coincides in all five countries.
l) In the last section of this paper, a conglomerate formed with the NIs of public and private IESs (regarding the global citation average) alongside with the data published in the SIR IBER 2020 Report is presented. This data

highlights Chile as the only Latin American country in group 1 with NI above the world average scale for both public and private IESs.

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