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Pro-Metrics

ORIGINAL ARTICLE

An analysis of Chilean universities based on their research outputs and funded projects (2008-2022)

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ABSTRACT

Objective. We analyzed the research output of Chilean universities with the primary objective of guiding leadership teams in formulating and prioritizing their strategic goals.

Design/Methodology/Approach. The research was descriptive and documentary in nature, involving a systematic, comprehensive, transparent, and detailed review of articles published in various indexed scientific journals. Between 2008 and 2022, we searched the Scopus database at each institution to obtain information on its scientific production.

Results/Discussion. We have demonstrated the presence of a select group of universities with exceptionally high levels of scientific productivity, as indicated by significant performance metrics. The analysis of university productivity shows that, in absolute terms, the most outstanding institutions are the *Universidad de La Frontera,* the *Universidad de Tarapacá,* and the *Universidad de Chile*. This study highlights the efficiency and performance of these academic institutions in terms of their scientific output. Only 12 institutions manage to exceed the national average in terms of productivity, while 19 universities perform at an alarmingly low level.

Conclusions. This research provides valuable insights into institutions that achieve commendable results but remain underrepresented in rankings due to their smaller size. It underscores the importance of valuing outcomes over raw numbers, providing a more nuanced understanding of scientific productivity.

Keywords: research productivity; Chilean universities; higher education performance; scientific output; university governance.

1. INTRODUCTION

The so-called knowledge revolution has profoundly impacted the progress and development of modern societies, engendering an unprecedented dynamism across all areas of human life, including the field of new knowledge. Universities occupy a pivotal position in modern society, serving as a primary conduit for advanced education, creating new knowledge through research, and generating societal impact through engagement with the

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surrounding community. In light of these pivotal roles, it becomes essential to assess the performance of these institutions to ensure that they meet or exceed expected standards, allowing for corrective measures when their performance falls short (Arnaldo Valdés & Gómez Comendador, 2022; Di Nauta *et al.,* 2018; Phillips *et al.,* 2017).

Similarly, Chile is not exempt from this reality. Consequently, the university sector is one of the primary producers and disseminators of knowledge within society. Therefore, it is imperative to ensure the effective implementation of knowledge management, with leadership and governance that facilitate improvement in this area (Acosta-Silva *et al.,* 2021; Araya-Guzmán *et al.,* 2019; Bernasconi & Rodríguez-Ponce, 2018; Ganga-Contreras *et al.,* 2018, 2019; Hassan *et al.,* 2021). The assessment of this role is one of the tasks promoted by governments and different private organizations with the objective of reflecting the state and dynamics of research activity from the learning perspective, at the institutional level, and in terms of its participation at the national and international levels. (Rodríguez-Ponce *et al.,* 2024).

The significance of Chilean universities as sources of knowledge is evident in numerous ways, and their multifaceted contributions serve as a crucial driving force for innovation, economic advancement, and enhanced quality of life. Notwithstanding the aforementioned considerations, there is a notable dearth of studies that specifically address the scientific productivity of universities. The existing studies are predominantly linked to data envelopment analysis, which primarily seeks to evaluate efficiency, with research being only one of the variables examined. Similarly, other studies concentrate on disparate aspects of university performance, frequently neglecting the intricate role of research within the broader institutional context (Cáceres *et al.,* 2014; Muñoz, 2016; Ramírez & Alfaro, 2013). The principal objective of this research is to examine the findings of Chilean universities in order to inform the priorities that management teams should assign to their strategic objectives.

In addition to their role in educating individuals, these institutions serve as crucial drivers of research and development, making a substantial contribution to the advancement of Chilean society in a globally competitive context. This study illuminates the impact and potential of these institutions, underscoring their vital role in shaping Chile's future prosperity and promise.

1.1. Universities as knowledge generators

Universities serve a multifaceted role in society, fulfilling a range of vital functions that contribute to the advancement and growth of communities and societies. These tasks can be classified into three fundamental dimensions: the education of individuals, the generation of new knowledge, and the establishment of connections with local and global territories (Bitencourt *et al.,* 2021; David, 2019; Salmi, 2009; Skrbinjek, 2020).

One of the primary functions of universities is the training of individuals. Universities provide an environment conducive to the acquisition of skills, knowledge, and perspectives, equipping students with the tools to navigate the challenges of professional and personal life (Scott, 2006). By offering rigorous academic programs, universities facilitate the development of critical thinking, problem-solving abilities, and technical skills. Such training benefits not only the students themselves but also society at large, ensuring the availability of a skilled and adaptable workforce (Cedeño, 2019).

In addition, these higher education institutions are instrumental in generating new knowledge (Gibbons, 1994). We can advance science, technology, and culture through research and the development of innovative ideas. Wilhelm von Humboldt first proposed the concept of the modern university in Germany in 1810. This led to the view that such institutions should provide researchers with the necessary resources and space to explore new frontiers of knowledge rather than simply transmitting knowledge for immediate use (Zagorac, 2017).

Consequently, this results in discoveries that can directly impact improving the quality of life, economic growth, and the resolution of global problems. Therefore, the ability of universities to conduct high-quality research is an invaluable asset for society (Luque-Martínez *et al.,* 2023).

As Kumar and Thondikulam (2006) have observed, organizations must pass through three

stages to reach the knowledge generation stage. The first stage concerns identifying the actions required to acquire, elaborate, and conserve information as databases. The second stage allows organizations to share the information they have acquired. The third stage is where they can generate new knowledge. However, universities play a particularly crucial and strategic role in the generation of new knowledge.

The generation of new knowledge is the basis for innovation and progress. Universities should, therefore, act as catalysts for research and development, providing the resources and enabling environment for researchers to explore and discover new frontiers of knowledge (Bitencourt *et al.,* 2021; Carayannis *et al.,* 2015). Consequently, this directly impacts scientific and technological advancement and contributes to the resolution of complex societal issues (Edwards-Schachter, 2018).

Universities are also expected to maintain vital relationships with the territories in which they are located. Liaison with the local and global community is essential to ensure that research and education have real-world relevance (Sánchez-Barrioluengo & Benneworth, 2019). Consequently, these entities function as nexuses for exchanging and collaborating knowledge with businesses, nonprofit organizations, and government. Establishing strategic alliances can effectively address local and global problems, offering solutions based on evidence and expert knowledge derived from diverse learning activities (Rodríguez-Ponce *et al.,* 2023).

Salmi (2009) delineates the attributes that a university must possess to be considered world-class. Three elements must be aligned in order to achieve this goal: the concentration of talent, abundant resources, and favorable governance. These elements facilitate the training of individuals at both the undergraduate and graduate levels, the generation of new knowledge through scientific research, and the transfer of technology through patents. Nevertheless, the latter can also be evaluated based on its impact on market interrelations.

This multidimensional approach underscores the pivotal role of fundamental elements, including a robust strategic vision, sufficient funding, the recruitment of esteemed academic professionals, research excellence, global networks, effective governance, contemporary infrastructure, and a sterling reputation. When properly aligned, these elements can enhance the quality and status of an academic institution on a global scale. Furthermore, the national and regional context is of paramount importance in the effective implementation of this strategy (Lee, 2021).

Establishing and maintaining academic institutions of excellence requires a significant investment in financial resources (Agasisti *et al.,* 2023). This investment encompasses the acquisition of public funding and the capacity to generate supplementary funds, attract donors, and manage available resources effectively.

With regard to the human element, two fundamental aspects can be identified: firstly, the attraction of students with exceptional abilities and high levels of motivation, which may necessitate the implementation of targeted strategies to attract both national and international students; secondly, the capacity to attract academic and research personnel, whose quality is of paramount importance. Consequently, this entails the recruitment and retention of highly qualified professors, as well as the encouragement and promotion of advanced research and teaching activities (Suarez-Amaya *et al.,* 2022).

Universities must prioritize pursuing new knowledge to enhance education, as teaching and scientific research are inextricably linked. Teaching disseminates and discloses the findings generated by scientific research, which employs the scientific method to uncover new insights (Santos *et al.,* 2022). As a consequence of this indivisible connection, the training process should be based on reliable and up-to-date knowledge that enables the comprehension of phenomena and provides responses to significant questions posed by society. This implies the recognition, understanding, and addressing of research with regional relevance, with the objective of benefiting the community and the territories (Choi & Jang, 2023; Fitjar *et al.,* 2019; Owen *et al.,* 2012; Pereira & Franco, 2023; Rivera-García *et al.,* 2017; Sigl *et al.,* 2020).

Universities pursue this relevance through various actions, primarily by promoting and strengthening the connection with their surrounding socioeconomic environment. Consequently, universities implement measures that facilitate the transfer of research outcomes from the academic realm to the productive and

business sectors and society at large (Cedeño, 2019; Corso, 2020; Di Nauta *et al.*, 2018; Lendel & Qian, 2017). These results can be further enhanced by facilitating identifying, clarifying, and resolving local, regional, and national issues. Research is pivotal in advancing and expanding diverse communities, as asserted by The United Nations Educational, Scientific and Cultural Organization (UNESCO, 2015).

As defined by the literature, the formal research results produced at universities are called scientific output (Lee & Bozeman, 2005; Print & Hattie, 1997). These institutional results are expressed in the publication of articles, chapters, books, and patents, among other formats (Hurley, 2003; Martínez-Méndez *et al.,* 2010; Rousseau, 2001), and in their impact, which is quantified by the number of citations. The term "scientific performance" is also related to the concept of scientific production. The latter is a complex term based on the results obtained from participation in research projects, whether won or executed. In the last decade, this indicator has become a standard feature in most manuals on quantitative indicators in this field (Díaz Corrales & Pedroza Pacheco, 2018; Sáenz León *et al.,* 2022).

In light of the aforementioned considerations, it is noteworthy that the field of scientific research evaluation is characterized by many classification systems (Palomares-Montero *et al.,* 2008). However, the classification system that has gained significant prominence at the international level is one that employs quantitative indicators to assess the outcomes of scientific production (as previously discussed). This methodology is also reflected in various global university rankings (output indicators) and other metrics derived from the internal management of academic institutions (process indicators).

2. METHODOLOGY

The research is descriptive and documentary in nature, entailing a systematic, comprehensive, transparent, and detailed review of articles published in various indexed scientific journals. This approach enabled the presentation of evidence from the scientific literature in a clear and organized manner (Kerlinguer & Lee, 2002). Furthermore, an analysis of the Scopus database was conducted at each institution between 2008 and 2022 to obtain information on scientific production. To ascertain the publication output of each university, the Scopus organizational search tool was employed, and the publications of each institution were subsequently selected. The results were filtered by the requisite years and transferred to an Excel spreadsheet for the purpose of maintaining a record. The utilization of this database is of particular significance, as it is currently regarded as the largest in the world and one of the most esteemed (Pranckutė, 2021).

In the study of the scientific production of Chilean universities, considering a territorial classification that allows for a detailed and contextualized analysis of the data is of the utmost significance. This geographical categorization is based on the understanding that academic institutions are not only differentiated by their fields of study and areas of research but also by the socioeconomic, cultural, and geographical particularities of the regions in which they are located. The rationale for this territorial classification is that it allows for a more profound and meaningful interpretation of the results, thereby facilitating informed decision-making at the institutional and governmental levels.

The decision to allocate the universities into different geographic regions, such as the Macro Northern Zone, Macro Central Zone, and Macro Southern Zone, is based on the following considerations:

- Socioeconomic Context and Regional Development: The socioeconomic context of each Chilean region exerts a distinctive influence on the orientation and focus of local universities. The institutions are classified according to their territorial location, considering the intrinsic connection between the regional environment and academic priorities. This allows for a more accurate assessment of each university's specific contributions and challenges.
- Identification of Regional Trends and Patterns: The application of territorial classification enables the discernment of regional trends and patterns in scientific production. The regional classification of universities can be particularly valuable in understanding how these institutions respond to research

stimuli and policies in different geographic areas. Furthermore, it can be used to identify areas of strength and opportunity that regional dynamics may influence.
- Effective Benchmarking and Comparison: Clustering universities based on their geographic location establishes a coherent framework for comparison and benchmarking within analogous regions. Consequently, evaluating the comparative performance of institutions within a more homogeneous context is feasible while simultaneously acknowledging notable discrepancies between disparate geographic regions.
- Information for Strategic Decision-Making: The findings yielded by this territorial classification can be employed to facilitate strategic decision-making at the institutional and governmental levels. Incorporating regional particularities can facilitate the formulation of policies and strategies that address each geographic area's specific needs and opportunities.

The scientific productivity of the universities was determined using two indicators:

- Published Articles: This indicator considers the number of articles published in scientific journals indexed in the Scopus database during the 2008-2022 period, thereby providing insight into the research activity of Chilean universities. The data were collected annually and subsequently categorized into five distinct periods: 2008-2010, 2011-2013, 2014-2016, 2017-2019, and 2020-2022. The annual results were averaged to obtain a representative value for each period. This approach permits the examination of trends and patterns across disparate time intervals, thereby facilitating a more structured interpretation of the data.
- Fondecyt Projects: In order to ensure the transparency of the process, research projects funded by the National Fund for Scientific and Technological Development (Fondecyt) were considered. To this end, the complete list of Fondecyt projects, classified according to the affiliation of the principal investigator, was requested from the National Agency for Research and Development (ANID, 2023). This assessment encompassed the conferral of Fondecyt projects at the inception, regular, and postdoctoral stages, conducted by researchers in accordance with their institutional affiliation between 2011 and 2022. The data were collected annually and subsequently grouped into four distinct periods: 2011-2013, 2014-2016, 2017-2019, and 2020-2022. The annual data were averaged for each period to produce a single representative value. This method was employed to facilitate the analysis of temporal trends and patterns, thereby enabling a more coherent and structured interpretation of the data over time.

The aggregated data on publications and awarded projects for each university within each period were normalized by the full-time equivalent (FTE) of academic staff at each institution. This approach permitted calculating an average value per academic for both the publication and project indicators. The data were extracted from the Higher Education Information System (SIES, 2022a, 2022b) for the period between 2008 and 2022.

While the SIES lists 58 universities as active as of September 2023, numerous institutions are undergoing closure processes, and others lack approved projects or publications. Consequently, Table 1 includes only the 52 selected universities with either publications or projects awarded during the period under analysis. Therefore, the following universities were excluded from this study: Universidad Bolivariana, Universidad de Arte y Ciencias Sociales (ARCIS), Universidad del Pacifico, Universidad Iberoamericana de Ciencias y Tecnología (UNICIT), de Artes, Ciencias y Comunicación (UNIACC), and Universidad de la República.

3. RESULTS AND DISCUSSION

3.1. Scientific production of Chilean universities

The following tables present the mean number of scientific publications in journals indexed in Scopus for each university in Chile for the years 2008-2022, organized into three-year intervals. Over time, a number of changes and trends have emerged in the scientific output of universities in different geographic regions.

Zone	University	Acronym	University	Acronym	University	Acronym
North	Universidad de Tarapacá	UTA	Universidad Arturo Prat	UNAP	Universidad de Antofagasta	UA
	Universidad Católica del Norte	UCN	Universidad de Atacama	UDA	Universidad de la Serena	ULS
Center	Pontificia Universidad Católica de Valparaíso	PUCV	Universidad Técnica Federico Santa María	UTFSM	Universidad de Playa Ancha de Ciencias de la Educación	UPLA
	Universidad de Aconcagua	UACON	Universidad Viña del Mar	UVM	Universidad de Valparaíso	UV
	Universidad de Chile	UCH	Pontificia Universidad Católica de Chile	PUC	Universidad de Santiago de Chile	USACH
	Universidad Andrés Bello	UNAB	Universidad Adolfo Ibáñez	UAI	Universidad Diego Portales	UDP
	Universidad Mayor	UMAYOR	Universidad de los Andes	UANDES	Universidad Santo Tomas	UST
	Universidad Bernardo O'Higgins	UBO	Universidad de las Américas	UDLA	Universidad Alberto Hurtado	UAH
	Universidad Tecnológica Metropolitana	UTEM	Universidad Finis Terrae	UFT	Universidad Central de Chile	UCEN
	Universidad Metropolitana de Ciencias de la Educación	UMCE	Universidad Católica Silva Henríquez	UCSH	Universidad Academia de Humanismo Cristiano	UAHC
	Universidad SEK	USEK	Instituto Nacional de Capacitación Profesional	INACAP	Universidad del Alba	UDALBA
	Universidad Gabriela Mistral	UGM	Universidad Miguel de Cervantes	UMC	Universidad Los Leones	ULL
South	Universidad de O'Higgins	UOH	Universidad de Talca	UTALCA	Universidad Católica del Maule	UCM
	Universidad de Concepción	UDEC	Universidad del Bio-Bío	UBB	Universidad Católica de la Santísima Concepción	UCSC
	Universidad San Sebastián	USS	Universidad del Desarrollo	UDD	Universidad Adventista de Chile	UADVEN
	Universidad Católica de Temuco	UCT	Universidad de la Frontera	UFRO	Universidad Autónoma de Chile	UAUTO
	Universidad Austral de Chile	UACH	Universidad de los Lagos	ULAGOS	Universidad de Aysén	UAYSEN
	Universidad de Magallanes	UMAG				

Source: Prepared by the authors based on the SIES database available at www.mifuturo.cl.

Table 1. Acronyms of Chilean universities.

It is crucial to note that these figures represent only the average number of articles published in journals indexed in Scopus and do not reflect the quality or impact of the research. Furthermore, factors such as institutional policies, investment in research, and international collaboration may influence these trends. An institution with a larger number of academics should have a greater number of publications.

3.1.1. Northern zone universities

The universities in the northern region of Chile have demonstrated a consistent upward trajectory in scientific output over time, with a notable increase of over 100% between the 2008-2010 and 2020-2022 periods.

Table 2 illustrates that an analysis of the scientific production of universities in the northern

zone of Chile between the periods 2008-2010 and 2020-2022 reveals a notable diversity in growth trajectories. The Universidad de Atacama (UDA) is distinguished by its exceptional growth despite its initial low performance, with an impressive increase of 1891.98%. Similarly, universities such as the Universidad de Tarapacá (UTA) and the Universidad Arturo Prat (UNAP) demonstrate noteworthy growth of 448.79% and 452.44%, respectively, which substantiates their sustained dedication to research and knowledge generation.

In contrast, other institutions, such as the Universidad de Antofagasta (UA) and the Universidad de la Serena (ULS), demonstrate more moderate growth rates, indicating potential challenges or areas for improvement in research.

Northern Zone Universities	2008-2010	2011-2013	2014-2016	2017-2019	2020-2022
UCN	198.67	274.00	351.67	465.67	683.00
UTA	101.67	154.33	231.67	297.33	558.00
UA	84.33	112.67	174.00	286.33	391.00
ULS	69.00	111.33	128.00	212.67	268.33
UDA	11.67	24.00	43.33	157.33	232.33
UNAP	32.33	51.33	73.33	102.00	178.67

Source: Prepared by the authors based on Scopus data.

Table 2. Scientific output average number of articles in three years by Chilean universities in country's northern regions from 2008 to 2022.

3.1.2. Central zone universities

A similar pattern of uninterrupted growth in scientific output is evident among the universities of central Chile in Santiago and Valparaíso. The Universidad de Chile (UCH) and the Pontificia Universidad Católica de Chile (PUC) are the foremost institutions in this field within the country, demonstrating a consistent and robust commitment to scientific advancement over time.

With regard to the scientific production of universities in the central zone of Chile, three institutions have demonstrated the most notable growth over the specified evaluation periods. The UCH is the unquestionable leader, exhibiting an exceptional growth of 110.48% since 2008, thereby establishing itself as a prominent force in research. Similarly, PUC evinces a robust dedication to generating knowledge, exhibiting an increase of 163.14%, which maintains its status as a regional reference institution. Similarly, the Universidad Andrés Bello (UNAB) has demonstrated an exceptional growth of 730.43% since 2008, establishing itself as a notable contributor to scientific advancement.

In contrast, three institutions are distinguished by comparatively modest growth rates or a lack of increase in their scientific production. The Universidad Central de Chile (UCEN) reports a notable increase of 2977.39%, although its growth rate is less pronounced than that of the leading institutions. The Universidad Metropolitana de Ciencias de la Educación (UMCE) has experienced a relatively slower rate of progress, with an increase of 446.83%. This indicates potential areas for strengthening the institution's research impact. Lastly, the Universidad de Las Américas (UDLA) exhibits a fluctuating growth rate, with periods of decline interspersed with periods of growth. The most recent period, for instance, saw an increase of 3845.58%. It is evident that addressing consistency in scientific production is of significant importance in this case.

The emphasis on universities in the Valparaíso region demonstrates that the Pontificia Universidad Católica de Valparaíso (PUCV) has also gradually increased output, with the publication of over 1,000 articles during the most recent period. Despite increasing its average production by 165.60%, the Universidad Técnica Federico Santa María (UTFSM), which had the

highest number of publications in this area in the first period, ranks second after the PUCV. Another noteworthy case is that of the Universidad de Valparaíso (UV), which exhibited a 325% growth rate over the period in question.

The Universidad de Aconcagua (UACON) and Universidad Los Leones (ULL) represent distinctive academic institutions that have demonstrated a consistent publication rate. In the case of the former, there are periods during which no publications were generated. Conversely, the ULL has yet to achieve institutional autonomy, which constrains its capacity for growth in enrollment and programs. These institutions are not accredited by the National Accreditation Commission (CNA), which has determined that they are not yet compliant with the minimum accreditation standards. This situation is of particular significance, as per the stipulations of Law No. 21091 (2018), which requires that institutions obtain accreditation.

Moreover, research, creation, and innovation are essential university criteria. This situation thus implies that both institutions must request authorization from the National Council of Education (CNED) to enroll new students. In the event that, within a three-year term, they have not achieved accreditation, the Council requests the Ministry of Education to revoke the official recognition, which would result in the institution's closure. The aforementioned results are presented in Table 3.

Central Zone Universities	2008-2010	2011-2013	2014-2016	2017-2019	2020-2022
UCH	1759.67	2115.33	2864.33	3230.00	3698.00
PUC	1291.67	1805.00	2465.33	2839.00	3400.00
UNAB	161.00	333.33	555.00	816.00	1336.00
USACH	349.00	479.33	657.33	888.67	1164.00
PUCV	251.33	350.33	604.33	800.33	1034.00
UTFSM	304.00	507.33	604.33	719.67	807.67
UV	165.00	276.00	412.67	512.33	703.00
UAI	52.33	100.67	199.67	316.67	529.00
UDP	131.33	225.33	413.00	430.67	518.67
UMAYOR	21.00	44.67	77.67	267.67	473.00
UANDES	75.67	126.67	220.67	302.67	435.67
UST	25.33	44.00	100.00	160.33	326.33
UBO	0.33	8.00	61.33	161.33	285.33
UDLA	5.67	2.67	6.67	46.67	223.67
UAH	29.33	54.33	92.33	158.00	212.33
UTEM	22.00	12.33	24.00	109.67	191.00
UFT	5.00	25.33	71.67	90.00	163.00
UPLA	9.33	25.67	106.67	138.00	162.33
UCEN	4.33	26.67	72.33	85.00	133.33
UMCE	23.00	26.33	37.67	43.00	125.67
UCSH	6.33	17.33	13.67	33.67	75.33
UVM	6.33	8.33	13.00	27.00	65.67
UAHC	6.00	9.33	17.67	33.33	45.67
USEK	0.33	2.00	5.33	10.67	28.67
INACAP	2.00	2.33	4.00	54.67	20.67
UDALBA	2.33	5.33	2.00	5.67	13.00
UGM	1.33	2.00	5.00	13.33	9.33
UMC	0.33	0.00	0.00	2.33	4.67
UACON	—	0.33	—	—	3.67
ULL	—	—	—	—	—

Source: Prepared by the authors based on Scopus data.

Table 3. Scientific output average number of articles in three years by Chilean universities in the central regions from 2008 to 2022.

3.1.3. Southern zone universities

Notable growth in scientific production has also been observed among universities located in the country's southern region, though there are variations among them.

The Universidad de Concepción (UDEC) has demonstrated a consistent and substantial output, with over 1,700 articles published in the most recent period. Conversely, the Universidad Austral de Chile (UACH) has emerged as the leading institution in this region, exhibiting a notable trajectory of growth, with over 1,000 articles published in the most recent period. Similarly, other universities have also demonstrated increased scientific production, including the Universidad del Bío-Bío (UBB) and the Universidad de Talca (UTALCA). In recent periods, the positive performance of universities such as the Universidad Católica del Maule (UCM) and the Universidad del Desarrollo (UDD) is worthy of note.

The Universidad de O'Higgins (UOH), established in 2016, has demonstrated the highest percentage growth among universities. This is particularly noteworthy given that it is still in its infancy, experiencing continued growth in enrollment, academic staff, and publications. In contrast, the Universidad Adventista de Chile (UADVEN) has a relatively limited number of publications, with only the Universidad de Aysén having a smaller output. The final case to be discussed is that of the Universidad Autónoma de Chile (UAUTO), which has exhibited a growth of 5326.32%. This high percentage can be attributed to the fact that the number of articles in question was relatively low to begin with. The number of academics with doctoral degrees at this institution has increased significantly, which may contribute to this notable surge. Table 4 presents the mean number of publications produced by Chilean universities in the country's southern zone during the specified period.

Southern Zone Universities	2008-2010	2011-2013	2014-2016	2017-2019	2020-2022
UDEC	790.33	951.33	1152.67	1423.00	1791.67
UACH	338.67	431.00	553.67	742.00	1025.67
UFRO	214.00	315.67	467.67	621.00	881.67
UAUTO	13.33	58.33	359.33	552.33	723.33
UTALCA	193.33	248.67	390.33	510.67	692.33
UCM	39.67	72.67	86.00	232.67	589.00
UDD	84.00	158.00	251.67	344.33	541.67
UBB	102.00	144.00	216.67	341.00	470.33
UCSC	52.67	66.00	100.67	237.33	452.33
USS	12.33	26.00	187.33	262.00	382.67
UCT	54.00	91.33	129.67	235.33	349.33
ULAGOS	47.33	62.33	94.33	193.00	274.00
UMAG	48.33	51.33	98.00	135.00	181.33
UOH	—	—	0.67	51.00	169.67
UADVEN	0.33	1.00	3.67	27.33	54.00
UAYSEN	—	—	—	10.67	37.67

Source: Authors' design, based on Scopus.

Table 4. Scientific output average number of articles in three years by Chilean universities in the country's southern regions from 2008 to 2022.

3.2. Fondecyt projects

The following tables present the results of projects funded by academics in the category of responsible researcher, classified according to their institutional affiliation. All Fondecyt projects considered are from 2011 to 2022, encompassing a three-year period. The projects are of three types: initiation projects, which are oriented to researchers who have recently obtained their doctoral degree; postdoctoral projects, which finance postdoctoral research as their name indicates; and regular projects, which are the most prestigious, have the largest budget, and a duration of up to four years.

Although authorities and researchers regard Fondecyt projects as an indicator of institutional capacity to award competitive resources, their primary objective is to provide funding for research development. It is, therefore, anticipated that an institution that is able to secure a greater number of projects across the various categories (initiation, regular, and postdoctoral) will gain access to substantial resources that will have a notable impact on scientific publications.

In general, the total number of projects awarded has remained relatively consistent. This suggests that an institution that successfully obtains projects may benefit at the expense of other institutions.

3.2.1. Northern zone universities

As illustrated in Table 5, the educational institution that has demonstrated the most significant growth in the number of awarded projects is the UTA, with a percentage increase of 67.74%. The UDA and the UNAP have also demonstrated an increase in the number of projects awarded. The remaining institutions have either maintained their adjudication rates or experienced slight decreases, as observed in the cases of the Universidad Católica del Norte (UCN) and the ULS. A noteworthy exception is the UA, which exhibits a cyclical pattern with pronounced fluctuations in the number of projects awarded.

Northern Zone Universities	2011-2013	2014-2016	2017-2019	2020-2022
UTA	31	31	40	52
UCN	45	41	54	41
ULS	29	21	23	28
UA	26	15	26	18
UNAP	7	10	16	17
UDA	1	6	11	13

Source: Prepared by the authors based on the Fondecyt ANID database.

Table 5. Number of Fondecyt initiation, regular, and postdoctoral projects awarded by the head researchers of the northern zone universities from 2011 to 2022.

3.2.2. Central zone universities

The central zone encompasses the majority of the country's institutional infrastructure, which significantly influences the number of research projects awarded within this region.

As illustrated in Table 6, the Universidad Mayor stands out as an institution with particularly robust growth, with the number of projects awarded increasing eightfold. Another institution that has demonstrated remarkable growth is the Universidad Técnica Metropolitan (UTEM), which has quadrupled the number of projects awarded. It is noteworthy to mention the UDLA, which has increased its portfolio from zero to nine projects over the past two periods. Furthermore, the Universidad Adolfo Ibáñez, UNAB, UV, Universidad de los Andes (UANDES), and Universidad Alberto Hurtado (UAH) have also demonstrated noteworthy growth.

In terms of the universities that have experienced a decline in the number of awarded projects, the UCH is a notable example, with 164 projects representing its most successful outcome. Conversely, the PUC has experienced a decline of 135 projects since the 2014-2016 period. Additionally, the PUCV and the UTFSM have experienced a decline, albeit to a lesser extent.

3.2.3. Southern zone universities

As evidenced in Table 7 and in previous cases, the institutions that have historically been responsible for the allocation of projects have experienced a notable decline in their output. In this situation, the UDEC is analyzed, which awarded 39 fewer projects in the last period; a similar trend is observed in the case of the UACH, which saw a reduction of six project awards.

Central Zone Universities	2011-2013	2014-2016	2017-2019	2020-2022
UCH	669	688	559	524
PUC	517	630	564	495
USACH	172	160	149	152
PUCV	160	172	175	129
UNAB	101	120	114	128
UAI	53	54	97	106
UTFSM	108	103	117	102
UV	63	85	92	90
UANDES	45	65	59	74
UAH	29	49	58	66
UDP	49	74	77	61
UMAYOR	5	27	50	42
UTEM	6	11	24	27
UPLA	8	18	35	25
UBO	3	11	12	21
UCSH	3	5	9	19
UST	3	5	6	16
UCEN	2	15	8	15
UAHC	12	12	19	12
UMCE	9	5	2	12
UFT	4	9	9	11
UDLA	0	0	9	7
USEK	0	1	1	1
INACAP	1	1	2	0
UGM	0	1	0	0
UMC	0	0	0	0
UDALBA	0	0	0	0
ULL	—	—	—	—
UVM	0	1	2	0
UACON	0	0	0	0

Source: Prepared by the authors based on the Fondecyt ANID database.

Table 6. Number of Fondecyt initiation, regular, and postdoctoral projects awarded by researchers responsible for the central zone universities from 2011 to 2022.

In contrast, the UAUTO has experienced a remarkable 600% expansion in project awards, while the UDD has doubled its project awards. The Universidad de La Frontera (UFRO) has also demonstrated a notable growth of 46.84%, and the UTALCA has exhibited a 20.99% increase in project awards.

The case of the UOH is noteworthy, particularly given that, despite its recent establishment, it has been awarded many projects, with an average of over four dozen in the most recent period under review.

3.3. Performance in universities

In the present circumstances, it is crucial to evaluate the performance and impact of higher education institutions to ascertain their contribution to the advancement of knowledge. Given the significant variation in size and resources across universities, it is nevertheless important to ensure that the number of scientific publications and research projects accurately reflects the quality and commitment of academics. The concept of "Weighted Productivity by

Southern Zone Universities	2011-2013	2014-2016	2017-2019	2020-2022
UDEC	253	235	233	214
UACH	150	134	153	144
UFRO	79	103	106	116
UTALCA	81	102	97	98
UAUTO	7	55	51	49
UDD	23	21	41	47
UBB	36	35	44	45
UOH	-	6	30	42
UCSC	18	22	43	40
UCT	19	29	30	35
UCM	17	14	34	32
USS	6	10	24	29
ULAGOS	25	16	30	25
UMAG	8	15	17	15
UAYSEN	—	—	7	5
UADVEN	0	0	1	0

Source: Prepared by the authors based on the Fondecyt ANID database.

Table 7. Number of Fondecyt initiation, regular, and postdoctoral projects awarded by researchers responsible for the southern zone universities from 2011 to 2022.

Institutional Size" is paramount in addressing the existing variability and achieving a more equitable assessment.

The FTE, defined as the amount of work time of an academic hired for 44 hours per week, emerges as a fundamental unit of measurement for assessing the workload and, consequently, the capacity of each academic in the institution. This measure is of particular importance as it provides a standardized and equitable view of the individual contribution of each faculty member to the academic work.

The FTE assumes a pivotal role in this evaluation, offering a uniform and impartial gauge of academics' workloads. The FTE enables the estimation of each academic's contribution in terms of scientific production and awarded projects, irrespective of the size of the university to which they belong.

In this instance, the methodology employed in the "Weighted Productivity by Institutional Size" calculates the number of scientific publications generated and the number of projects awarded by each university in comparison to each FTE unit. Thus, the assessment of each institution's contribution to scientific production, irrespective of its relative size, can be conducted more equitably and balanced.

Applying the "Weighted Productivity by Institutional Size" methodology to the various universities provides a more accurate and equitable representation of their academic and scientific contributions. This approach allows for the revelation of patterns and trends that might otherwise remain unnoticed by comparing only the overall number of articles published and projects awarded.

3.4. Scientific articles per FTE academic

3.4.1. Northern zone universities

As demonstrated in Table 8, UTA exhibits the most exemplary performance in terms of scientific publications per academic, with an average of 1.59 articles per academic per FTE. The 354.29% growth of this institution renders it a critical case study, the objective of which is to determine the causes of this proportional increase. Similarly, the UCN, which also exceeds the one-per-FTE-academic threshold, is positioned among the highest percentages in the country. Despite its smaller absolute growth, its growth rate is no less impressive.

In general, all the universities in this zone exhibited a notable increase in proportional yields per academic.

Northern Zone Universities	2008-2010	2011-2013	2014-2016	2017-2019	2020-2022
UTA	0.35	0.46	0.65	0.83	1.59
UCN	0.42	0.57	0.63	0.74	1.24
UA	0.24	0.33	0.45	0.68	0.91
ULS	0.22	0.35	0.37	0.58	0.87
UDA	0.08	0.13	0.17	0.48	0.62
UNAP	0.08	0.17	0.19	0.21	0.42

Source: Authors' design, based on Scopus databases for publications and SIES for academics.

Table 8. Publications in Scopus by academics according to full-time equivalent in the northern zone universities from 2008 to 2022.

Central Zone Universities	2008-2010	2011-2013	2014-2016	2017-2019	2020-2022
UCH	0.99	1.13	1.33	1.39	1.57
PUCV	0.46	0.61	0.96	1.22	1.54
PUC	0.76	0.93	1.18	1.26	1.50
UTFSM	0.75	0.91	0.92	0.99	1.11
UAI	0.30	0.34	0.53	0.65	0.99
USACH	0.39	0.55	0.64	0.79	0.98
UANDES	0.18	0.35	0.38	0.53	0.81
UV	0.24	0.35	0.46	0.58	0.79
UBO	0.003	0.10	0.27	0.45	0.76
UAH	0.18	0.28	0.43	0.66	0.74
UDP	0.35	0.43	0.62	0.64	0.70
UNAB	0.14	0.24	0.31	0.38	0.56
UTEM	0.06	0.05	0.08	0.33	0.51
UMAYOR	N/A	N/A	0.07	0.24	0.50
UMCE	0.08	0.09	0.12	0.13	0.42
UPLA	0.03	0.07	0.27	0.34	0.39
UFT	0.04	0.13	0.20	0.22	0.34
UAHC	0.06	0.07	0.14	0.25	0.28
UCEN	0.02	0.07	0.17	0.17	0.27
UST	0.05	0.05	0.09	0.14	0.26
UCSH	0.05	0.10	0.06	0.12	0.24
UDLA	0.01	0.00	0.01	0.05	0.22
USEK	0.01	0.02	0.04	0.07	0.21
UGM	N/A	N/A	0.08	0.16	0.17
UVM	0.04	0.05	0.04	0.07	0.17
UMC	0.01	0.00	0.00	0.04	0.07
UDALBA	0.03	0.02	0.01	0.02	0.06
INACAP	N/A	N/A	0.00	0.06	0.05
UACON	0.00	0.00	0.00	0.00	0.02
ULL	N/A	N/A	N/A	N/A	N/A

Source: Authors' design, based on Scopus databases for publications and SIES for academics.

Table 9. Publications in Scopus by academics according to full-time equivalent in the central zone universities from 2008 to 2022.

3.4.2. Central zone universities

In this particular zone, intriguing outcomes have been documented. Despite the fact that in all other instances, the PUCV (very close to the UCH) and the UCH consistently occupy the top two positions, in this case, the PUCV has secured the second position. In the subgroup with an indicator exceeding one, UTFSM occupies the fourth position. The institutions exhibiting the poorest performance are Universidad Miguel de Cervantes, Instituto Nacional de Capacitación Profesional (INACAP), UACON, and Universidad del Alba (see Table 9).

3.4.3. Southern zone universities

Table 10 indicates that UFRO has the highest performance in this area, a position it also holds at the national level. Another noteworthy case is that of the UCM, which demonstrated a 581.25% increase in productivity. As is the case in other regions of the country, all universities have demonstrated increased productivity.

Southern Zone Universities	2008-2010	2011-2013	2014-2016	2017-2019	2020-2022
UFRO	0.57	1.00	1.27	1.47	1.72
UDEC	0.61	0.74	0.83	0.98	1.21
UTALCA	0.63	0.71	0.91	0.98	1.16
UCM	0.16	0.23	0.23	0.55	1.09
UACH	0.43	0.52	0.59	0.82	1.07
UBB	0.17	0.32	0.43	0.67	0.94
UOH	N/A	N/A	N/A	0.84	0.88
UCSC	0.17	0.16	0.20	0.45	0.75
UMAG	0.23	0.26	0.38	0.58	0.64
UAYSEN	N/A	N/A	N/A	0.47	0.64
UCT	0.18	0.27	0.30	0.47	0.63
UAUTO	0.03	0.10	0.43	0.54	0.62
ULAGOS	0.16	0.17	0.26	0.42	0.59
UDD	0.25	0.32	0.29	0.41	0.50
UADVEN	0.00	0.01	0.03	0.16	0.31
USS	0.03	0.03	0.12	0.15	0.22

Source: Authors' design, based on Scopus databases for publications and SIES for academics.

Table 10. Publications in Scopus by academics according to full-time equivalent in the southern zone universities from 2008 to 2022.

3.5. Fondecyt projects per FTE academic

3.5.1. Northern zone universities

As illustrated in Table 11, the UTA is the most prolific institution in this zone with regard to the conferral of academic projects, followed by the ULS and then by the UCN. However, these latter two institutions have witnessed a decline in the number of projects awarded. Conversely, the UA has experienced a decline, a phenomenon that has not occurred at the UDA and UNAP.

3.5.2. Central zone universities

Table 12 illustrates that the university with the optimal performance in this zone and the country is the UAH, which has a proportional award rate of 0.23, followed by the UCH and the PUC. These three institutions have the most favorable results at the national level. However, the latter two have experienced notable declines, which may be attributed to the intensified competition in this category of projects. Similarly, the Universidad de Santiago de Chile (USACH) and the PUCV have also notably declined.

Northern Zone Universities	2011-2013	2014-2016	2017-2019	2020-2022
UTA	0.09	0.09	0.11	0.15
ULS	0.09	0.06	0.06	0.09
UCN	0.09	0.07	0.09	0.07
UA	0.08	0.04	0.06	0.04
UNAP	0.02	0.03	0.03	0.04
UDA	0.01	0.02	0.03	0.03

Source: Authors' design, based on SIES database for academics and Fondecyt ANID for projects.

Table 11. The Fondecyt project awarded by academics according to full-time equivalent in the northern zone universities from 2011 to 2022.

Central Zone Universities	2011-2013	2014-2016	2017-2019	2020-2022
UAH	0.15	0.23	0.24	0.23
UCH	0.36	0.32	0.24	0.22
PUC	0.27	0.30	0.25	0.22
UAI	0.18	0.14	0.20	0.20
PUCV	0.28	0.27	0.27	0.19
UTFSM	0.19	0.16	0.16	0.14
UANDES	0.12	0.11	0.10	0.14
USACH	0.20	0.16	0.13	0.13
UV	0.08	0.10	0.10	0.10
UDP	0.09	0.11	0.12	0.08
UNAB	0.07	0.07	0.05	0.05
UTEM	0.02	0.04	0.07	0.07
UAHC	0.10	0.09	0.14	0.07
UCSH	0.02	0.02	0.03	0.06
UPLA	0.02	0.05	0.09	0.06
UBO	0.04	0.05	0.03	0.06
UMCE	0.03	0.02	0.01	0.04
UMAYOR	N/A	0.02	0.04	0.04
UCEN	0.01	0.03	0.02	0.03
UFT	0.02	0.03	0.02	0.02
UST	0.00	0.00	0.01	0.01
UDLA	0.00	0.00	0.01	0.01
USEK	0.00	0.01	0.01	0.01
INACAP	N/A	0.00	0.00	0.00
UGM	N/A	0.02	0.00	0.00
UMC	0.00	0.00	0.00	0.00
UDALBA	0.00	0.00	0.00	0.00
UACON	0.00	0.00	0.00	0.00
UVM	0.00	0.00	0.01	0.00
ULL	N/A	N/A	N/A	N/A

Source: Authors' own design, based on the SIES database for academics and Fondecyt ANID for projects.

Table 12. The Fondecyt project awarded by academics according to full-time equivalent in the central zone universities from 2011 to 2022.

3.5.3. Southern zone universities

The UFRO, which ranks among the top institutions in the country (alongside the UAH), has experienced a slight decline in proportional terms. Conversely, despite its recent establishment, the UOH occupies the second position.

The UTALCA has experienced the most significant decline in productivity within this region. However, it is not the only institution that has done so, with the Austral and Concepción universities also exhibiting a reduction in their respective outputs. The results of the universities in the southern zone are presented in Table 13.

Southern Zone Universities	2011-2013	2014-2016	2017-2019	2020-2022
UFRO	0.25	0.28	0.25	0.23
UOH	N/A	N/A	0.49	0.22
UTALCA	0.23	0.24	0.19	0.16
UACH	0.18	0.14	0.17	0.15
UDEC	0.20	0.17	0.16	0.15
UBB	0.08	0.07	0.09	0.09
UAYSEN	N/A	N/A	0.31	0.09
UCSC	0.04	0.04	0.08	0.07
UCT	0.06	0.07	0.06	0.06
UCM	0.05	0.04	0.08	0.06
ULAGOS	0.07	0.04	0.07	0.05
UMAG	0.04	0.06	0.07	0.05
UDD	0.05	0.02	0.05	0.04
UAUTO	0.01	0.07	0.05	0.04
USS	0.01	0.01	0.01	0.02
UADVEN	0.00	0.00	0.01	0.00

Source: Authors' own design, based on SIES database for academics and Fondecyt ANID for projects.

Table 13. The Fondecyt project awarded by academics according to full-time equivalent in the southern zone universities from 2011 to 2022.

4. CONCLUSIONS

The analysis of university productivity indicates that, in absolute terms, the most distinguished institutions are, in descending order, the UFRO, the UTA, and the UCH. This study underscores the efficacy and output of these academic institutions with respect to their scholarly output.

Notably, only 12 institutions have exceeded the threshold of one average publication per year in terms of academic productivity. In comparison, 19 institutions exhibited a productivity rate below 0.5 publications per academic on average over the course of the analyzed period. This finding indicates the necessity for a review and potential adjustment of institutional policies in these universities with the aim of enhancing their research performance.

In the domain of proportional grant acquisition, institutions such as the UAH and the UOH merit particular attention. This study has revealed their exceptional capacity to obtain grants. The UFRO, which exhibits exemplary performance across all proportional indicators analyzed in this study, is included in this list.

It is noteworthy that only 15 institutions have attained an award rate exceeding 0.10 projects per academic. These figures represent ambitious benchmarks for the other institutions, providing a target against which the efficiency and success of research project adjudication can be measured.

It is also noteworthy that the universities with the highest productivity levels do not always align with the most internationally renowned institutions, as reflected in the rankings. This phenomenon may be attributed to

the size bias inherent in such rankings, whereby larger institutions receive greater visibility.

From this perspective, it is evident that there are notable discrepancies between the positions of Chilean universities as indicated in the rankings and the results presented in this paper. The study by Sáez *et al.* (2023) revealed that only 5% of the 60 institutions studied in Chile have representation in the three rankings analyzed (Academic Ranking of World Universities (ARWU), Times Higher Education (THE) World University Rankings, and QS World University Rankings). Among these institutions are the UCH, the PUC, the UDEC, and the UTFSM. This figure rises to 11.6% when those appearing in two of the three rankings are included, such as the UNAB, UACH, PUCV, UANDES, USACH, UTALCA, and Universidad Diego Portales. Conversely, 68% of the institutions are not represented in any of the rankings.

In contrast with the aforementioned results, this study has facilitated the visibility of institutions in the research context and the allocation of research projects, incorporating those not included in the rankings. Notable examples of excellence in this domain include the UFRO, UTA, UCN, and UCM. It is particularly important to consider multiple dimensions of university performance that extend beyond visibility in international rankings.

This study acknowledges a significant limitation associated with the limited availability of data on non-academic university personnel, including research personnel. The lack of data on non-academic university personnel, including research personnel, could significantly impact the productivity of institutions with dedicated research collaborators.

This paper proposes a novel approach to analyzing scientific productivity, diverging from the conventional methodology of assessing research output based on the institutions' mission objectives. The paper highlights the necessity of proportionately valuing results over raw numbers, thereby challenging the assumption that organizational size invariably indicates research success.

One aspect that this research must address is the role of governance in the achieved outcome. The present study does not address critical success factors that are independent of the ability to attract talent and resources, as proposed by Salmi (2009). Consequently, future research should be oriented towards understanding the impact of governance on institutional success, also considering an adequate legal framework that allows the full development of universities (Asimiran & Ismail, 2019).

Data availability statement

The data supporting this study's findings are available from the corresponding author upon reasonable request.

Ethics statement

This study was conducted per the institutional research committee's ethical standards, the 1964 Helsinki Declaration, and its later amendments or comparable ethical standards.

Author contributions

Francisco Ganga-Contreras was responsible for the manuscript's conceptualization, analysis, and review, as well as project funding. Emilio Rodríguez-Ponce participated in data review and manuscript revision. Liliana Pedraja-Rejas contributed to the data review, manuscript and conclusion revision, and translation. Patricio Viancos-González collected the data, conducted the analyses, and drafted the manuscript and conclusions.

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Conflict of interest

The authors declare that they have no conflict of interest. ●

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