

## RESEARCH ARTICLE

**Doctoral Training and Scientific Production in HEIs: Some Indicators for Colombia with Respect to Chile****Formación doctoral y producción científica en IES. Algunos indicadores para Colombia con respecto a Chile****Formação de professores doutores e produção científica em IES sul-americanas. Caso: Colômbia comparada ao Chile.**\*ELIZABETH APONTE JARAMILLO \*\*FREDY EDUARDO VÁSQUEZ-RIZO \*\*\*JESÚS GABALÁN COELLO 

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## ABSTRACT

This article analyzes the relationship between doctoral training and scientific production in Colombia with respect to Chile, due to its similarity in the total number of new knowledge products. The results of the statistical and documentary review show that doctors in Colombia are concentrated in Higher Education Institutions (HEIs), while in Chile they do so in industry. For this, an exploratory and descriptive analysis of official sources (ministries of education, science and technology entities) and the Scopus database is carried out, calculating variables and indicators related to productivity. This gives some evidence about the efforts that these countries have made; however, this does not seem to be enough, given that the results show an indicator of a number of articles per doctor of less than 1. In this way, it contributes to the discussion about the relevance of public policy in the formation of human capital, and its scientific and development implications.

## RESUMEN

Este artículo analiza la relación entre la formación doctoral y la producción científica en Colombia con respecto a Chile, por su similitud en el total de productos de nuevo conocimiento. Los resultados de la revisión estadística y documental reflejan que los doctores en Colombia están concentrados en las Instituciones de Educación Superior (IES), mientras que en Chile lo hacen en la industria. Para ello, se realiza un análisis exploratorio y descriptivo de fuentes oficiales (ministerios de educación, entidades de ciencia y tecnología) y la base de datos Scopus, calculando variables e indicadores relacionados con la productividad. Esto otorga alguna evidencia sobre los esfuerzos que han hecho estos países; sin embargo, esto no parece ser suficiente dado que en los resultados se obtiene un indicador de un número de artículos por doctor inferior a 1. De esta manera, se aporta a la discusión sobre la pertinencia de la política pública en la formación del capital humano y sus implicaciones científicas y de desarrollo.

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Conflict of interest:

The authors declare that they have  
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## RESUMO

Este artigo analisa a relação entre a formação doutoral e a produção científica na Colômbia em relação ao Chile, devido à sua semelhança no número total de novos produtos de conhecimento. Os resultados da revisão estatística e documental refletem que os médicos na Colômbia estão concentrados nas Instituições de Ensino Superior (IES), enquanto no Chile o fazem na indústria. Para isso, é realizada uma análise exploratória e descritiva de fontes oficiais (ministérios da educação, entidades de ciência e tecnologia) e da base de dados Scopus, calculando variáveis e indicadores relacionados à produtividade. Isto fornece algumas evidências sobre os esforços que estes países têm feito; Contudo, isso não parece ser suficiente tendo em vista que os resultados mostram um indicador de número de artigos por médico menor que 1. Dessa forma, contribui para a discussão sobre a relevância das políticas públicas na formação do capital humano. suas implicações científicas e de desenvolvimento.

## Introduction

In recent years, Colombia has been working hard in the context of science and technology, with a prominent task being the training of human resources for teachers. Thus, since the mid-1990s, an era of massive support by the State to higher education institutions (HEIs) and research centers to promote postgraduate teacher training, the formation of research groups and the opening of graduate programs in universities has been determined (Jaramillo, 2010; Villaveces, 2017).

Thus, the number of teachers with master's and doctoral degrees has increased in the country in the last 10 years, by 192.59% for the first level of education (61,716 master's degrees by 2021) and by 286.63% for the second (17,700 doctoral degrees by 2021) (Ministry of National Education, 2021). Likewise, there is evidence of an increase of 114.63% in research groups (8,070 in 2021) (Ministry of Science, Technology and Innovation, 2021) and 64.06% in postgraduate programs (12,060 in 2021) (Ministry of National Education, 2021).

At the South American level, there is also an increase in this type of indicators, which is proportional to the economic capacity of each nation, the relevance given to the quality of education and the creation of an academic-research culture, among other factors. This situation also impacts the correlations that can be established from these aspects, for example, in the intellectual production generated by universities and their researchers (Álvarez and Pérez, 2016).

The most prominent countries in South America are Brazil and Argentina. Bolivia and Paraguay are at the other end of the scale. Colombia is in a middle position, relatively shared with Chile (the percentage share of this production in Chile is 10.25% and in Colombia it is 8.28%). It is worth noting that the latter two countries began to work on these issues in the 1980s. In general, after this decade, the nations of South America have been committing themselves more decisively to this reality, which has given rise to studies related to the field.

In these terms, the literature related to the association between academia and research, in which different indicators correlated with intellectual production are used (research expenditure with respect to Gross Domestic Product (GDP), scientific publications per million inhabitants, publications and citations in journals in high impact databases, among others) (Martínez, 2020); however, not many studies are found that directly associate the postgraduate training of human resources with the generation of knowledge products (Moreno, 2019; Aronne, 2019).

An example of this absence is given in the most recent report on Science of the United Nations Educational, Scientific and Cultural Organization (Unesco) (2021), where it is analyzed, for example, that there is a strong incidence of spending on research and development in scientific publication worldwide, with a marked leadership of China, the United States and some European countries, and with an average for South America below the world average (0.66%); as well as emphasizing the ratio of 1,368 researchers per million inhabitants in the

world, compared to 593 in South America. However, none of its indicators take into account education as a factor of incidence, much less postgraduate education.

Therefore, this forum invites to consider this indicator as relevant, to the extent that it is understood that postgraduate education is aimed at strengthening science and technology, through the emphatic preparation of research processes and methods, which connect the new knowledge generated with societies, considering their requirements and problems in social and scientific matters (Cardoso, Cerecedo and Vanegas, 2013).

The structure and system of rules that constitute the scheme of higher education quality imply that the institutions have a human resource trained at a higher level and that this responds, to a certain extent, to human and social needs that can be studied through professional action combined with research (Jaramillo, 2009; Nilholm *et al.*, 2021). And it is precisely under this parameter that the 'research culture' is built (Canti *et al.*, 2021), understood as a need in HEIs and nations to be able to give a universal character to the knowledge that is produced, which is diffused through scientific products, in line with an intention of social construction, placed at the service of the community, not only in terms of projects and other research exercises, but in academic training processes, where postgraduate degrees play a fundamental role (Restrepo, 2004; Government of Chile, 2019; 2023).

Therefore, the training of high-level teachers, within the university institutional context, allows leveraging research tasks that result in important academic and scientific environments, which move within the framework of the heterogeneity of the academic context (Yang and Zhao, 2021), where teachers play a very important role, as they are the image of the social responsibility of the institution (Méndez and Vera, 2015). Thus, it is understood that not only the qualification of human resources is crucial, but also the results derived from such training, one of them being the production of new knowledge (Jaramillo, 2006).

To this extent, enhancing social capital by raising levels of schooling is to aim at scientific development, since publication is what makes the result of the new knowledge generated have an impact on society (Carvajal and Carvajal, 2019). This is a condition that South America recognizes, but which, for various reasons, has not been able to make fully effective, despite the efforts made (Economic Commission for Latin America and the Caribbean (ECLAC, 2008).

Based on the above, this article explores some variables related to doctoral training and scientific production in Colombia, for the period 2010-2019, making a numerical comparison with Chile, which tends to reflect the current importance of the synergy that should exist in HEIs, between their substantive functions of teaching and research.

## Methodology

The methodology followed in this research is exploratory and descriptive, since it works with secondary information sources, both documentary and statistical, involving a work of systematization of data from the Scopus database.

In particular, the statistical information comes from official data (from the ministries of education and science and technology, both in Colombia and Chile, as well as from Scopus). These records show the levels of training of teacher-researchers and their intellectual production results. From these records, indexes were constructed to correlate the relationship between publications and researchers in Colombia and Chile.

Scopus is taken as support because, although it is understood that in South America databases such as Redalyc, Scielo or Latindex (Álvarez and Pérez, 2016) have a higher level of acceptance, it is this tool, together with Web of Science (WoS), which has the highest prestige and impact, and where the largest number of South American documents appear (mainly from Brazil, Argentina, Colombia and Chile; the latter two with a very similar number).

In addition, reports, documents and web pages generated by other sources related to academia and research, such as ECLAC, the Colombian University Observatory, UNESCO and the Ibero-American Network of Science and Technology Indicators (RICYT, for its Spanish acronym), are reviewed and analyzed to support the discussion.

Based on the above, an attempt is made to correlate graphically the trends in the number of publications with the number of PhDs, and to establish some variables and indicators related to productivity measures (percentage distribution of researchers by level of training, index of publications in Scopus, index of higher education teachers and ratio between publications and university teachers with PhDs), which allows us to observe the strength of this dynamic and, at the same time, its weakness as a goal.

## Results

Table 1 shows the evolution of publications in South American countries (period 2010-2019) in the Scopus database, according to RICYT (2021). It can be seen that Brazil is the first, followed by Argentina, Chile and Colombia, while Bolivia and Paraguay are the countries that report the least number of articles in this period. The total production constitutes only 4% of the total number of documents contained in this database worldwide.

**Table 1.** Number of publications of South American countries in Scopus.

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total Period	Growth % period	Participation % in total South America
Argentina	10.695	11.627	12.134	12.251	13.530	13.579	13.904	14.438	15.257	14.921	132.336	39,51	11,86
Bolivia	246	257	252	283	315	329	336	310	398	422	3.148	71,54	0,28
Brazil	50.402	54.865	60.428	64.016	68.364	70.391	75.049	79.316	84.647	87.399	694.877	73,40	62,27
Chile	7.113	7.824	8.907	9.321	11.107	11.738	13.351	13.675	15.193	16.162	114.391	127,22	10,25
Colombia	4.910	5.635	6.645	7.452	8.314	9.106	10.411	11.869	13.426	14.645	92.413	198,27	8,28
Ecuador	457	484	648	762	1.060	1.675	2.453	3.616	4.656	5.270	21.081	1.053,17	1,89
Paraguay	99	122	145	157	169	228	249	324	468	409	2.170	313,13	0,19
Peru	1.090	1.283	1.376	1.535	1.773	2.103	2.473	2.983	3.520	4.463	22.599	309,45	2,03
Uruguay	927	1.088	1.106	1.170	1.469	1.377	1.614	1.604	1.856	1.943	14.154	109,60	1,27
Venezuela	2.221	1.975	2.070	1.972	2.030	1.787	1.647	1.807	1.615	1.648	18.772	25,79	1,68

Source: Prepared by the authors, based on RICYT (2021).

In particular, regarding the qualification of human resources for Colombia and Chile, according to the comparative data of RICYT (2021) and El Observatorio de la Universidad Colombiana (2021), for the period 2010-2019, researchers in both countries have, for the most part, doctoral degrees (Table 1), the relative weight being higher for Colombia than for Chile, although it is known that in the latter country much of the research is carried out through companies, with suitable personnel for this (Ministry of Economy, Development and Tourism, 2021). According to the report of Unesco and its International Institute for Higher Education in Latin America and the Caribbean (IESALC, 2020), 95% of researchers in Colombia are attached to a university, while in Chile this percentage is 60%.

**Table 2.** Percentage distribution of Chilean and Colombian Researchers by level of training

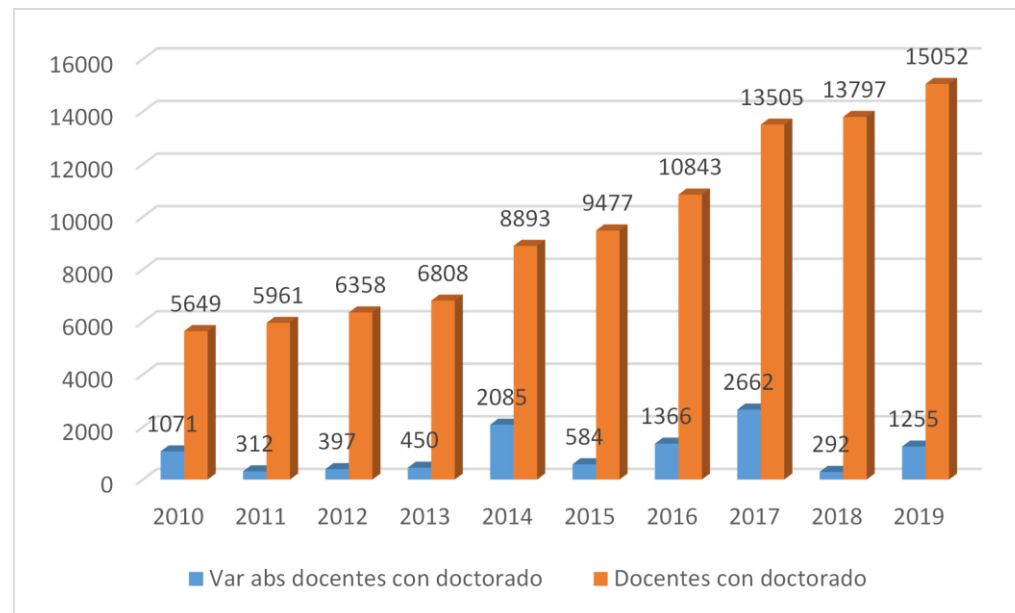
Country	Education level	Average 2010-2019
Chile	PhD	45,86%
	Master's Degree	17,8%
	Bachelor's degree or equivalent	32,16%
	Non-university tertiary	2,92%
	Others	1,3%
Colombia	PhD	67,82%
	Master's Degree	27,8%
	Bachelor's degree or equivalent	4,38%
	Non-university tertiary	0,0%
	Others	0,0%

Source: own elaboration, based on El Observatorio de la Universidad Colombiana (2021) and RICYT (2021).



For the Colombian case, it is worth highlighting the effort to advance within its universities with PhD teachers. Figure 1 shows this dynamic with a very positive trend, although it is also important to note that the absolute change of new teachers with doctorates varies markedly, probably due to: limited time for research because of other academic and administrative responsibilities and/or adverse working conditions, which, in the same sense, may affect the processes of high impact publication, especially reflected in important databases such as Scopus.

Evolution of the number of university professors with doctoral degrees in Colombia.

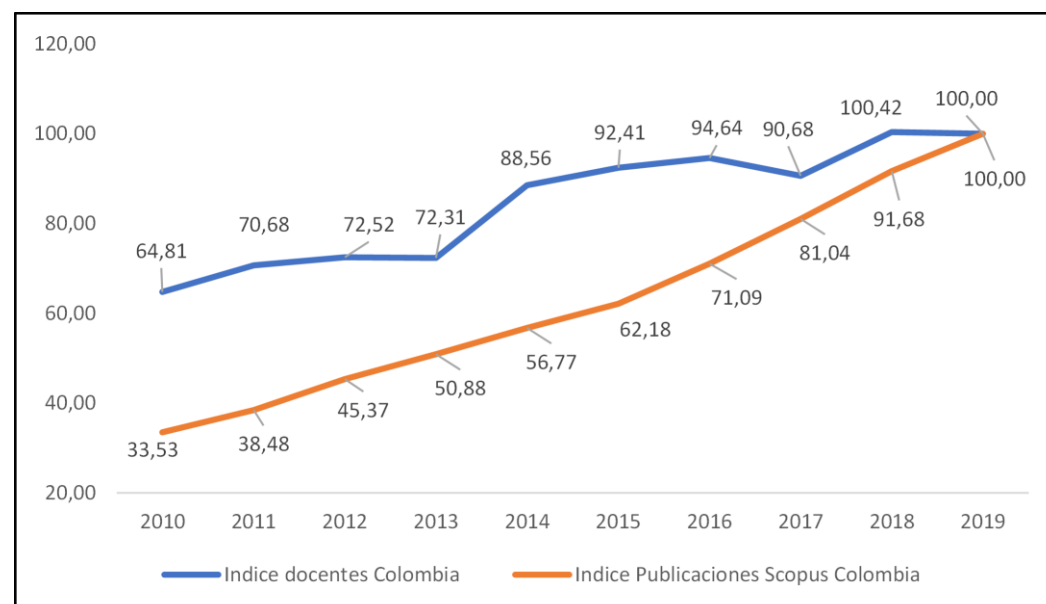


Source: own elaboration, based on El Observatorio de la Universidad Colombiana (2021).

The above graph shows that, during the period analyzed, although there is a gradual increase in the number of PhDs per year, it also shows that this change (absolute variation) is not uniform (sometimes it increases more, sometimes less).

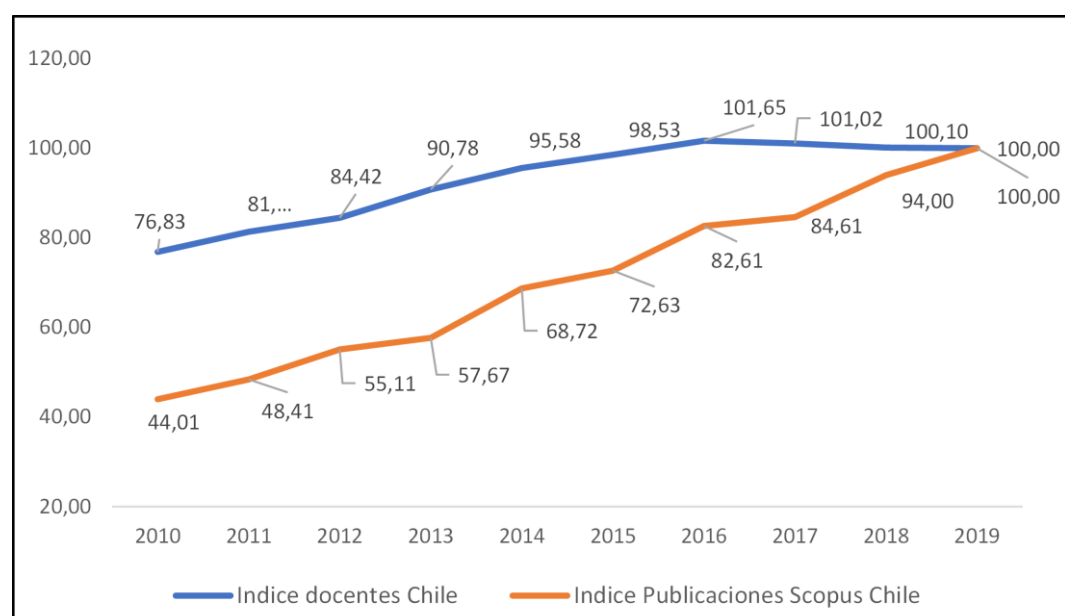
Based on the above, the correlation between the general number of university professors and the articles published in Scopus is presented for both countries (Figures 2 and 3).

Index of publications in Scopus vs. index of higher education teachers in Colombia.



Source: prepared by the authors, based on RICYT (2021) and Elsevier (2021).

Index of publications in Scopus vs. index of higher education teachers in Chile.



Source: prepared by the authors, based on RICYT (2021) and Elsevier (2021).

As can be seen, the evolution of the number of higher education teachers contrasted with the publications in Scopus of both countries maintains an increasing trend; however, their trajectories only show an effective correlation in the last years analyzed, which implies that the policies and guidelines of the nations are only just becoming stronger, in terms of teachers producing this type of high-impact publications.

However, when calculating the ratio of publications per faculty member in the last year analyzed (number of publications/ number of PhDs per country), it continues to be low when compared to the world level, being 0.09 for Colombia and 0.19 for Chile, which indicates that less than one Scopus article per faculty member is published per year.

When the data are treated more finely for Colombia, given that in this country researchers are concentrated in HEIs (this is not the case for Chile, where they are more associated with industry), the correlation with the number of articles published per doctor improves, going from 0.09 to 0.97; in fact, the annual average (Table 3) reflects practically one article, still being low at world level (a result that does not place the region very well), although in terms of South America it is among the most acceptable (Bonilla, 2021).

**Table 3.** Colombia: indicator of ratio of publications - university professors with doctoral training

Year	University professors with doctorate degrees	Scopus publications	Publications / Doctors
2010	5653	4910	0,87
2011	5960	5635	0,95
2012	6361	6645	1,04
2013	6810	7452	1,09
2014	8898	8314	0,93
2015	9479	9106	0,96
2016	10839	10411	0,96
2017	13506	11869	0,88
2018	13804	13426	0,97
2019	15055	14645	0,97

Source: own elaboration, based on El Observatorio de la Universidad Colombiana (2021) and RICYT (2021).

## Discussion

Globalization has made it possible to enhance collaborative work, both among researchers in the same country and among nations, and has made it possible to increase the options for publication and participation in

multiple and diverse national and international scenarios (Castillo and Powel, 2019). The increase in doctoral training of teachers in Higher Education Institutions (HEIs) has also contributed to their greater possibility of publication in important contexts, as has been seen throughout this document.

In South America, countries such as Colombia and Chile, for example, have increasingly supported high-level training of human resources, understanding this activity as a necessary condition for the achievement of scientific goals and development in general, and have encouraged the realization of many of these studies abroad, in order to comply with the existing policy on the internationalization of education (Casimiro, Casimiro and Casimiro, 2020; Ministry of Science, Technology, Knowledge and Innovation, 2020). However, as has been seen, this is still not enough to position itself as a country and region in the universe of high impact publications, despite having already begun to appear (Espinoza and Gonzalez, 2009).

Therefore, it is necessary that countries continue to implement, perhaps with greater commitment and demand, a policy of academic-scientific development that allows articulating educational advances with the capacity to generate high-impact knowledge products. Knowledge that should take full advantage of the academic-research advances achieved by teachers in their higher studies (in this case doctoral studies), which should respond, as a logic of this level of training (the highest), to the resolution of a specific cutting-edge problem, with an impact on society or in the specific context of the field of knowledge, in synergy with the multiple needs and possibilities offered by the academy (relationships, networking, networking, agreements, mobility, etc.).

In this sense, it is pertinent that South American countries demand greater commitment and reciprocity from their PhDs in terms of dissemination of the results of their research, with the intention of ensuring that this growth demonstrated in training also has an impact on the indicators of their scientific productions, an element through which the capacity of researchers, their institutions and their nations is measured, in important part (Rodríguez, González and Maqueda, 2017). In turn, these results should be reflected in the motivational and working conditions of teachers and their rankings, which should be an open field for future research.

## Conclusions

During the last few years, South American HEIs have undergone strict evaluation and monitoring processes of their academic quality, considering the compliance and complementarity between their substantive functions (teaching, research and social projection), a necessary synergy for the development of their educational systems and nations (Gil, Morales and Mesa, 2017; Van Der Berg, 2018; Ministry of Science, Technology, Knowledge and Innovation, 2020). However, as this paper has shown, it would seem that one of the great efforts that these institutions have made, by training their teachers in doctoral studies does not yet have the impact that was thought in terms of generating publications that appear in important databases.

Therefore, this study, rather than presenting general and positive indicators on the increase in the number of PhDs and publications (which is a fact), reflects the scarce relationship that historically exists between these two aspects, with the intention of serving as an input for subsequent analyses of another type, perhaps of impact, that will make it possible to generate objective judgments on these developments and the proposal of public policies to follow, which will serve the community and the nations. Even thinking that it could become an input for making economic, legislative, educational, political and social decisions related to the formation of human capital and the returns that this effort should represent.

It is also relevant to consider the subsequent activities and conditions in which these researchers work in their universities and to call for a deeper analysis of the heterogeneity of the contexts of the region and the characteristics of each nation, in terms of a contribution to the analysis of higher and postgraduate education, taking Colombia as the epicenter of analysis, where, despite an evident massification of these processes, there is still much to build and demonstrate, especially in terms of bringing the knowledge acquired to a high impact scientific publication.

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