

Analysis of the scientific production of Chile indexed in Scopus for the period 2009-2020

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Abstract.

The aim of this paper was to perform a descriptive analysis of Chile's scientific production registered in Scopus for the period 2009 to 2020. An increase of 230% in scientific production and the number of universities ranked in SIR was observed. However, citations dropped drastically to 9%. A moderate positive relationship was observed between investment in research and development, and the number of universities ranked in CRS, as well as the number of articles published per million inhabitants. Chile has maintained its international position since 2009, placing itself among the first four Latin American countries that stand out for their scientific production. Nevertheless, the impact of its publications has decreased significantly in terms of citations received.

Keywords: Chile, scientific production, universities, academic rankings, Latin America.

I Introduction

Latin America is a region made up of countries that have faced similar difficulties. Among these difficulties are: limitations with respect to its scientific production, low investment in research and development (R&D), low number of professionals dedicated to research and technological development, and limitations for access and use of technological infrastructure for connectivity [1][2]. By 2017, the investment in R&D on the Gross Domestic Product in the region was 0.71%, while the world average was 2.14% [3]. For that year, 161932 articles indexed in Scopus were published in Latin America and the Caribbean, compared to 3838463 worldwide [4], corresponding to 4.2%.

In this sense, there are several studies that report the positive relationship between investment in R&D and scientific production [5][6][7]. Even though publication is one of the most complex aspects in the research process, the increase in investment in science and the indexing of national journals in recognized databases have contributed to its growth [8]. Thus, the analyses of scientific production in the region that refer to the scientific reality of these countries identify limiting factors that, combined with proposals on education, research and development

policies, offer diagnoses for the strengthening of research in the region [8][9].

Among the most visible results of scientific research in general in a country are original publications. Their importance is measured by different citation rates to assess the impact on future research [10]. Chile (according to World Bank data for 2017) [3] represents 3% of the Latin American population and devotes 0.36% of its GDP to research and development. It is among the first fifty countries in the world in scientific production, and it has also stood out as a country in global indexes on innovation [11] and social progress [12]. Its main universities, the Universidad de Chile and the Pontificia Universidad Católica de Chile, founded in 1842 and 1888 respectively, in 2020 are ranked eighth and ninth in Latin America for their excellence in research [13].

Scientific research, which is fundamental to social and economic development, is an interesting factor to be analyzed in this country. For this reason, this paper analyzes a set of indicators regarding Chile's scientific production indexed on Scopus during the 2009-2020 period, the evolution of this country's positioning in Latin America and that of its main universities. It also explores the relationship of

these indicators with economic and demographic variables of the country.

2 Methodology

In order to analyze the scientific production of Chile registered for the period 2009 to 2020, data on published articles and citations received from the Scimago Journal & Countries Ranking (SJR) [4] was collected for each year, in addition to the annual positioning of the country at the Latin American level. Additionally, during the same period, the list of universities in the Scimago Institutions Ranking (SIR) was compiled by year in order to know the number of catalogued universities, and the evolution of

the first Chilean universities positioned in 2009 [13].

The descriptive analysis is complemented with economic and demographic variables by year, obtained from the indicators published by the World Bank [3], namely: investment in R&D as a percentage of the Gross Domestic Product and the country's population. In order to standardize the number of publications, citations and the number of universities positioned in SIR per year, the value per million inhabitants is determined for each. Finally, a correlation analysis between the variables of the study was carried out. Chart 1 shows the description for the variables.

Chart 1. Study variables.

Variable	Description	Source
Investment in Research and Development	Percentage of Gross Domestic Product devoted to research and development activities.	World Bank [3]
Universities per million inhabitants	Total number of universities ranked in SIR divided by the total population of the country.	SJR Scimago [13] World Bank [3]
Documents per million inhabitants	Total number of documents indexed in Scopus divided by the total population of the country.	SJR Scimago [13] World Bank[3]
Citations per million inhabitants	Total citations to documents indexed in Scopus divided by the total population of the country.	SJR Scimago [13] World Bank [3]

3 Results

3.1 Positioning of Chilean universities in Latin America

In 2009, the Scimago Institution Ranking (SIR) began to be published, with 2207 universities worldwide [13] mainly catalogued by their scientific publications indexed in the Scopus database. By 2020, 3897 institutions are present in this global ranking. In the case of Chile, it can be seen that from 2009 to 2020 the number of universities positioned in this global ranking has increased by 292%, reaching 11% with respect to the Latin American region (Fig.1). Alternatively, for its scientific production, Chile

has maintained the fourth position in Latin America from 2009 to 2018, behind Brazil, Mexico and Argentina. In 2009, Chile ranked third in Latin America, with Argentina moving up to fourth place (Chart 2).

The number of universities positioned in SIR per million inhabitants increased from 0.71 in 2009 to 1.69 in 2020, representing an increase of 238%. It is also observed that this indicator shows a moderate correlation with the investment in R&D (0.47) in the period 2009-2017.

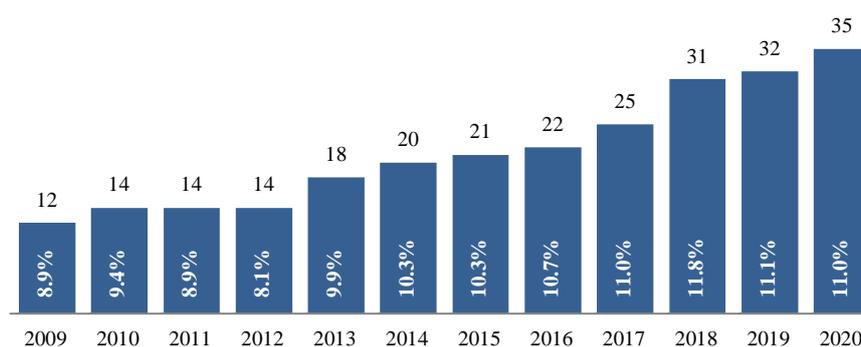


Fig. 1. Number of Chilean universities ranked by year in the Scimago Institution Ranking (SIR) and the percentage they represent in Latin America.

Chart 2. Collected and calculated data related to Chile's scientific production.

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Chile Universities in SIR	12	14	14	14	18	20	21	22	25	31	32
LatAM Universities in SIR	135	149	158	172	182	194	204	206	228	263	288
Chile's position in SIR LatAM	4	4	4	4	4	4	4	4	4	4	3
Chile's Investment in R&D (%GDP)	0.35	0.33	0.35	0.36	0.39	0.38	0.38	0.37	0.36		
Universities per million inhabitants in Chile	0.71	0.82	0.81	0.80	1.02	1.13	1.17	1.21	1.35	1.66	1.69
Items per million inhabitants in Chile	399	419	458	517	536	626	655	737	735	799	817
Citations per million inhabitants in Chile	8405	8521	8653	9506	8533	8533	7780	7359	4848	2935	647

3.2 Scientific production in Chile

During the period 2009-2019, a total of 120,500 articles were published in Chile, representing 8% of Latin American scientific production. In 2009, 6733 articles were published, increasing to 15487 in 2019, which means a 230% increase (Fig. 2). There is also an increase of 205% in the total number of items per million inhabitants, from 399 to 817 (Chart 2). However, the volume of citations received during that period dropped drastically, being reduced to 9% of the citations received in 2009 by 2019. This drop is more pronounced from 2016 onwards. The number of citations per million inhabitants has also

decreased significantly (from 8405 to 647), falling to 7% of what was reported in 2009. It has also been observed a high correlation of -0.8 between articles and citations per million inhabitants, which shows an unusual behavior of the impact of scientific production for this country.

Regarding the ratio of investment in R&D to items per million inhabitants, a moderate correlation of 0.5 was found for the period 2009-2017. This coincides with other studies [1][6][10] that point to the relationship between GDP investment in R&D and scientific production: a factor that affects the differences

observed among Latin American countries in terms of scientific production. As for the correlation of investment in R&D with citations

per million inhabitants, it was found that this is zero.

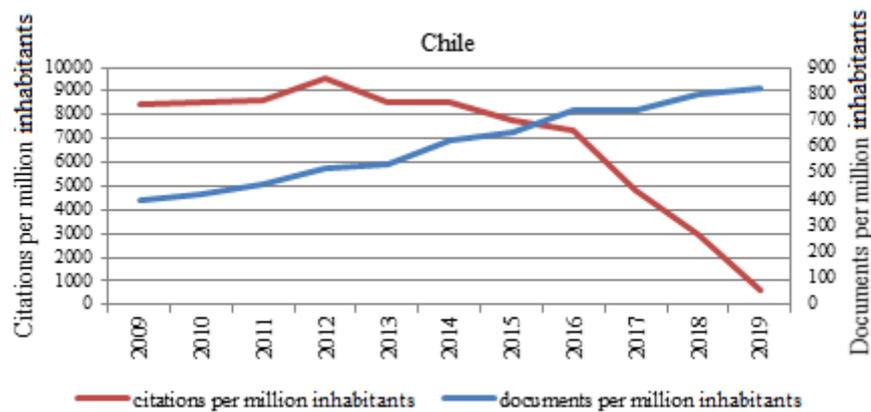


Fig. 2. Per year, number of articles published and citations received, per million inhabitants.

3.3

3.4 Chilean universities positioned in 2009: evolution of their positioning until 2020

In the first publication of the SIR Ranking in 2009, the first 12 Chilean universities were ranked among 135 Latin American universities for that year, representing 9% of them (Fig.1). These 12 universities are listed in Fig.3, which shows the evolution of their positions until 2020, staying in the top 17 positions in 2020 among a total of 35 universities ranked that year in Chile (which corresponds to 11% of the Latin American total).

The following is a description of the changes in positioning at country level in 2020 of the Chilean universities that started in the SIR Ranking in 2009:

- a) Five (5) universities maintained their position in SIR (Fig. 4): Universidad de Chile (position 1), Pontificia Universidad Católica de Chile (position 2), Universidad de Concepción (position 4), Universidad de Santiago de Chile (position 5), and Universidad Austral de Chile (position 8).
- b) Three (3) universities moved up in the SIR ranking: Universidad Andres Bello (+3), Universidad de la Frontera (+2) and Universidad de Talca (+2).
- c) Four (4) universities show decreases in their SIR positions: Pontificia Universidad Católica de Valparaíso (-3), Universidad de Valparaíso (-4), Universidad Católica del Norte

(-10), and Universidad Técnica Federico Santa María (-13).

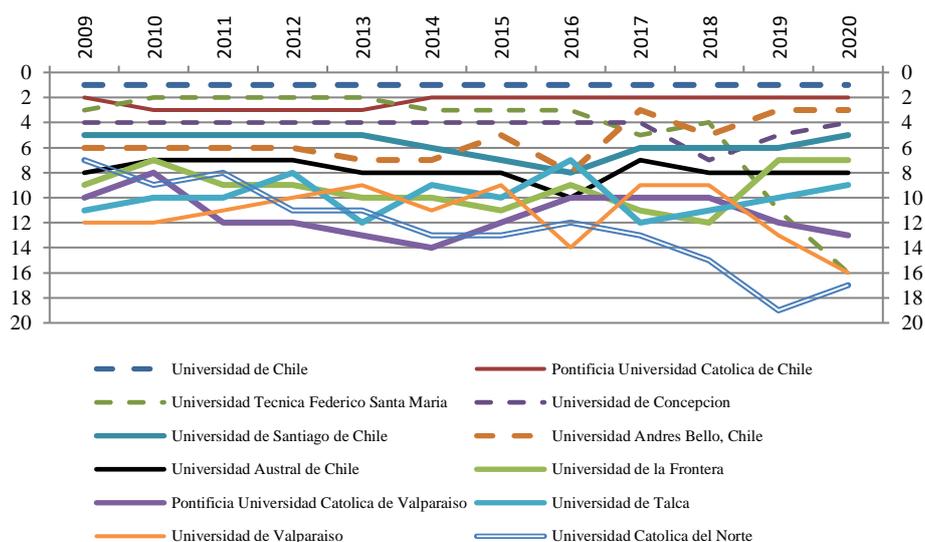


Fig. 3. Chronology of the positioning of Chilean Universities in the SIR ranking 2009 to 2020.

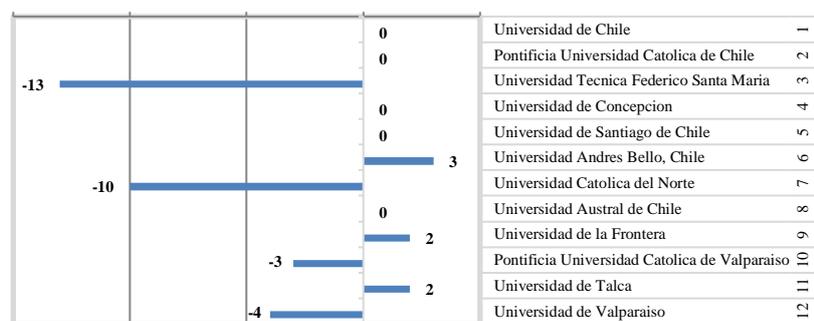


Fig. 4. Changes in the positioning to 2020 of the first universities ranked in SIR Chile in 2009.

4 Conclusions

The analysis carried out in this paper first shows the 230% increase experienced in Chile in the number of scientific articles indexed in Scopus during the 2009-2020 period, representing 8% of Latin American scientific production. Likewise, in a similar proportion, the number of universities ranked in the Scimago Institutions Ranking (SIR) increased, representing 11% of Latin American universities in that ranking. Thus, Chile has maintained a prestigious fourth place in Latin America, rising to third place in 2019, behind Brazil and Mexico. This reflects the strengthening that the country is giving to this activity.

On the other hand, in spite of the increase of scientific production and significant improvements of the international positioning of

Chilean universities, an important decrease of citations of their publications is observed (being reduced to a 9% of those received in the year 2009). An unusual behavior of the impact of the publications is observed when a correlation of -0.8 is obtained between published articles and citations. It remains to be reviewed whether this behavior is similar in other Latin American countries, and to identify its possible causes.

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