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Review Article

Investigation Related to Intellectual Capital and Scientific Production in Colombia Public Universities: A Review from Scopus

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This research aims to provide a general visualization of studies focused on the intellectual capital developed in Colombia. Firstly, detailed information on research articles on this topic was obtained from the Scopus database. Secondly, the information was analyzed using Excel through the direct comparison and analysis of graphs with references and theories related to intellectual capital. Finally, the results exposed that Colombian scientific production is associated with 32 public universities, representing 45,029 elaborate documents by 9,758 authors on three relevant topics: physics and astronomy, agricultural and biological science, and medicine. Also, the data obtained exposed that 56.61% of the institutions are above the average considering the overall public institutions. However, this behavior depends on the institution's number of researchers and full-time teachers related to intellectual capital. Finally, the hypotheses agree with the results obtained, considering that the quantity and quantity of intellectual capital significantly influence scientific production, the size and location of the public universities of Colombia, and the national and international scientific collaboration.

1. Introduction and Overview

The intellectual capital study has emerged since the 1960s, with the interest of recognizing both personal and collective knowledge in organizations to establish the knowledge value that people contribute to the organization and generate value [1]. This study gave rise to the valuation and visualization of intangible assets in the accounting and financial balance sheets to reflect the real value of the companies and to establish the potential of knowledge in the generation of wealth [2], considered by Galbraith [3] as the result of the use of people's intellectual capacities, which creates value and individual and collective strengths.

Intellectual capital is considered the personal and collective knowledge contained in the human resource, its processes, and internal and external relationships of the organizations necessary to generate value and competitive advantage [4]. In this way, Rastogi [5] considers that intellectual capital (IC) and knowledge management (KM) are those activities related to knowledge from the stock to knowledge management. KM and IC have a strong relationship in both directions. Therefore, IC represents the stock of knowledge in human, structural, and relational capital [6]. Guthrie [7] establish that relational capital is derived from the creation of knowledge in the long term in organizations, and therefore, KM strategies are constituted through the application of knowledge to integrate it to create value [8–10].

Considering the above, in the open literature, several studies about intellectual capital (IC) seek to apply the theoretical foundations in empirical investigations, as is the case of the study carried out by Yudianto et al. [11] who showed that university governance affects intellectual capital and scientific production in universities. Therefore, in

Indonesia, they are not optimal to obtain the expected performance of Public Universities-Legal Entity (SU-LE) and Public Universities-Agency of Public Services (SU-PSA), concluding that good university governance and IC have a significant and positive influence on the performance of these institutions. On the other hand, Sanchez-Limon et al. [12] characterized and compared IQ in four Mexican public universities in business and administration areas, concluding that this type of organization is a source of scientific knowledge. Besides, IQ has a considerable positive impact and constitutes its competitive advantage that improves their performance according to the IQ levels in each institution. On the other hand, Nicolo et al. [13] examined the drivers of intellectual capital in Italian public universities, where it was determined that the size of the university positively influences the diffusion of intellectual capital through the annual reports of these institutions; for this reason, the practices of CI are driven and influenced by the administrative management of these institutions, generating competitive advantage and in turn increasing their performance.

Investigations developed around the world demonstrated the incidence of the number of publications and intellectual capital from the higher institutions and thus the quality of their administrative processes. For example, in Ecuador, the academic and scientific production in the Universidad Metropolitana del Ecuador, in the 2020-2021 period, according to Rojas-Valladares et al. [14], 13% are found in scientific databases, while 87% belong to regional databases, which means that, for every 100 published articles, only 13 are in world-renowned scientific databases and 87 in regional databases. These publications correspond to research products of research, development, and innovation projects linked to social and academic networks.

Millones-Gómez et al. [15] studied the influence of research policies on scientific production in 97 public and private Peruvian universities, concluding that research policies do not influence scientific production published in Scopus or Web of Science in 2019 or 2020. Finally, it recommends strengthening policies to finance projects, research training strategies, and the establishment of scientific collaboration networks to increase the productivity of groups and researchers.

The study conducted by Barcia and González [16] presented an analysis of the scientific production of virtual and blended university education in the period of 2007–2020 in Spanish education journals that are part of Web of Science and Scopus. 72 publications were selected, highlighting the publications of the Universidad Nacional de Educación a Distancia (UNED) as a public institution, whose articles are mainly the product of empirical studies and with the highest number of citations. In addition, its evolution, profile of the authors, prominent institutions, and research methods and techniques used in the of publications with the greatest impact were evaluated. Liberatore et al. [17] analyzed the scientific production in the period 1978–2019 of the Universidad Nacional del Mar del Plata (UNMDP), taking into account the publications found on the Web of Science and Scopus, obtaining results that 38% of the UNMDP publications were carried out in international collaboration, of which half was carried out through collaboration networks with the United States, Latin America (Brazil, Chile, and Mexico), and Europe (Spain, Germany, and France). Elango [18] examined the growth of the scientific production of the ten most productive countries between 1996 and 2015 using the Scopus database by determining the compound annual growth rate and the relative growth rate. Of the most productive countries—the United States, China, the United Kingdom, Germany, Japan, France, Canada, Italy, India, and Spain—it was observed that the highest growth rate is obtained in China, with 15.11%, and India, with 9.86%, and lower proportion in Japan, with 1.32%. However, the United States, China, and the United Kingdom continue to be the most productive, it is also important to point out that, in the analysis for the first ten years (1996–2005), the growth of scientific production is more reduced, while in the last ten years (2006–2015), all the countries analyzed except India experience an increase of almost 50%. Finally, it was observed that the first ten countries analyzed concentrate their scientific production in the areas of information technology, decision-making, economics, energy, environmental sciences, psychology, and social sciences.

In the scientific production [19], historically, a logarithmic evolution has been presented by the constant linear increase in the annual growth of scientific production in all areas of knowledge according to the number of articles and reviews published in the most productive countries worldwide such as Australia (AU), Canada (CA), China (CN), Germany (DE), Spain (ES), France (FR), India (IN), Italy (IT), Japan (JP), South Korea (KR), United Kingdom (UK), and United States (USA), as shown in Figure 1.

From Figure 1, there was a decrease in scientific production in almost all countries, in the period of the Second World War (1939–1945), where the most affected countries were Germany (DE), Japan (JP), and Italy (IT), while the United Kingdom (UK), the United States (USA), and Canada (CA) were less affected. There were also significant increases in the period of 1995–2002, thanks to the dot com bubble and the rise of computing and information technologies, and technology and research companies were financed, which generated an increase in the number of articles published in the field of medicine, biochemistry, and engineering in many countries. Another important aspect in the study of scientific production is statistical analysis, which began to be carried out from the beginning of the first quarter of the 20th century, comparing the scientific productivity of various countries. Later, in 1969, the term bibliometrics was used for the first time, considered as the statistical methods for analyzing the scientific publications contained in databases. On the other hand, university rankings originate between the years 1870 and 1890, with the aim of classifying the scientific quality of the research carried out. Finally, in Colombia, the measurement of scientific production arises from the 1990s, through regulations such as decree 1444 of 1992, decree 60 of 1995, and decree 1279 of 2002 that give recognition to universities through the evaluation of the production of their teachers [19].

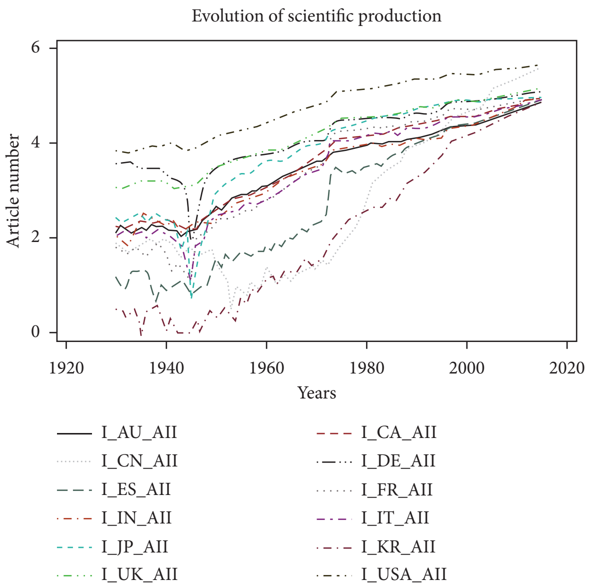

Figure 1: Evolution of scientific production worldwide. Source: [19].

In Latin America, important studies have been developed on scientific production in Higher Education Institutions, such as the research carried out by the authors Kuong Morales and Kuong Morales [20], who carried out an analysis of the position occupied by the universities of Peru in the ranking compared with the universities of Latin America. The results obtained showed that the first university appears in position 37, concluding that these Peruvian universities have an ascending presence but far from the first places in Latin America, due to the low scientific production of high impact. Carranza-Esteban et al. [21], analyzed the scientific production of the rectors of the Peru universities registered in the publications of Scopus and Web of Science (WOS). The results confirmed that only 14.29% have published scientific articles, representing an average h-index of 3.62 in Scopus and 1.14 in WOS, concluding that the scientific production of the rectors is very low and it needs policies that encourage such scientific production. Carranza Esteban et al. [22], who analyzed the scientific production of nursing directors from 42 state and private Peruvian universities in Scopus, Web of Science and Redalyc, SciELO and Latindex, in the period 2014 to 2019, concluded that 42 managers were identified, of which 17 made at least one scientific publication, which is equivalent to an average of 2.32 published articles, obtaining an H index of 0.25, which is a very low scientific production. Suarez-Amaya et al. [23] showed that, in the University of Tarapacá, they use temporary, economic, and hierarchical incentives to increase scientific production, and they also carry out internal calls to finance research projects, but there are limitations in high-impact research, concluding that incentives and good practices are required that allow promoting the positioning of Chilean universities in the scientific community and society in general.

In Cuba, some studies have been carried out which examined the scientific production in ResearchGate and Google Scholar of the University of Camagüey, where it was observed that there is little presence of the institution in the scientific community in the two platforms, concluding that there is little positioning of this university in the collaborative scientific platforms of academic social networks, ignoring the importance of the development and visibility of open science [24]. Similarly, Galbán-Rodríguez et al. [25] analyzed the scientific production of Cuba in 200 certified Cuban journals and thirteen national and foreign databases. The results showed that publications in Cuban journals increased both in number of journals and articles in the period from 2000 to 2018, while foreign publications experienced minimal growth until 2018, especially in Scopus and Web of Science, which represents 22% of the annual scientific production of Cuba in foreign journals.

For the case of Ecuador, Herrera-Franco et al. carried out a bibliometric analysis of the scientific production in Ecuador in the period 1920–2020. The results showed a consolidation of the scientific production of 30,205 documents published in 27 subject areas, using 13 languages in 84 countries. The main research topics were biology, higher education, technology, web applications and computer science, medicine, and energy. There are also a significant number of publications dealing with the sustainable development goals (SDGs), sustainability, and climate change.

Scientific production in Colombian universities began to be institutionalized and developed after the creation of the Departamento Administrativo de Ciencia, Tecnología e Innovación (Colciencias) and the Instituto Colombiano para la Evaluación de la Educación (ICFES) in 1968, as well as in 1991, the National Science and Technology System (CSS&T) was created. These government institutions allocate financial resources, qualified human capital, and strategies to develop research [26]; this is because scientific production is concentrated in higher education institutions, mainly universities [26]. According to the above, scientific research in Colombia in recent years has become a significant factor in the development of science, especially within the universities, which are the leading institutions that contribute significantly to the country's research activity. In Colombia, the scientific production of groups and researchers is classified according to the measurement model of the Ministerio de Ciencia, Tecnología e Innovación [27], according to the six major areas of scientific knowledge defined by the Organización para la Cooperación y el Desarrollo Económicos (OECD), which are natural sciences, engineering and technology, medical and health sciences, agricultural sciences, social sciences, and humanities. Consistent with the foregoing, research on intellectual capital and scientific production has been carried out in Colombia from different perspectives, considering that the IC theory is a means to achieve KM in HEIs in Colombia, analyzing the three dimensions of intellectual capital: human (HC), structural (SC), and relational capital (RC) [28]. The HC and IC model can be implemented for research groups in Colombian universities [29]. The degree of maturity of their processes is analyzed within the framework of the AENOR of GC UNE-412001 and the UNE-16002 : 2006 standards. $R+D+i$ process management is mainly based on evaluating the knowledge generated within the group [30].

According to Jin and Rousseau [31], scientists rely on scientific metrics and bibliometric analysis to make scientific decisions, providing a reference point for what they want to study. Therefore, the production of scientific knowledge in universities depends on feedback within these institutions by strengthening the intellectual capital it possesses and its accumulation over time. Bucheli et al. [32] developed an analysis of the scientific publications of Colombian public universities in ISI Web of Science (WoS) between 1958 and 2008, in the categories, such as early exponential growth (EEG), late exponential growth (LEG), and linear and irregular growth (LIG) of the different universities, and also analyzed the relationship between these categories and their relationship with IQ, concluding that 9% of these institutions have obtained an EEG from their scientific publications, 47% LEG, and the remaining 44% LIG.

Moreno-Lopez et al. [33] carried out a study on scientific production in Institutions of Higher Education (IES) accredited in high quality in Colombia, based on the theory of human capital, obtaining as results the identification of classified researchers and their training, classification of groups of research and its productivity indicators in seven regions: capital district, coffee region, Pacific, Caribbean, Middle East, central south, and plains.

On the other hand, the effects of COVID-19 have generated delays in the development of scientific production in different subjects of science and technology, mainly in disciplines such as biology, medicine, socio-economics, and tourism from a worldwide perspective, as reported by Moreno-López et al. [34]. In this way, Casado-Aranda et al. [35] exposed that the educational field is in an initial process, and research is related to mental health, students with various disorders, and higher education trends to be oriented to apply effective pedagogical methods.

Specifically in Colombia, Pertuz-Peralta et al. [36] developed a literature review to analyze the approaches to intellectual capital in companies and universities in Colombia [37]. The results showed that intellectual capital in companies focuses on the paradigm of fixed capital centered on relational capital, made up of clients, suppliers, strategic alliances, and the reputation of organizations, while in universities, it focuses on intellectual capital—dynamic, Newtonian, integrative, and transformative, based on human capital. IC in universities and companies improves the organizations' performance, and to measure it, each organization must develop indicators aligned with its strategies and its own characteristics because perhaps a universal model has never been developed. Cricelli et al. [38] explored the relationship between IQ and the performance of public universities in terms of research, innovation, and education [39]; this study shows that the different aspects of IC are associated with university performance. The authors found that universities must reach critical mass to obtain outstanding research and innovation results. The findings also identify the importance of international student and teacher mobility programs for most performance variables.

León Cano et al. [40] talk about the scientific production in Colombian psychology indexed in Scopus in the period from 2015 to 2019, considering the number of documents, the citation index, and international collaboration. Scimago Journal & Country Rank was used to collect data from the Latin American countries where they were carried out publications of this type. The results showed that Colombia presents a significant growth in scientific production, but its total contribution to science is less than other countries such as Brazil, Mexico, and Chile. It was also identified that Colombia is the second most important country in Latin America with ten psychology journals in Scopus. However, Velascoet al. [41] evaluated the trends in scientific production on Economics in Colombia in the period 2007 to 2019, through Scopus publications, which were evaluated by indicators of production, citation, and scientific collaboration. It was determined that Colombian researchers have an average annual growth rate of 13% in Scopus, in addition to participating in national and international scientific collaboration networks, with a very significant trend of coauthored publications, with an important participation of institutions of higher education and research institutes. Beizaga-Luna et al. [42] analyzed the scientific production of Peru and Colombia in Social Sciences that was published in Web of Science in the period from 2011 to 2020, with the purpose of measuring indicators of collaboration and analysis of coauthorship and cocitation networks between institutions and countries. For this research, 2,888 publications from Peru and 12,747 from Colombia were obtained, in which the patterns of scientific collaboration in both countries were identified. Consistent with the above, there is a significant difference in the number of published documents, but there is a similar dynamic in both countries. Finally, Moreno-López et al. [43] analyzed the knowledge production of Colombian researchers linked to higher education institutions (IES) with high-quality accreditation; based on the dimensions of the theory of human capital, the results present the descriptive statistical information of the seven regions: capital district, coffee region, Pacific, Caribbean, Middle East, south center and Llanos of Colombia according to the information on the website of the Administrative Department of Science, Technology and Innovation of Colombia, Colombia (Colciencias), identifying the researchers and classified groups, the training of researchers, and productivity indicators for each of the seven regions mentioned above.

Nowadays, in the open literature, there does not exist a document that analyzes the scientific production in the public universities in Colombia and how this is related to the intellectual capital of the higher institutions. In this way, this review article presents a documental analysis of the scientific production of the current 32 public universities in Colombia, which were selected according to the information of the Sistema Nacional de Informacion de la Educacion Superior (SNIES, Colombia), considering the first published document of the public universities in Colombia. The data were collected directly from the Scopus database and other sources on the public higher education institutions. In this way, an analysis of the public universities in Colombia was carried out to establish the publication of scientific material (articles and books mainly), journals in which the authors publish, and the main collaboration networks. Finally, this review analysis will demonstrate the implications of human, relational, and social capital and structural elements involved in intellectual capital in Colombian institutions and then quantitatively evaluate the scientific production and behavior of the most relevant Colombian institutions and interest areas.

2. Materials and Methods

2.1. Colombia Overview. The subject of intellectual capital has been widely studied by the international scientific community, for which the study of all the publications carried out in all countries would be very complex, which is why the country of Colombia was selected as the object of study, considering that we, the authors, know the public policies that govern scientific publications, compiling information directly from the Scopus database, which is the best known internationally from which detailed information is obtained by Colombian institutions [4]. The following hypotheses are proposed as a result of the literature review on intellectual capital and scientific production for Colombian public universities:

(i) H1: the public universities of Colombia with the highest human capital are the most scientifically productive

(ii) H2: the quantity and quality of the intellectual capital of the public universities of Colombia have a positive and significant influence on national and international scientific collaboration

2.2. Scientific Production in Colombia. Scientific production is the direct result of research activity, from which products such as research articles, books, book chapters, patents, utility models and technological products, architecture, and design, among others, are derived [27]. Employees create human capital by their inherent and acquired knowledge, skills, talents, and competencies. In this way, the HC can be considered a dynamic index and a significant factor in today's organization's prosperity [44].

In Colombia, the development of research, and therefore, scientific production, arises in the 1990s from the generation of national standards to manage the development of the country's research processes. In this sense, Colciencias calls for the classification of journals, research groups, and researchers, establishing categories C, B, A2, and A1 for journals and research groups and junior, associate, senior, and emeritus categories for researchers. Finally, the categorization of research groups and researchers has been an important parameter to increase the scientific production in Colombian HEIs.

Regarding taxonomies and models of scientific production, they depend on the particularities of each region or country, for which trends and policies have been established that mark the direction of research processes. Therefore, the classifications and models are adjusted to the characteristics and needs of each country. For example, in the Colombian case, there is a model for classifying the scientific production of research, technological development, or innovation groups proposed by Colciencias and based on decree 1279 of 2002, which regulates the remuneration of professors at public universities.

According to Colciencias [27], the scientific production typologies are classified in Table 1. The categorization of research article types A1, A2, B, and C is defined according to the quartile (Q) that the journal occupies in the citation index systems, corresponding to Q1, Q2, Q3, and Q4, respectively. To the extent that Colombia positions knowledge as a relevant capital for social and economic development, it is necessary to have a detailed list and reliable indicators of national capacities in science, technology, and innovation (STI). These capacities can be, simultaneously, institutional, relational, and individual. Likewise, they can be willing to generate new knowledge, technological development and innovation, social appropriation of knowledge, and training human resources for research [27].

In the literature, there is a consensus on the definitions of scientific production, considering it as a product of the results of research that is developed mainly in higher education institutions and/or universities that have established in their substantive functions, considering that the mission of scientific production through research processes is to improve the processes carried out in the HEIs [36]. Consequently, the scientific production of university professors has become a fundamental instrument for the improvement of academic quality in HEIs worldwide, where publications are considered the main component of scientific activity and a fundamental pillar in higher education, allowing in this way to classify universities according to their scientific production and academic indicators [27]. Also, there are consensuses where it is established that scientific production depends mainly on the impact of research and innovation policies and trends in the way research is carried out in each country, which affects local and global dynamics of scientific production.

2.3. Data Collection. The data were compiled in December of 2021, directly from Scopus database scientific publications on the intellectual capital in higher education institutions for all documents published in the Colombia institutions. The information was analyzed considering the methodology proposed in Figure 2, which consists of three steps. First, it is important to mention that the data collection was developed based on the governmental page that provides information about the 32 public universities in Colombia (only focused on public higher institutions in Colombia) [45]. Second, the information about the scientific production (articles and books) was classified by areas and collaboration networks whose information was automatically provided by the Scopus database without the use of other software [46–49]. Third, this information was analyzed and discussed, considering intellectual capital and scientific production theories in higher education institutions and other publications. Notice that the scientific production analysis related to production universities was developed considering only the information provided directly by Scopus about the authors and articles by areas and collaboration networks [50].

Table 1: Typologies of scientific production of groups and researchers in Colombia.

Product name	Category	Quality requirements
(1) Research articles (A)	A1 N-A1	The journal that is in Q1 (top 25% of the journal citation reports (JCR) (science citation index (SCI) and social sciences citation index (SCI)) or SCImago journal rank (SJR)
	A2 N-A2	The journal that is in Q2 (between 74.9% and bottom 50% of the JCR (SCI and SSI) or SJR)
	B N-B	The journal that is in Q3 (between 49.9% and bottom 25% of the JCR (SCI and SSI) or SJR)
(2) Scientific notes (N)	C N-C	The journal that is in Q4 (in the bottom 24.9% of the JCR (SCI and SSI) or SJR or indexed in index medicus, psych INFO, arts and humanities citation index (A&HCI))
	D N-D	Journal that is found in two (2) or more bibliographic databases that have a scientific committee
(3) Research results books (LIB).)	LIB-A1	The book must have one or several national or international awards or special mentions, awarded by juries and edited by an editorial fund (not printing) external to the institution to which the author is affiliated
(4) Chapters in the research result book (CAP-LIB)	LIB-A1 CAP-LIB-A1	The book or book chapter is located in the top Q1 (of your large area of knowledge) according to the citations calculated from Google Scholar, Scopus, and Web of Science and edited by an editorial fund (not printing press) external to the institution to which the author is affiliated
	LIB-A CAP-LIB-A	Book or book chapter located in the upper Q2 (of your major area of knowledge), according to citations calculated from Google Scholar, Scopus, and Web of Science
	LIB-B CAP-LIB-B	Book or book chapter located in the top Q3 (of your major area of knowledge), according to citations calculated from Google Scholar, Scopus, and Web of Science
(5) Training books	LIB-FOR1	Training book located in upper Q1 (of its large area of knowledge), according to citations calculated from Google Scholar, Scopus, and Web of Science

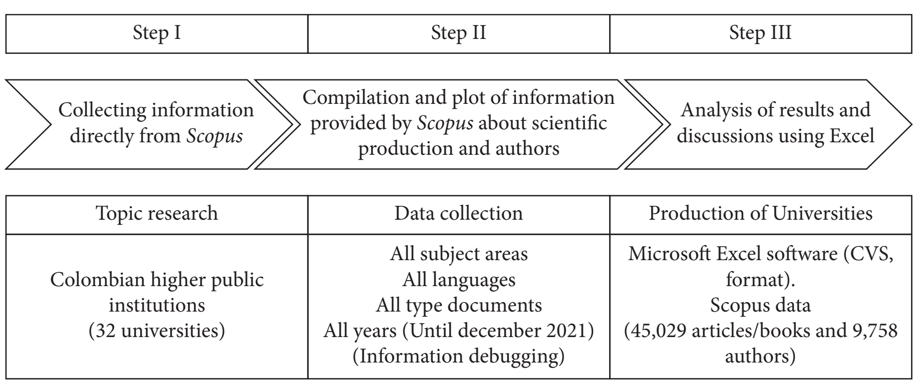

Figure 2: Methodology proposed.

However, the Scopus database was selected because it had the most high-impact documents, access facility, easy visualization of the data through the years, and graphical information actualized from the scientific production [51].

For this study, the publications collected were considered only for the authors with at least one affiliation with higher public Colombian institutions (only 32 universities). In this way, aspects were considered as document types (articles, books, book chapters, letters, conference articles, and others), obtaining information on all areas and languages from the data obtained (step II). Notice that the information was taken into account until the year 2021. Besides, Excel software was used to clean data and delete duplications and mistakes on the names or institutions in the last step (dots, tildes, or commas) [52]. On the other hand, figures and information were plotted using the Excel software.

Finally, this article presents an analysis from Scopus considering only higher public Colombian institutions in three main parts: scientific production through the years, publication areas and collaborating institutions, and the collaborative documents and country networks.

3. Results and Discussion

3.1. Scientific Production. The review analysis of scientific production was carried out from the Scopus database. Relevant information was extracted from each public institution only in Colombia, considering all the publications found in *Scopus* (it means 100% of the scientific productions and authors up to December 2021). Figure 3 shows the number of documents published by the 32 public institutions of public education in Colombia. Note that the Universidad Nacional de Colombia has the most significant

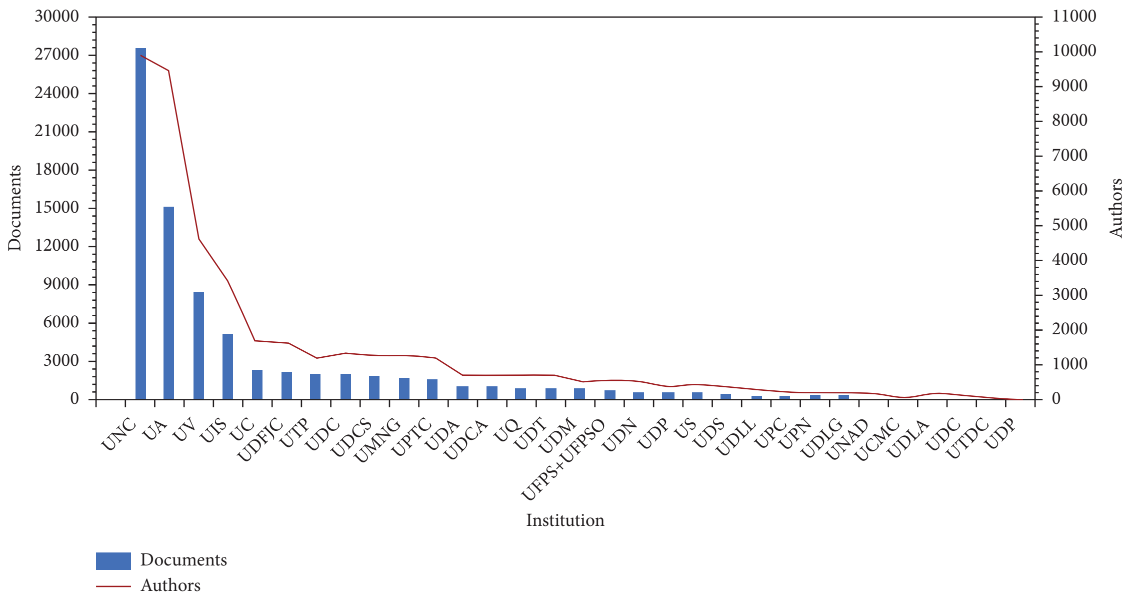

Figure 3: Colombian institutions by the number of authors and documents (scientific production).

number of published documents considering that this university is one of the first officially founded universities in Colombia [53].

From Figure 3, it is possible to observe that, in Colombia, the public universities with the largest number of authors or researchers are the ones that publish the most scientific articles in Scopus, which confirms H1. The public universities of Colombia with the greatest human capital are the most scientifically productive. This agrees in part with the results obtained in the investigation carried out by Ariaz-Perez et al. [54] which analyzed the relationship between intellectual capital management and the performance of research groups in public and private universities in Colombia. It concludes that, in Colombia, there is a traditional approach to the management of intellectual capital that is carried out indirectly, evaluating indicators in terms of human capital such as the number of doctors or full-time professors, terms of structural capital, financial resources, and a number from undergraduate and graduate academic programs, scientific articles, and research groups. Relational capital, student, or teacher mobility, leaving aside aspects such as the systematic evaluation of competencies and the group knowledge inventory and analyzing the existence of a clear strategy to develop new competencies and acquire new knowledge.

3.2. Publication Areas and Collaborating Affiliations. From Table 2 and Figure 2, it is concluded that intellectual capital is directly related to the quantity and quality of publications and, therefore, to the number of collaborative networks that can be generated depending on the areas related to the academic programs of higher education institutions. Notice that Tables 2 and 3 show the three main areas by documents (1, 2, and 3) considering the information provided by Scopus about each institution.

On the other hand, the documents by area and collaborating affiliations of all higher education institutions in Colombia are summarized in Table 3. Three main areas of the institution were highlighted in different colors depending on the knowledge area, such as medicine (blue), agricultural and biological science (green), engineering (orange), computer science (purple), physics and astronomy (pink), and others in a low rate of appearances such as veterinary, chemistry, arts and humanities, social sciences, business and management, environmental sciences, mathematics, psychology, and biochemistry. As was observed, the institutions present a change in the three areas due to the different academic programs and the impact in the region, published mainly in English (80%) and Spanish and Portuguese (20%).

Specifically, in the case of the 31 public universities in Colombia, 45,029 articles/books have been published by 9,758 authors in the following journals with greater frequency of appearance and quality: Journal of Physics Conference Series, Espacios, Dyna Colombia, Boletin de Investigaciones Marinas y Costeras, Acta Biologica Colombiana, Revista Facultad de Medicina, Revista de Salud Pública, Informacion Tecnologica, Revista Mvz Cordoba, ACM International Conference Proceeding Series, Communications In Computer And Information Science, Revista Iberica de Sistemas y Tecnologias de Informacion (RISTI), Proceedings of SPIE: the International Society for Optical Engineering, Biomedics, Zootechnics, Communications in Computer and Information Science, and Psychological Medicine.

Considering the 100% of the total published articles by the different main areas from the Scopus database by the 32 public universities in Colombia, 53% of the publications represent 44% of the total authors of Colombia which Universidad Nacional de Colombia has developed. Universidad de Antioquia and Universidad del Valle are ones of

Table 2: Publication areas and collaboration of the universities in Colombia.

University	ID	Documents by area			% from Scopus by area	Collaborating affiliations			Amount by collaboration
		1	2	3		1	2	3	
Universidad Nacional de Colombia	UNC	3881	3360	1957	56.3	777	621	510	1908
Universidad de Antioquia	UA	5288	2294	1913	57.5	681	517	463	1661
Universidad del Valle	UV	2521	1406	1311	60.6	271	234	228	733
Universidad Industrial de Santander	UIS	1125	1029	943	53.1	230	174	137	541
Universidad de Cartagena	UC	1072	284	278	56.7	182	93	85	360
Universidad Distrital Francisco José de Caldas	UDFJC	922	781	518	68.5	329	63	59	451
Universidad Tecnológica de Pereira	UTP	735	623	331	45.0	173	121	94	388
Universidad del Cauca	UDC	797	510	345	58.0	146	74	55	275
Universidad de Caldas	UDCS	493	487	215	57.7	194	87	81	362
Universidad Militar Nueva Granada	UMNG	599	454	342	49.4	168	166	76	410
Universidad Pedagógica y Tecnológica de Colombia	UPTC	341	304	279	58.0	227	56	46	329
Universidad del Atlántico	UDA	214	186	182	52.8	160	78	74	312
Universidad de Córdoba	UDCA	444	192	171	55.8	69	57	56	182
Universidad del Quindío	UQ	279	196	196	54.5	87	61	55	203
Universidad del Tolima	UDT	385	159	149	82.2	60	58	45	163
Universidad del Magdalena	UDM	408	167	124	50.2	102	51	32	185
Universidad Francisco de Paula Santander	UFPS + UFPSO	409	144	83	59.7	44	39	33	116
Universidad de Nariño	UDN	261	113	105	50.5	67	41	34	142
Universidad de Pamplona	UDP	124	107	105	56.7	57	55	35	147
Universidad Surcolombiana	US	171	162	74	64.0	67	24	22	113
Universidad de Sucre	UDS	222	86	81	45.8	57	44	29	130
Universidad de Los Llanos	UDLL	171	60	45	57.0	38	15	14	67
Universidad Popular del Cesar	UPC	114	92	89	47.5	32	20	15	67
Universidad Pedagógica Nacional	UPN	159	55	42	49.3	35	14	10	59
Universidad de La Guajira	UDLG	78	74	63	67.4	32	20	19	71
Universidad Nacional Abierta y a Distancia	UNAD	46	43	39	53.5	36	14	13	63
Universidad Colegio Mayor de Cundinamarca	UCMC	116	33	18	47.6	81	73	59	213
Universidad de La Amazonía	UDLA	67	46	13	57.8	22	15	9	46
Universidad de Cundinamarca	UDC	33	24	21	56.7	20	9	8	37
Universidad Tecnológica del Chocó	UTDC	19	6	3	63.2	6	4	4	14
Universidad del Pacífico	UDP	14	5	4	68.9	6	2	2	10

Note: the documents and collaborative affiliation by area are described in Table 2.

the eldest institutions in Colombia (central and west area, which are strategics zones for different industrial sectors) where the number of programs is in growth and the governmental economic aids to improve the institutions and therefore had the most representative amount of researchers by different areas.

Notice that, from the collaborating affiliations of the 32 institutions in Colombia, the Universidad Nacional de Colombia, Universidad de Los Andes, and the Universidad de Antioquia are the most collaborative institutions analyzed. Still, Universidad de los Andes is a prestigious private institution in Colombia that collaborates with various public institutions. It is evident regarding the collaboration with international higher education institutions as Harvard Medical School, Universidad de Castilla-La Mancha, Universidade de Sao Paulo–USP, University of Oklahoma, University of Florida, Universidade Federal de Mato Grosso, and Instituto Politécnico Nacional mainly.

According to Departamento Administrativo Nacional de Estadística (DANE Colombia), the main growth areas of the economy is based in the financial sector (20%), service sector (15.3%), commerce sector (12%), industrial sector (8.3%), mining and oil sector (8%), construction sector (6.9%), the agricultural sector (6%), and the electricity and gas sector (2.6%). Notice that is evident the contribution of the Colombian public universities to the development of the areas/sectors of the economy, considering that are an important point the relationship with the university-company-government. Notice, as was previously mentioned, the interest areas of the documents are agricultural and biological sciences, engineering, and environmental sciences due to the number of times of appearance.

From Table 1, is evident that the 80,529 articles were published mainly in areas of knowledge such as medicine, agricultural and biomedical, and psychology and astronomy. However, these areas differ according to the most relevant academic programs of public institutions of higher education. Furthermore, other areas with fewer publications, such as environmental science, social sciences, and arts and humanities, among others, are evidenced by Scopus database analysis as shown in Figure 4 for the percentage of the relation of the most relevant subject areas in Colombia.

Table 3: Summarization of the documents by area and collaborating affiliations.

University	Documents	Authors	Documents by area			Collaborating affiliations		
			1	2	3	1	2	3
UA	—		Medicine	Agricultural and biological science	Physics and astronomy	Universidad Nacional de Colombia, Medellin	Hospital Pablo Tobon Uribe	Universidad Pontificia Bolivariana
	15173	9412	5288	2294	1913	681	517	463
UDCS	—		Agricultural and biological science	Medicine	Arts and humanities	Universidad Nacional de Colombia	Universidad de Manizales	Universidad Autónoma de Manizales
	1935	1337	493	487	215	194	87	81
UC	—		Medicine	Chemistry	Agricultural and biological science	Universidad Nacional de Colombia	Universidad Pontificia Bolivariana	Universidade de Sao Paulo - USP
	2396	1650	1072	284	278	182	93	85
UDCA	—		Agricultural and biological science	Engineering	Computer science	Universidad Nacional de Colombia	Universidad de Sucre	Universidad de antioquia
	1073	781	444	192	171	69	57	56
UDC	—		Agricultural and biological science	Medicine	Social sciences	Universidad Nacional de Colombia	Instituto Nacional de Psiquiatría Ramon de la Fuente	Harvard Medical School
	108	126	33	24	21	20	9	8
UDLA	—		Agricultural and biological science	Veterinary	Environmental science	Universidad Nacional de Colombia	Universidad de Antioquia	Universidad del Valle
	149	229	67	46	13	22	15	9
UDLG	—		Engineering	Business, Management and Acc	Agricultural and biological science	Universidad Popular del Cesar	Universidad de Cartagena	Universidad Del Zulia
	242	187	78	74	63	32	20	19
UDLL	—		Agricultural and biological science	Veterinary	Engineering	Universidad Nacional de Colombia	Universidad Industrial de Santander	Universidad de los Andes
	358	336	171	60	45	38	15	14
UDN	—		Agricultural and biological science	Computer Science	Engineering	Universidad del Valle	Universidad Nacional de Colombia	Universidad de Antioquia
	693	552	261	113	105	67	41	34
UDP	—		Engineering	Medicine	Physics and astronomy	Universidad Industrial de Santander	Universidad De Los Andes, Merida	Universidad Simón Boliva r, Cúcuta
	617	402	124	107	105	57	55	35
UDS	—		Agricultural and biological science	Medicine	Engineering	Universidad de Córdoba	Universidad de Antioquia	Universidad del atlántico
	511	376	222	86	81	57	44	29
UDA	—		Physics and astronomy	Engineering	Agricultural and biological science	Universidad de la Costa	Universidad del Norte	Universidad del Valle, Cali
	1081	726	214	186	182	160	78	74
UDC	—		Computer Science	Engineering	Medicine	Universidad del Valle	Universidad de Castilla -La Mancha	Universidad del Quindio
	2004	1376	797	510	345	146	74	55
UDM	—		Agricultural and biological science	Engineering	Environmental science	Universidad Nacional de Colombia	Universidad Industrial de Santander	Universidad del Norte
	987	563	408	167	124	102	51	32
UDP	—		Agricultural and biological science	Environmental Science	Arts and Humanities	University of Florida	Autoridad Nacional de Acuicultura y Pesca	Universidade Federal de Mato Grosso
	20	12	14	5	4	6	2	2
UQ	—		Agricultural and biological science	Computer Science	Medicine	Universidad del Valle	Universidad Nacional de Colombia	Universidad del Cauca
	1010	728	279	196	196	87	61	55
UDT	—		Agricultural and biological science	Medicine	Biochemistry, Genetics and Mole	Universidad Nacional de Colombia	Universidad de los Andes	Consejo Superior de Investigaciones Científicas
	996	710	385	159	149	60	58	45
UV	—		Medicine	Engineering	Physics and astronomy	Universidad de Jaen	Universidade de Sao Paulo - USP	Universidad de antioquia
	8442	4567	2521	1406	1311	271	234	228
UDFJC	—		Computer Science	Engineering	Mathematics	Universidad Nacional de Colombia	Pontificia Universidad Javeriana	Universidad de los Andes
	2146	1652	922	781	518	329	63	59
UFPS+ UFPSO	—		Physics and astronomy	Engineering	Computer science	Universidad del Atlántico, Colombia	Universidad Nacional de Colombia	Universidad Militar Nueva Granada
	778	619	409	144	83	44	39	33
UIS	—		Physics and astronomy	Engineering	Medicine	Ecopetrol	Universidad Nacional de Colombia	Universidade de Sao Paulo - USP
	5290	3475	1125	1029	943	230	174	137
UNNG	—		Engineering	Medicine	Computer science	Hospital Militar Central, Bogota	Universidad Nacional de Colombia	Pontificia Universidad Javeriana
	1711	1238	599	454	342	168	166	76
UNAB	—		Agricultural and biological science	Engineering	Social sciences	Universidad Nacional de Colombia	Universidad de los Andes	University of Leeds
	223	181	46	43	39	36	14	13
UNC	—		Medicine	Agricultural and Biological Science	Physics and astronomy	Universidad de Los Andes	Pontificia Universidad Javeriana	Consejo Super ior de Investigaciones Científicas
	27610	9943	3881	3360	1957	777	621	510
UPN			Social Sciences	Arts and Humanities	Psychology	Universidad Nacional de Colombia	Universidad Distrital Francisco Jose de Caldas	Universidad de los Andes
	251	190	159	55	42	35	14	10
UPTC			Agricultural and biological science	Physics and A stronomy	Engineering	Universidad Nacional de Colombia	Universidad de Los Andes	Universidad de antioquia
	1564	1251	341	304	279	227	56	46
UPC	—		Physics and A tronomy	Engineering	Computer science	Universidad de la Guajira	Universidad de Antioquia	Universidad Nacional de Colombia
	288	244	114	92	89	32	20	15
US	—		Engineering	Medicine	Physics and astronomy	Universidad Nacional de Colombia	University of Oklahoma	Universidad de antioquia
	548	487	171	162	74	67	24	22
UTP	—		Medicine	Engineering	Computer science	Fundación Universitaria Autónoma de las Américas	Audifarma S.A.	Universidad Nacional de Colombia Manizales
	2114	1276	735	623	331	173	121	94
UTDC	—		Agricultural and biological science	Environmental science	Biochemistry, Genetics and Mol	Universidad Nacional de Colombia	Instituto Politécnico Nacional	Universidad Jorge Tadeo Lozano
	33	30	19	6	3	6	4	4
UCMC	—		Medicine	Psychology	Agricultural and biological science	Harvard Medical School	Instituto Nacional de Psiquiatría Ramon de la Fuente	Institut Municipal d'Investigacio Medica
	178	105	116	33	18	81	73	59

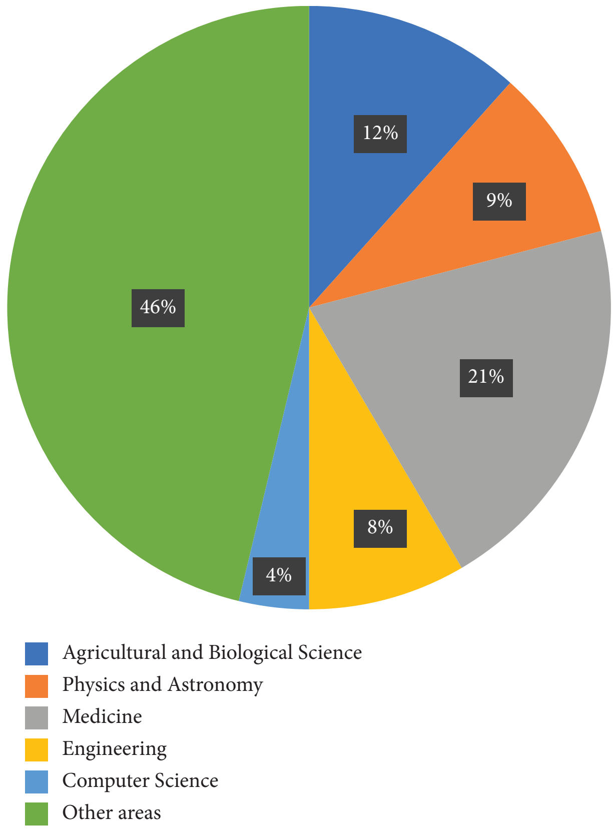

FIGURE 4: Percentage of relevant topic areas in Colombia.

In Colombia, research on intellectual capital in higher education institutions corresponds to 18 documents published in the Scopus database during the period 2015 to 2021, of which 4 belong to research carried out in research groups from public and private universities, evaluating IC topics related to relational capital, Machiavellianism and organizational narcissism, and scientific production. The other 14 documents were developed on the following topics: efficiency for investment in scientific research; knowledge generation; structural capital; relational capital; and literature review in institutions in the Aburrá Valley; Universidad Tecnológica y Pedagógica de Colombia (UTPC); Universidad Autonoma de Manizales (UNAM); and other studies do not mention the institution where the research was carried out.

Figure 5 shows the percentage of the relevance of public institutions in Colombia. It can be observed that the Universidad Nacional de Colombia is the institution that most collaborates with the 31 universities in the country by around 27%, followed by the Universidad de Antioquia and the Universidad de Los Andes. In the case of collaborations, public and private institutions, research centers, companies, and universities from abroad are involved. Other national institutions include the Universidad del Atlántico, the Universidad Pontificia Bolivariana, the Universidad del Norte, and the Universidad del Valle mainly, and internationally, with Harvard Medical School, University of Oklahoma, and the National Polytechnic Institute.

3.3. Collaborative Documents and Country Networks. Figure 6 shows the percentage of collaborative documents of universities in Colombia with others at the international and national levels considering the data and graphs for each Colombian university from the Scopus database (32 in total). It is observed that the means is around 68%, where the UA, UDCS, UDC, UDLL, UDN, UDS, UDP, UDT, UDFJC, UFPS + UFPSO, UNNG, UPN, US, UTP, UTCD, and UCMC are in the group by above average (51.61%) and the other institutions under the average. This behavior partly depends on the number of researchers and full-time teachers in the institution, as was evidenced previously. Notice also that the number of articles related to the areas depends on the intellectual capital and the different aspects of IC schemes, which indicates that H2 is confirmed.

On the other hand, in Colombia, the study of the influence of intellectual capital on scientific production and disseminating knowledge has occurred to a lesser extent, as shown in Figure 7. Research has been carried out independently since the 80s and 90s, thanks to the rise of information and communication technologies. Still, articulation is not visualized in said study variables. Simultaneously, in higher education institutions, there is an absence of documents published on said topics studied, reflecting a lack of interest in the national scientific community [4]. The behavior of collaboration between institutions is evidenced in Table 2. This way observed how the countries of the institutions collaborate concerning Colombia universities with others.

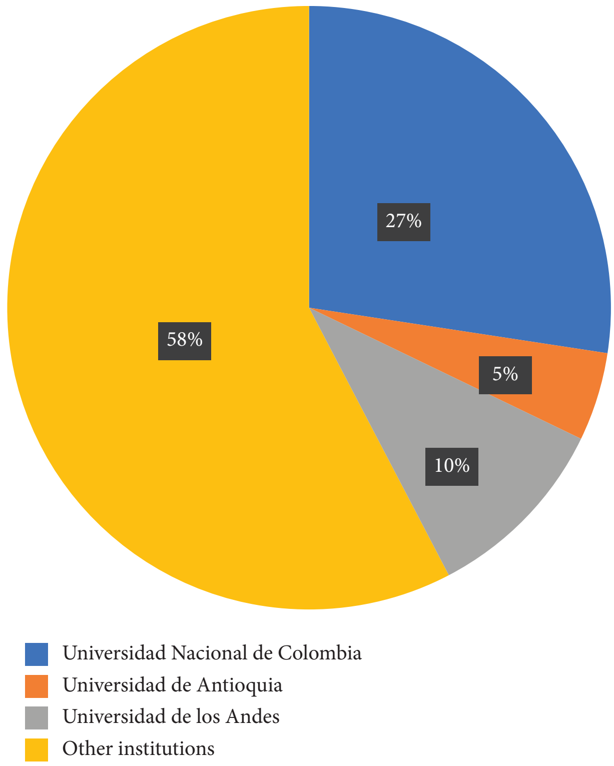

Figure 5: Percentage of relevant institutions by collaborations in universities in Colombia.

According to Tables 2 and 3 and Figures 5–7, the Colombian public universities that have more strengths in intellectual capital (human capital, structural capital, and relational capital) are the most frequently ones belonging to networks of scientific collaboration through cocitation with researchers at the national and international level, which confirms H2—the quantity and quality of the intellectual capital of public universities in Colombia positively and significantly influence national and international scientific collaboration.

According to the literature review carried out in different bibliographic sources, it became necessary to analyze the influence of scientific production from human capital, structural capital, and relational capital as its three main components, where no publications were found either. Therefore, it was necessary to break down these capitals in subvariables as follows.

Regarding the influence of human capital in the dissemination of knowledge through the labor mobility subvariable that is part of the said human capital, Maliranta and Nurmi [55] carried out a study in Finland through the Finnish longitudinal owner-employer-employee database (FLOWN), demonstrating that the dissemination of knowledge is carried out through the labor mobility of owners and employees, as well as corroborating that a business owner's high education in a technical field is positively related to business performance.

In affinity to the above, human development is also a subvariable of human capital that influences the dissemination of knowledge. Asongou and Nwachukwu [36] conducted a study in sub-Saharan Africa where they found that the dissemination of knowledge influences or conditions in human development through mobile phones, analyzing the complementary role of the diffusion of knowledge in the inclusive benefits of the penetration of mobile telephony in sub-Saharan Africa from 2000 to 2012 through the use of the generalized method of moments.

In the same way, relational capital influences the dissemination of knowledge through the subvariable of knowledge networks that is part of the said relational capital. In this sense, Xiao et al. [56] carried out a bibliometric analysis to determine the index of inductive citations in the diffusion patterns and knowledge networks in the economic, geographic, environmental, and sociocultural domains of tourism research through knowledge networks typically integrated into the patterns of knowledge coauthorship of the main sources. On the other hand, the effects of policy-induced knowledge networks on the propensity for cross-regional patent citations in the same country or continent in a general way. Finally, in correspondence with what was stated above, the social network is also a subvariable of relational capital that influences the dissemination of knowledge, Maghssudipour et al. [38] showed that economic and social network ties positively affect knowledge diffusion.

3.4. Incidence of the COVID-19 Pandemic on Intellectual Capital and Scientific Production. The COVID-19 pandemic has exposed the importance of intellectual capital in higher education institutions, through human capital made up of teachers, students, and support staff in relation to curricular innovation in the educational process; structural capital in

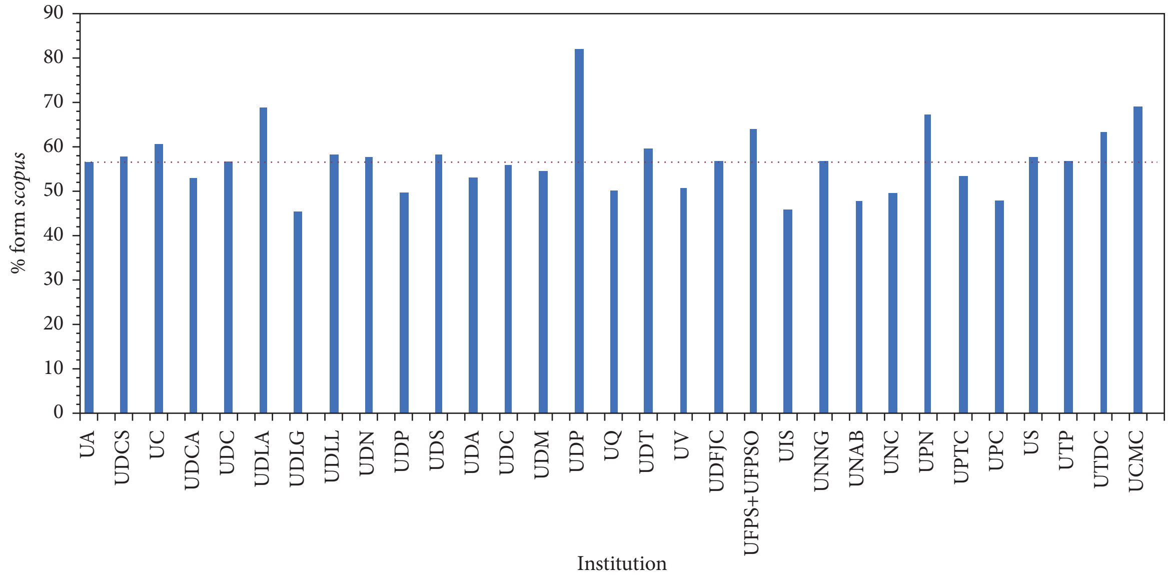

Figure 6: Percentage of collaborative documents of universities in Colombia.

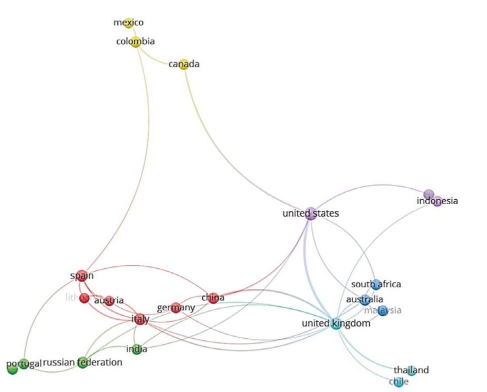

Figure 7: Networks of collaborations by countries. Source: [4].

relation to virtual learning platforms; and relational capital that consists of communication between all the actors through the use of virtual learning platforms to counteract the confinement in said health emergency throughout the world, as shown by the following studies.

The research carried out by Fernandezet al. [57] analyzed synchronous and asynchronous learning in 655 students during the COVID-19 pandemic, supported by intellectual capital in India. The results showed that synchronous learning in the students is stressful. Also, this practice demands greater responsibility, supported by intellectual capital in the educational process through human capital made up of teachers, students, and support staff about curricular innovation in the educational process and structural capital, especially in virtual learning platforms. On the other hand, technological equipment such as cell phones, iPad, computers, and relational capital that consists of communication between all actors using virtual learning platforms, which occurs online due to confinement in the COVID-19 health emergency, was also identified as currently universities are prepared to offer their services virtually. Finally, it is concluded that educational institutions have intellectual capital for creating and disseminating knowledge imparted by virtual means due to COVID-19. A similar study was developed by Milicevic et al. [58] for the engineering and technology area and the influence of virtual education on intellectual capital, concluding that the digital era had an important scenery on the human capital, structural capital, and relational capital in the pandemic situation generated by the COVID-19 and the development of the higher institutions.

Ng F. [59] studied university survival, recovery, and revolution due to the COVID-19 pandemic through intellectual capital and analyzed the limitations of accounting and financial information in a university during the health emergency. The results obtained reveal that intellectual capital in universities is the primary source of dissemination of knowledge in the provision of educational services and therefore contributes significantly to the survival of the institutions. In addition, it considerably influences the recovery from the educational crisis. Furthermore, the COVID-19 pandemic is revolutionizing face-to-face education to virtual university education, adapting to the needs of students in a hybrid education and the importance of intellectual capital, and finally accounting measures of the impact of the health crisis. Rancan et al. [60] analyzed the initiation programs of Brazilian academic scientific production and the impact of the COVID-19 pandemic in its many aspects, concluding that the said production is in a survival situation in the face of the new problems and challenges resulting from the COVID-19 pandemic. For this reason, the scientific initiation of researchers is less stimulating. Moreover, Abramoet al. [61] argue that the COVID-19 pandemic and confinement brings with it negative effects which have generated a general slowdown in research and scientific production, due to spending on research and development (R&D) and economic growth. Therefore, the stagnation of scientific research also slows down the recovery from the pandemic worldwide. In the same way, it was shown that scientific production is uneven according to gender because in few countries, women increased their scientific production, while men were more scientifically unproductive. Another important study on the effects of COVID-19 on scientific production was published by Ortiz-Martínez et al. [62] who concluded that the COVID-19 pandemic has negatively affected international scientific production at all levels in some countries with a protracted decline in research and scientific production, but in other countries, it has increased significantly.

4. Conclusions and Trends

Empirical studies on intellectual capital have been mainly developed with a measurement approach. However, particularly in higher education institutions in Colombia, studies on intellectual capital are scarce, and therefore, it is recommended to carry out future studies where other approaches are analyzed, such as the relationship of intellectual capital with other study variables such as scientific production, knowledge management, and innovation in organizations.

This study provides information about all scientific production developed by the higher public Colombian universities, data that were collected directly from the Scopus database. The information was analyzed using Excel software and data obtained from Scopus containing the data of 44,761 documents which involucrate three main areas and relations with three countries such as Mexico, Spain, and the United States of America.

Colombian scientific production is associated with 31 public universities, representing 80,529 scientific products published by 44,761 authors in three relevant subjects: agricultural and biological sciences, physics and astronomy, and medicine. The data obtained show that 56.61% of the universities are above average. This behavior depends on the number of full-time researchers and professors, the physical and technological infrastructure, and the relationships with their stakeholders that the institutions have related to intellectual capital, which indicates that H1 is confirmed: the public universities of Colombia with the highest human capital are the most scientifically productive because Figure 2 shows that, in Colombia, the public universities with the highest number of authors or researchers are the ones that publish the most scientific articles in Scopus.

Due to COVID-19, digital tools provide great sources and take place an essential scenery on the human capital, structural capital, and relational capital in the development of scientific production and new strategies for improving the practices in higher education in the different areas.

Considering the 100% of the total published articles by the different main areas from the Scopus database by the 32 public universities in Colombia, 53% of the publications represent the 44% of the total authors of Colombia, which Universidad Nacional de Colombia has developed, Universidad de Antioquia and Universidad del Valle, which are some of the largest and oldest universities in Colombia, located in the central and western areas, which are strategic areas for the financial, service, commercial, and industrial sectors, indicating that H2 is confirmed.

The quantity and quality of intellectual capital (IC) are related to the size of the universities and to scientific publications, which are directly associated with the quantification and qualification of the intellectual capital (IC) working in Colombia public universities. In this way, it is established that the greater the number of authors, the more significant the increase in publications will be substantial to their number, which represents a greater collaboration with other researchers from the same university and from other national and international universities, indicating that H2 is confirmed: the quantity and quality of the intellectual capital of public universities in Colombia positively and significantly influence national and international scientific collaboration. Taking into account tables and figures plotted, it is evident that the Colombian public universities that have more strength in intellectual capital (human capital, structural capital and relational capital) are those that frequently belong to scientific collaboration networks through cocitation with researchers at the national and international level.

The limitations of this study are focused on the use of only the Scopus database of excellent academic and scientific prestige due to its wide coverage in the publication of scientific articles, with information from which the data were statistically analyzed. Also, in the open literature, other databases can be used to develop this kind of review of information. Furthermore, Colombia country was selected due to the lack of research focused on scientific production in universities. Therefore, this study can be used and focused on other countries, and different results will be obtained.

Future research on this topic of study could focus on determining intellectual capital in other institutions such as private universities and government agencies and considering the association of intellectual capital with other study variables such as knowledge management, innovation, and organizational learning. Likewise, it proposed to carry out future research on intellectual capital as a strategic resource in universities due to its focus on creating and disseminating knowledge, which enables the generation of value and competitive advantage and its importance in decision-making for all types of organizations.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

W. Quintero-Quintero investigated, collected data, funding acquisition, formal analysis, prepared the original draft, and reviewed and edited the manuscript. A. B. Blanco-Ariza provided analysis tools, formal analysis, made other contributions. M. A. Garzón-Castrillón collected data, contributed to formal analysis, and other contributions.

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References

[1] P. H. Sullivan, *Profiting from Intellectual Capital: Extracting Value from Innovation*, WILEY, Hoboken, NJ, USA, 1998.

[2] J. Hekimian and H. Jones, *Put People on Your Balance Sheet*, Harvard Bu, Boston, MA, USA, 1967.

[3] J. K. Galbraith, *The New Industrial State*, Princeton, Boston, NJ, USA, 1967.

[4] W. Quintero-Quintero, A. B. Blanco-Ariza, and M. A. Garzón-Castrillón, "Intellectual Capital: A Review and Bibliometric Analysis," *Publications*, vol. 94 pages, 2021.

[5] P. N. Rastogi, "Knowledge management and intellectual capital – the new virtuous reality of competitiveness," *Human Systems Management*, vol. 19, no. 1, pp. 39–48, 2000.

[6] N. Bontis, "Assessing knowledge assets: a review of the models used to measure intellectual capital," *International Journal of Management Reviews*, vol. 3, no. 1, pp. 41–60, 2001.

[7] J. Guthrie, "The management, measurement and the reporting of intellectual capital," *Journal of Intellectual Capital*, vol. 2, no. 1, pp. 27–41, 2001.

[8] R. M. Grant, "Prospering in dynamically-competitive environments: organizational capability as knowledge integration," *Organization Science*, vol. 7, no. 4, pp. 375–387, 1996.

[9] P. J. Lane, J. E. Salk, and M. A. Lyles, "Absorptive capacity, learning, and performance in international joint ventures," *Strategic Management Journal*, vol. 22, no. 12, pp. 1139–1161, 2001.

[10] M. Meier, "Knowledge management in strategic alliances: a review of empirical evidence," *International Journal of Management Reviews*, vol. 13, no. 1, pp. 1–23, 2011.

[11] I. Yudianto, S. Mulyani, M. Fahmi, and S. Winarningsih, "The influence of good university governance and intellectual capital on university performance in Indonesia," *Academic Journal of Interdisciplinary Studies*, vol. 10, no. 1, p. 57, 2021.

[12] M. L. Sanchez Limon, Y. Sanchez Tovar, and J. Jasso Villazul, "Characterization of intellectual capital in public Mexican universities," *International Journal of Professional Business Review*, vol. 6, p. e203, 2021.

[13] G. Nicolo, F. Manes-Rossi, J. Christiaens, and N. Aversano, "Accountability through intellectual capital disclosure in Italian Universities," *Journal of Management & Governance*, vol. 24, no. 4, pp. 1055–1087, 2020.

[14] A. L. R. Valladares, R. L. Fernández, A. R. S. Castro, and J. L. L. González, "Estudio de la producción científica en la Universidad Metropolitana del Ecuador, en el período 2020-2021," *Universidad y Sociedad*, vol. 13, 2021.

[15] P. A. Millones-Gómez, J. S. Yangali-Vicente, C. M. Arispe-Alburqueque et al., "Research policies and scientific production: a study of 94 Peruvian universities," *PLoS One*, vol. 16, no. 5, Article ID e0252410, 2021.

[16] E. Lucas Barcia and J. Roa González, "Análisis de la producción científica sobre enseñanza universitaria virtual y semipresencial en revistas españolas de alto impacto," *Revista Complutense de Educación*, vol. 32, no. 4, p. 605, 2021.

[17] G. Liberatore, S. Sleimen, A. Vuotto, V. Di Césare, and N. Pallotta, "Estudio de la internacionalización de la Universidad Nacional de Mar del Plata desde la perspectiva de la producción científica. Análisis de la colaboración y liderazgo científico," *Informacion, Cultura y Sociedad*, pp. 13–32, 2021.

[18] B. Elango, "Growth of scientific publications: an analysis of top ten countries," *Library Philosophy and Practice*, vol. 2018, pp. 1–10, 2018.

[19] S. E. Monroy and H. Diaz, "Time series-based bibliometric analysis of the dynamics of scientific production," *Scientometrics*, vol. 115, no. 3, pp. 1139–1159, 2018.

[20] M. Kuong Morales and S. Kuong Morales, "Ranking bibliométrico internacional Scimago: una realidad para las universidades peruanas," *Revista Venezolana de Gerencia*, vol. 27, pp. 426–442, 2022.

[21] R. Carranza-Esteban, J. Turpo-Chaparro, R. M. Hernández, O. Mamani-Benito, and A. Apaza-Romero, "Scientific production of rectors of Peruvian universities," *Frontiers in Education*, vol. 7, 2022.

[22] R. F. Carranza Esteban, R. M. Hernández, O. J. Mamani-Benito, J. E. Turpo Chaparro, and P. G. Ruiz Mamani, "Producción científica de directivos de la carrera de enfermería en universidades peruanas," *Revista Cubana de Enfermería*, vol. 38, 2022.

[23] W. Suárez-Amaya, M. Rodríguez-Altamirano, and F. A. Ganga Contreras, "Estrategias para promover la producción científica universitaria en Chile," *Revista de Ciencias Sociais*, vol. 28, pp. 350–363, 2022.

[24] Y. Cuba Rodríguez, T. R. Hernández Campillo, B. M. Carvajal Hernández, J. Ubeda Medina, G. Herrera Pupo, and E. Sierra Gil, "Ciencia abierta Y La producción científica de La Universidad de Camagüey en redes sociales académicas open science and the scientific production of the university of Camagüey in academic social networks," *An. Investig*, vol. 18, no. 1, pp. 1–18, 2022.

[25] E. Galbán-Rodríguez, D. Torres-Ponjuán, Y. Martí-Lahera, and R. Arencibia-Jorge, "Measuring the Cuban scientific output in scholarly journals through a comprehensive coverage approach," *Scientometrics*, vol. 121, no. 2, pp. 1019–1043, 2019.

[26] J. Sanchez Maríñez, *El rol de las universidades en el desarrollo científico y tecnológico—Informe sobre Cuba*, Universidad de La Habana, Havana, Cuba, 2010.

[27] Colciencias, "M. de medición de grupos de investigación, desarrollo tecnológico o de innovación y de reconocimiento de investigadores del sistema nacional de ciencia, tecnología e innovación," 2021, https://minciencias.gov.co/sites/default/files/ckeditor_files/Anexo 1 - Documento Conceptual 2021 %281%29.pdf.

[28] F. A. Alzate Ortiz and A. Jaramillo Arenas, "La gestión del conocimiento un desafío para las instituciones educativas en Colombia: emergencias y tensiones desde la teoría del capital intelectual," *Gestión de la educación*, vol. 5, no. 2, pp. 137–150, 2015.

[29] E. Bueno, *Propuesta de nuevo Modelo Intellectus de Medición, gestión e información del capital intelectual*, Madrid, Spain, 2011.

[30] I. Bibiana Bedoya and I. Parra Mesa, "Modelo de gestión del conocimiento y capital intelectual en un grupo de investigación, alineado a un estándar internacional," *Gestión de Las Personas y Tecnología*, vol. 9, no. 27, pp. 50–64, 2016.

[31] B. Jin and R. Rousseau, "Evaluation of Research Performance and Scientometric Indicators in China BT," *Handbook of Quantitative Science and Technology Research: The Use of Publication and Patent Statistics in Studies of S&T Systems*, Springer, Berlin, Germany, 2005.

[32] V. Bucheli, "Crecimiento de la producción científica en las universidades colombianas: un enfoque basado en el capital intelectual," *Espacios*, vol. 38, no. 53, p. e20, 2017.

[33] G. Moreno-López, L. M. G. Marín, L. Gómez-Bayona, and J. M. R. Mora, *In Developments and Advances in Defense and Security, Smart Innovation, Systems and Technologies*, 2022.

[34] L.-A. Casado-Aranda, J. Sánchez-Fernández, and M. I. Viedma-del-Jesús, "Analysis of the scientific production of the effect of COVID-19 on the environment: a bibliometric study," *Environmental Research*, vol. 193, Article ID 110416, 2021.

[35] A. Corell-Almuzara, J. López-Belmonte, J.-A. Marín-Marín, and A.-J. Moreno-Guerrero, "COVID-19 in the field of education: state of the art," *Sustainability*, vol. 13, p. 5452, 2021.

[36] V. P. Pertuz-Peralta, A. B. Perez-Orozco, N. C. Boscán-Romero, M. D. S. Bermudez Rojo, and C. Solorzano-Bastidas, "Intellectual capital: a comparative view between enterprises and universities," *International Journal of Advanced Science, Engineering and Information Technology*, vol. 8, no. 2, pp. 350–357, 2018.

[37] E. M. Londoño Montoya, B. Mora González, H. Tobón Montoya, M. A. Becerra Botero, and J. S. Cadavid, "Modelo de Capital intelectual para la función de investigación en las universidades colombianas," *Opción*, vol. 18, no. 1, pp. 964–990, 2018.

[38] L. Cricelli, M. Greco, M. Grimaldi, and L. P. Llanes Dueñas, "Intellectual capital and university performance in emerging countries: evidence from Colombian public universities," *Journal of Intellectual Capital*, vol. 19, no. 1, pp. 71–95, 2018.

[39] C. R. Vidal Tovar, "Modelo de capital intelectual para la investigación en las universidades públicas de la Costa Caribe colombiana," *Actualidades Investigativas en Educación*, vol. 17, no. 1, pp. 1–27, 2017.

[40] J. F. León Cano, V. d. l. Á. Agámez Llanos, E. J. Ordoñez, and J. F. Castillo García, "Producción científica colombiana en psicología en Scopus desde el 2015 al 2019," *Revista Española de Documentación Científica*, vol. 45, no. 2, p. e323, 2022.

[41] N. Y. G. Velasco, O. Gregorio-Chaviano, and A. L. B. Alfonso, "Dynamics of colombian scientific production in economics. a bibliometric study in scopus 2007–2019," *Lecturas de Economía*, vol. 95, 2021.

[42] V. Beizaga-Luna, C. Navarrete-Pérez, J. H. Ávila-Toscano, and C. H. Limaymanta, "Colaboración y estructura intelectual de la producción científica peruana y colombiana en Ciencias Sociales (2011–2020)," *Revista Española de Documentación Científica*, vol. 45, no. 2, p. e327, 2022.

[43] A. L. Ballesteros Alfonso, O. G. Chaviano, and N. Y. Gómez Velasco, "Dinámicas de la producción científica colombiana en economía: un estudio bibliométrico en Scopus 2007–2019," *Lecturas de Economía*, vol. 95, pp. 277–309, 2021.

[44] M. Antosova and A. Csikosova, "Intellectual capital in context of knowledge management," in *The Economic Geography of Globalization*Intechopen, London, UK, 2011.

[45] Snies-Mineducación, "Sistema Nacional de Información de la Educación Superior," 2022, https://hecaa.mineducacion.gov.co/consultaspublicas/ies.

[46] I. F. Aguillo, "Is Google Scholar useful for bibliometrics? A webometric analysis," *Scientometrics*, vol. 91, no. 2, pp. 343–351, 2012.

[47] R. A. García-León, J. Martínez-Trinidad, and I. Campos-Silva, "Historical review on the boriding process using bibliometric analysis," *Transactions of the Indian Institute of Metals*, vol. 74, pp. 541–557, 2021.

[48] R. A. García-León, J. A. Gómez-Camperos, and H. Y. Jaramillo, "Scientometric review of trends on the mechanical properties of additive manufacturing and 3D printing," *Journal of Materials Engineering and Performance*, vol. 30, no. 7, pp. 4724–4734, 2021.

[49] R. A. García-León, J. Gomez-Camperos, and H. Jaramillo, "Bibliometric analysis in brake disc: an overview," *Dyna*, vol. 88, pp. 23–31, May 2021.

[50] R. Pico-Saltos, P. Carrión-Mero, N. Montalván-Burbano, J. Garzás, and A. Redchuk, "Research trends in career success: a bibliometric review," *Sustainability*, vol. 13, p. 4625, 2021.

[51] M. Visser, N. J. van Eck, and L. Waltman, "Large-scale comparison of bibliographic data sources: scopus, Web of science, dimensions, crossref, and microsoft academic," *Quantitative Science Studies*, vol. 2, no. 1, pp. 20–41, 2021.

[52] P. Carrión-Mero, N. Montalván-Burbano, N. Paz-Salas, and F. Morante-Carballo, "Volcanic geomorphology: a review of worldwide research," *Geosciences*, vol. 10, p. 347, 2020.

[53] C. M. Romero, "Historia de la Universidad Nacional de Colombia vista desde los documentos históricos," 2020, http://www.archivo.bogota.unal.edu.co/pages/historia.php.

[54] J. Ariaz-Perez, N. Lozada, and E. Henao-García, "Intellectual capital management and performance of university research groups in an emerging country, Colombia case," *Informacion Tecnologica*, vol. 30, no. 4, pp. 181–188, 2019.

[55] M. Maliranta and S. Nurmi, "Business owners, employees, and firm performance," *Small Business Economics*, vol. 52, no. 1, pp. 111–129, 2019.

[56] H. Xiao, M. Li, and E. C. K. Lin, "Diffusion patterns and knowledge networks: an inductive analysis of intellectual connections in multidisciplinary tourism studies," *Journal of Travel & Tourism Marketing*, vol. 28, no. 4, pp. 405–422, May 2011.

[57] C. J. Fernandez, R. Ramesh, and A. S. R. Manivannan, "Synchronous learning and asynchronous learning during COVID-19 pandemic: a case study in india," *Asian Association of Open Universities Journal*, 2022.

[58] J. Milicevic, N. Sremcev, I. Cosic, M. Lazarevic, and N. Tasic, "The new role of teachers after the COVID-19 pandemic and the application of the lean concept in education," *Proceedings of the 32nd International DAAAM Symposium 2021*, vol. 32, pp. 0402–0407, 2021.

[59] F. Ng, "Accounting at your service: university survival, recovery and revolution from COVID-19," *Pacific Accounting Review*, vol. 33, no. 5, pp. 652–664, 2021.

[60] E. A. Rancan, E. I. Frota, T. M. N. D. Freitas, A. B. Chies, and O. D. Castro-e-Silva Júnior, "Academic research challenges in Brazil and its impairment by COVID-19 pandemic: a medical students point of view," *Medicina*, vol. 54, no. 4, pp. 1–9, 2021.
[61] G. Abramo, C. A. D'Angelo, and I. Mele, "Impact of Covid-19 on research output by gender across countries," *Scientometrics*, pp. 1–16, 2022.
[62] Y. Ortiz-Martínez, C. Mejia-Alzate, E. Marquez-Alfonso et al., "Has the COVID-19 pandemic had a positive impact on scientific production in medical education? A bibliometric analysis," *Educación Médica*, vol. 22, no. 6, p. 362, 2021.