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# Analysis of Scientific Production on Neutrosophy: A Latin American Perspective

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**Abstract:** Neutrosophy is a branch of philosophy proposed in 1998 by Romanian philosopher and mathematician F. Smarandache, which studies the origin, nature, and scope of neutrality and its interaction with different spectra of ideas. Because it is a relatively new field, specific scientific production on this subject may be limited, but as it develops, new research and contributions are likely to emerge. This is why it is becoming more necessary to undertake studies to understand the evolution, impact, and scope of research, especially in a context where it had never been examined in depth before: in the Latin American region. This research aims to describe the scientific production of Latin American authors in the Scopus database referring to Neutrosophic Science in the period 2019-2023 by carrying out a bibliometric study of a descriptive nature. The scientific production in Neutrosophy assumes patterns of behavior that vary from international patterns with a marked social focus. Although productivity levels have not increased in recent years, the impact and recognition from the international community have grown significantly, meaning the evolution of a process of transformation.

**Keywords:** Neutrosophy; bibliometric analysis; Latin America; scientific production

## 1. Introduction

Neutrosophy is a branch of philosophy proposed in 1998 by Romanian philosopher and mathematician F. Smarandache, which studies the origin, nature, and scope of neutrality and its interaction with different spectra of ideas. Neutrosophy examines the relationship between a proposition, theory, event, concept, or entity with its opposite and its neutrality. Since then, this logic has been applied in several fields of science. [1]

The dynamics of the opposites and their neutrals is an extension of dialectics that is the dynamic of opposites only. Neutrosophy is the basis of neutrosophic logic, neutrosophic probability, the neutrosophic set, and neutrosophic statistics. It is important to emphasize that neutrosophy allows the representation of information in a more complete and real way, allowing to embrace not only veracity or falsehood but also ambiguity, ignorance, contradiction, neutrality and saturation. [1, 2]

Although it is a relatively new concept, Neutrosophy has a background in other philosophical and epistemological currents, such as paradox, trivalent and multivalent logic, and Eastern philosophy. These backgrounds have contributed to shaping the fundamental principles and concepts of Neutrosophy as an innovative and complex philosophical theory. [3] His studies have

given way to a unique research method by constituting a unified field of logic for a transdisciplinary study that transcends the boundaries between the natural and social sciences. This science allows multidisciplinary work with other related, which allows an impact on the results of research. [4]

The scientific evolution of this knowledge enables a broader and more flexible view of the world, fosters tolerance, and interdisciplinary dialogue, facilitates conflict resolution, stimulates creativity and innovation, and enriches philosophical reflection on fundamental aspects of human existence. [5]

Because it is a relatively new field in philosophy and academic research, specific scientific production on this subject may be limited compared to other more established fields. However, there are some authors and academics who have contributed to the literature on Neutrosophy and have explored its philosophical and epistemological implications and its relationship with other disciplines [6-9]. Similarly, several studies have analyzed the evolution of scientific activity on the subject through bibliometry, where a growth in recent years of the global positioning of this discipline is reflected. [10 - 12]

While statistical analyses have been carried out that enable the obtaining of reliable indicators, associated with the quality, visibility and performance of the scientific production in Neutrosophy, no in-depth research of this phenomenon has been developed in Latin America. It is precisely in this region that from the year 2018 an initiative to promote the research, dissemination and development of Neutrosophy in the territory, the Latin American Association for Neutrosophic Sciences is emerging. (ALCN). This academic and scientific organization aims to promote academic exchange, collaboration among researchers and dissemination of knowledge, as well as support in the spread of neutrosophic thinking, but from an approach oriented to the solution of social problems. [13] The creation of the ALCN opened a new door for the development of research in the region and the growth of scientific publications on this subject.

As Neutrosophic Sciences continue to develop, new research and contributions are likely to emerge that will enrich our understanding of these and their implications for contemporary philosophy. This is why it is increasingly necessary to undertake studies to understand the evolution, impact and scope of research, as well as to foster collaboration among researchers and promote their recognition in the academic community. These types of studies can evaluate the relevance and visibility of scientific publications, especially in a context where they have never been examined in depth before: in the Latin American region.

The objective of this research is to describe the scientific production of Latin American authors in the Scopus database concerning Nuetrosophical Sciences in the period 2019-2023

## 2. Materials and Methods

This article presents a bibliometric analysis of the scientific output of Latin American scholars in the field of Neutrosophical Sciences. The study focuses on the articles indexed in the Scopus database from 2019 to 2023.

### 2.1 Characterization of information sources:

Scopus® (Elsevier, Netherlands): Multidisciplinary database, considered one of the most extensive in terms of coverage of bibliographic references and summaries of peer-reviewed scientific articles. More than 45,000 arbitrated journals are indexed and more than 29,000 are currently active. This database covers topics from various disciplines such as science, technology, medicine, social sciences, arts, and humanities, among others.

### 2.2 Dataset extraction:

The search was performed using the terms neutrosophy, neutrosophic, and their respective variants in the Spanish language in the fields Title, Abstract and Keyword to get as many results as

possible associated with this discipline. Following the search, a primary filtering process was applied to delimit the sample into original and review articles, published only in scientific journals within the period 2019-2023 and whose authorship was declared by researchers affiliated to Latin American institutions. This process resulted in the following formula:

*TITLE-ABS-KEY ( neutrosophy ) OR TITLE-ABS-KEY ( neutrosophic* ) OR TITLE-ABS-KEY ( neutrosofía ) OR TITLE-ABS-KEY ( neutrosófic* ) AND ( LIMIT-TO ( PUBYEAR , 2019 ) OR LIMIT-TO ( PUBYEAR , 2020 ) OR LIMIT-TO ( PUBYEAR , 2021 ) OR LIMIT-TO ( PUBYEAR , 2022 ) OR LIMIT-TO ( PUBYEAR , 2023 ) ) AND ( LIMIT-TO ( DOCTYPE , "ar" ) OR LIMIT-TO ( DOCTYPE , "re" ) ) AND ( LIMIT-TO ( AFFILCOUNTRY , "Ecuador" ) OR LIMIT-TO ( AFFILCOUNTRY , "Peru" ) OR LIMIT-TO ( AFFILCOUNTRY , "Colombia" ) OR LIMIT-TO ( AFFILCOUNTRY , "Cuba" ) OR LIMIT-TO ( AFFILCOUNTRY , "Mexico" ) OR LIMIT-TO ( AFFILCOUNTRY , "Chile" ) OR LIMIT-TO ( AFFILCOUNTRY , "Brazil" ) OR LIMIT-TO ( AFFILCOUNTRY , "Dominican Republic" ) OR LIMIT-TO ( AFFILCOUNTRY , "Argentina" ) OR LIMIT-TO ( AFFILCOUNTRY , "Paraguay" ) OR LIMIT-TO ( AFFILCOUNTRY , "Uruguay" ) OR LIMIT-TO ( AFFILCOUNTRY , "Dominica" ) OR LIMIT-TO ( AFFILCOUNTRY , "Panama" ) )*

As a result of the execution of the final formula, a total of 361 items were obtained. The search and retrieval of the data was carried out in May 2024.

**2.2 Dataset processing:**

The results obtained were exported in Comma-Separated Values (CSV) format, prioritizing the compilation of metadata with bibliographic information, information about quotes, and keywords from the article set. These elements were normalized and processed using OpenRefine, a tool that allows you to manage large volumes of data and perform analysis, cleaning, converting and reusing them.

To perform the visual analysis of information, generating graphs, tables, structural networks and co-occurrence maps were used the software Microsoft Excel, SCImago Graphica and VOSViewer, tools that allow to analyze, visualize and share large volumes of information through the elaboration of graphs and tables. In turn, VOSViewer allows you to build and visualize bibliometric networks.

**2.2 Dataset analysis:**

**2.2.1 Bibliometric indicators**

| | Indicator | Name | Definition |
|---|---|---|---|
| **Production** | Ndoc | Number of documents | Number of documents published in journals indexed in Scopus |
| | Tdoc | Document type | Document typology according to Scopus classification for publication sections (Article, Review, Conference paper, Book, Editorial, etc.) |
| | %Orig | Originality percentage | Percentage that original research represents with respect to the total number of documents in a given set. |

| | | | |
|---|---|---|---|
| | Cit | Number of citations | Number of citations received by documents published in journals indexed in Scopus. Only citations obtained from Scopus are recorded. |
| | CpD | Cites per Document | Average number of citations received in 1 year for the total number of documents published in journals indexed in Scopus. Only citations obtained from Scopus are recorded. |
| | H-Index | Hirsch Index | The h index expresses the journal's number of articles (h) that have received at least h citations. It quantifies both journal scientific productivity and scientific impact and it is also applicable to scientists, countries, etc. |
| **Impact** | SJR | SCImago Journal Rank | It expresses the average number of weighted citations received in the selected year by the documents published in the selected journal in the three previous years, --i.e. weighted citations received in year X to documents published in the journal in years X-1, X-2 and X-3 |
| | Q | Quartiles | The quartile distribution (Q1, Q2, Q3 and Q4) refers to citable papers indexed in journals occupying these quartile positions. Based on the SJR value, journals occupy a position from the division of their categories. This distribution determines the degree of visibility of the journals belonging to each quartile, the highest visibility is found in the first quartile, and it will decrease as it moves away in position. |
| | SNIP | Source Normalized Impact per paper | Is the ratio of a source's average citation count per paper and the citation potential of its subject field. |
| | CiteScore | Cite Score Metric | Calculating the CiteScore is based on the number of citations to documents (articles, |

| | | | |
|---|---|---|---|
| | | | reviews, conference papers, book chapters, and data papers) by a journal over four years, divided by the number of the same document types indexed in Scopus and published in those same four years. |
| | FWCI | Field-Weighted Citation Impact | Is the ratio of citations received relative to the expected world average for the subject field, publication type, and publication year. |
| **Collaboration** | %Icol | International Collaboration percentege | Document ratio whose affiliation includes more than one country address |

**2.2.2 Main elements discussed in each type of analysis**

| Analysis | Elements Included |
|---|---|
| Dataset overview | Scientific production evolution |
| | Scientific production impact |
| | Documents type |
| | Language of documents |
| | Average years from publication |
| | Average citations per document |
| | Average citations per year per document |
| | Keywords Analysis |
| | Thematic and subject areas |
| Source analysis | Document per source |
| | Journal Quartile |
| | Most relevant journals |
| | Bradford's law on source clustering |
| | Core Journals' growth (cumulative) based on the number of papers |
| Author analysis | Top authors based on number of documents |
| | Top authors based on number of cites |
| | Authors per document |
| | Documents per author |
| | Most relevant affiliations |
| | Collaboration index |
| | Most relevant corresponding author's |
| | Scientific production based on country |
| | Top countries with the most author |
| | Country collaboration map |
| | Authors' collaboration network |

| Analysis | Elements Included |
|---|---|

## 3. Results

*3.1 Dataset Overview*

The behavioral patterns of the Latin American scientific production on Neutrosophical Sciences at Scopus have remained stable over the last 5 years, taking into account the annual publication volumes as shown in Figure 1. With a total of 361 articles, the average annual publication reaches 72.2 and highlights the year 2020 as the period that most articles were published.

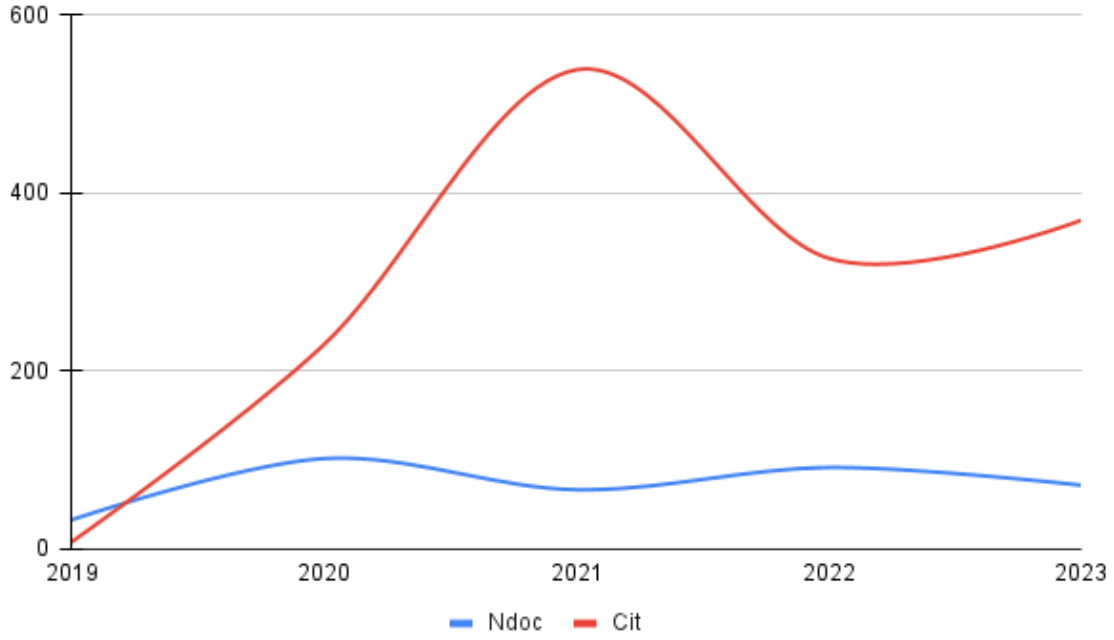


Figure 1: Evolution and impact of annual scientific production (2019-2023).

These results differ from general trends and analyses at the international level. Other studies a steady growth in the publication on Neutrosophy while forecasting an exponential increase in production, these forecasts are not fulfilled for the Latin American region. [4, 10 – 12] However, Delcea et al. (2023) describe in a more recent study that for the period 2021-2023 these values were stable and that the increase in previous years was also conditioned by the pandemic of COVID-19 which was boosted scientific production in all fields of research, including Neutrosophy. The analysis of Delcea et al. (2023) identifies similarities in behavior between patterns of scientific productivity in the Latin American region and the world.

Regardless of growth patterns, it is noteworthy that the volume of production in a relatively new discipline reflects the interest of the scientific community in its contributions to the region. Of course, nothing compared to other sciences with topics of study more historically positioned in the area, such as Biomedical and Biological Sciences. [14]

Nevertheless, the level of strength that this discipline has acquired in recent years is accompanied by an exponential increase in the impact of its publications. The evolution of quotation

levels shows an increase for the year 2021, where 36.6% of the total of 1469 quotations achieved were received. This impact-associated pattern had an average of 293.8 appointments per year. In this case, a notable coincidence was identified between the behavior regarding the growth of citation in the region and the global in the same period, as well as in the fulfillment of a trend towards the increase of this phenomenon. We emphasize that the similarity lies in growth variables and not in pure values, since levels of international impacts differ greatly from those of the region. [10-12]

The progress of the quotations received by the works associated with the examined discipline is a demonstration of the positive increase in quality in the evaluation from external and internal factors of the scientific community itself about the research and social activity of this branch. And it is that, although currently measuring the impact of a discipline is much more complex than carrying out a quotation analysis [15], no doubt the growth of quotations received denotes a development and solidification of Neutrosophy in Latin America.

The analysis of the distribution by publication quarters also allows approximations of the impact and visibility indices associated with the performance of the scientific publication. For this reason, Figure 2 shows this behavior in the case under study, taking into account the expected years.

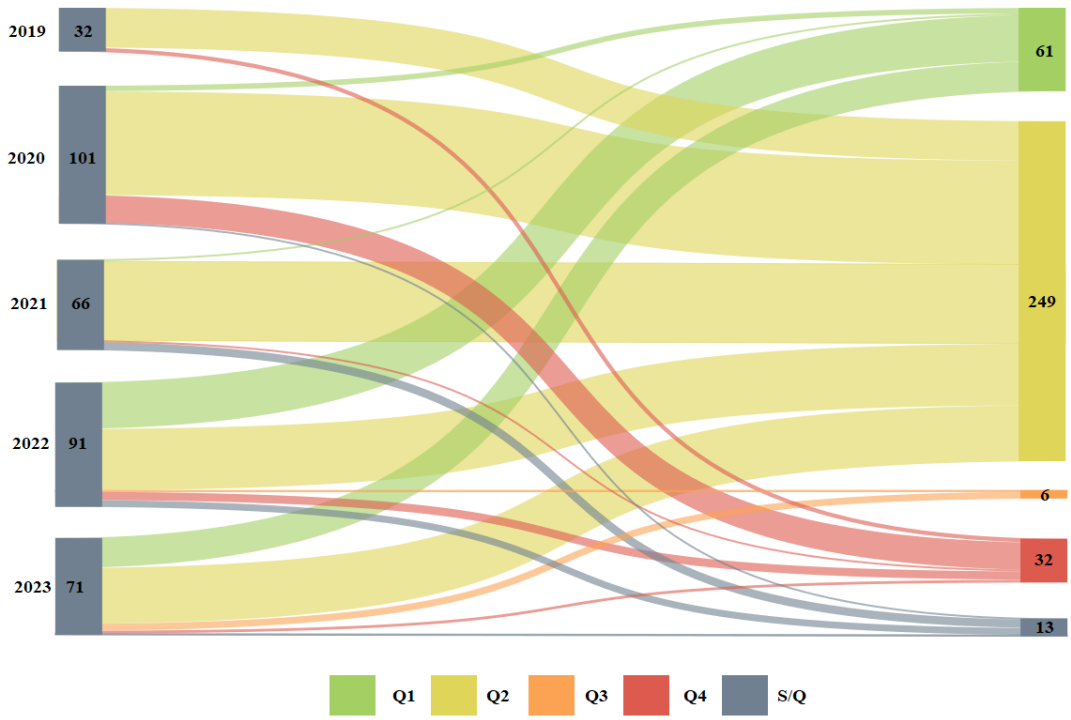


Figure 2**:** Distribution of Ndoc by SJR quartiles (2019-2023).

The highest percentage of papers 69% was published in Q2 journals, followed by 16.7% in Q1 which demonstrates that most of Latin American production on Neutrosophia was carried out in high impact sources. Similarly, it was possible to identify that this pattern was visualized to a greater extent during the last two years analyzed. Oppositely was the behavior of the items included in Q3, the year 2020 where the most work was concentrated which was decreasing over the years.

According to Zacca-González et al. (2015) publication in Q1 journals is a common pattern associated with quality of production and leadership that translates into high capacities of the

scientific potential to conduct research. In other words, the content is of greater international interest and enables the dissemination and transfer of new knowledge. [16]

In this regard, this study demonstrates the positive progress in terms of the level of visibility and quality of the publications on Neutrosophia in Latin America, reflected in the gradual and sustained positioning of more than 70% of the articles in journals of greater importance concerning their areas of knowledge.

Figure 3 provides another perspective on the performance of the publishing volume, this time analyzed from the average of Cites per Document received which generally averages about 4.33 quotes received for each published document. Again the year 2021 stands out with the highest recorded average (1,49) followed by the years 2023, 2022, and 2020 respectively. These indicators do not reach high values when compared with the international context, which shows a moderate impact at the article level. [11]

According to data consulted on the SJR portal (2024), the median of CpD in Latin America is 19.3. These values vary depending on the field of study, for example for the most published discipline in the region (Medicine) [14] there is 20.79 while for Mathematics this value drops to 7.9 quotes per document. These values are reduced even further if a sub-item such as Logic is analyzed specifically, where documents are given a median of 5.57. As we can see, these values are more similar to those identified for Neutrosophy, demonstrating that although they are not comparable to the same phenomenon internationally it is an expected value for the region.

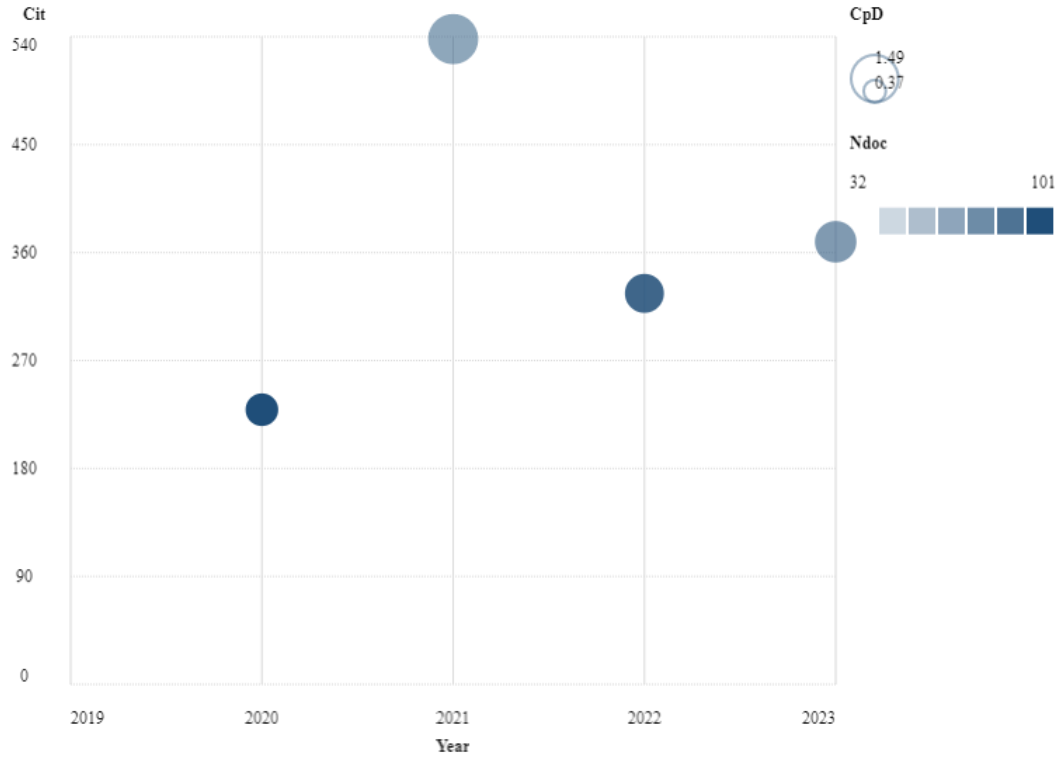


Figure 3: Distribution of CpD according to number of Cit and Ndoc published per year (2019-2023).

The largest number of documents were published in English 90.8%. This behavior shown in Table 1 is relevant, as it differs from other scientific disciplines where the publication trends in Latin America are more inclined towards the Spanish language. [17]

Table 1: Distribution and impact of scientific production according to publication language (2019-2023).

| | **Ndoc** | | **Cit** | | **CpD** | | **%Orig** | |
|---|---|---|---|---|---|---|---|---|
| **Year** | English | Spanish | English | Spanish | English | Spanish | English | Spanish |
| 2023 | 71 | 0 | 346 | 23 | 1 | 0,8 | 98,5 | 100 |
| 2022 | 87 | 3 | 281 | 45 | 0,8 | 1 | 100 | 100 |
| 2021 | 59 | 19 | 490 | 48 | 1,5 | 1 | 100 | 100 |
| 2020 | 82 | 7 | 211 | 18 | 0,6 | 0,4 | 100 | 100 |
| 2019 | 29 | 4 | 7 | 0 | 0,09 | 0,09 | 100 | 0 |
| **Total** | **328** | **33** | **1335** | **134** | **4,38** | **4,57** | **99,6** | **100** |

As expected, the highest percentages and averages of quotes and quotes for documents received were associated with English-language production. This is the language with the greatest weight in the processes of globalization and dissemination of scientific knowledge and its use implies advantages that allow for achieving a greater likelihood of generating visibility and impact. [18]

Another important indicator is the percentage of originality in research as the original articles constitute the fundamental material of scientific development and, at the same time, the main vehicle of scientific communication. [19] After its application, it resulted that the Latin American scientific production on Neutrosophy was composed of 99.7% of research that made new contributions to this scientific discipline.

Due to the recent creation of the scientific discipline, Neutrosophical Sciences are not included in any of the Scopus Subject Areas classifications. However, it was found as a result of the analysis of subjects that Mathematics was the one that concentrated the most work. It is for this reason that in the representation of the topics addressed in the documents Figure 4 you can see how 83.3% respond to this area. Nevertheless, after the analysis of the titles, summaries, and keywords it was confirmed that are Logic (81.1%), Applied Mathematics (76.3%), Statistic and Probability (63%) and Computational mathematics (56.8%) the sub-themes most dealt with within the Mathematics. In that sense, the rest of the themes analyzed that are addressed in the works studied are related to Social Science (3.4%) and Business, Management, and Accounting (3.2%).

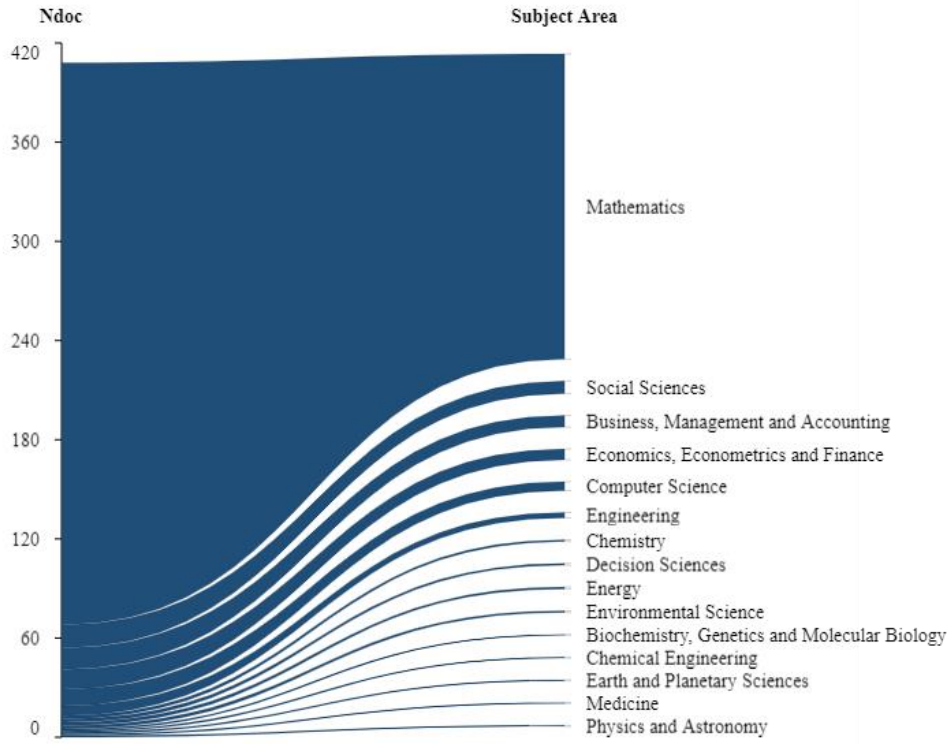


Figure 4: Distribution of Ndoc by Subject area.

Furthermore, a keyword analysis was carried out based on the co-occurrence and relationship of the terms used by the authors which can be seen in Figure 5. Pérez et al. argue that networks or graphs are the main tools for visually representing the relationships of the object studied, which are

transformed into maps of knowledge that allow the measurement of the phenomenon analyzed [20].

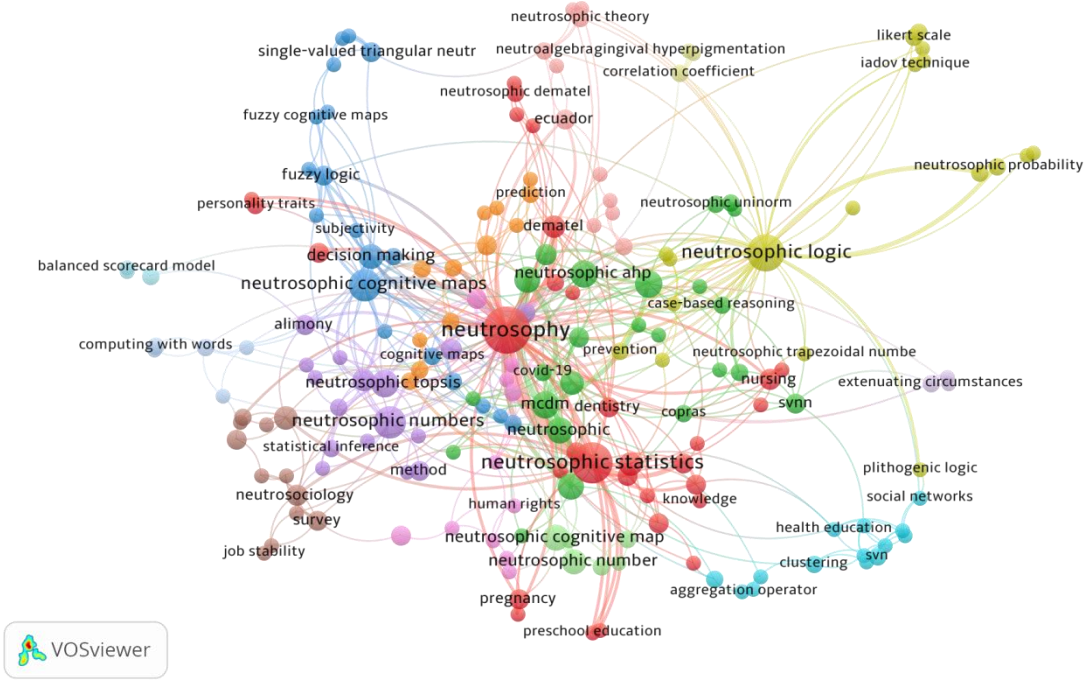


Figure 5: Co-occurrence map based on authors' keywords

Following a process of standardization and exclusion of terms based on criteria such as duplicate and unrelated words, a total of 899 items were identified. The presented co-occurrence network consists of 35 clusters, 1257 links and a total link strength of 1320. The term with the most occurrences (63) and links (101) was neutrosophy, followed by neutrosophic statistics: 31 occurrences and 58 links and of neutrosophic logic: 38 occurrences and 42 links.

This map casts results that coincide with the previous analysis because the most used terms and their relationships with higher frequencies are presented precisely in terms associated with themes of Mathematics, Logic, Statistics and Probability which represent the strongest dimensions of research within the main domain.

In this context, it is possible to delineate several zones consisting of nodes with weak links by their distance relationship with the mainstream. The words found in this case could be associated with relevant topics of Social Sciences, thus signifying a divorce between these disciplines. But this analysis is more complex and needs to be approached from another perspective.

It is that both the themes and the network of co-occurrence of keywords quantitatively show a strong tendency towards themes related to Mathematics because the very principles and statutes of Neutrosophy are based mainly on theories and concepts related to this discipline from its own conception [1, 2]. Therefore, the results obtained are inevitably observed in this way, especially if within the Scopus database itself Neutrosophic Science are not recognized as an independent discipline. That is why a rigorous analysis of the contents of the articles was carried out which produced even more conclusive results.

Within the documents classified under the domain Mathematics (340 Ndoc), let us remember that these represent 83.3% of the total, a 85.7% of articles that respond to the identification, analysis, and resolution of social problems by applying neutrosophic methods were detected. Even multidisciplinary studies were detected where several dynamic factors from other disciplines such as medicine and education are linked.

It is also identifiable a negative behavior of the authors about the use of keywords that are associated with the topics investigated, giving more protagonism to Neutrosophy, than to the very conception of the problem that they are trying to give it an answer or that are analyzing. This leads to a ghost behavior in the analysis of themes but it is important to identify them as it completely affects the analysis.

With this result, it is possible to establish a pattern that shows how the scientific production in Neutrosophy addresses social issues specific to Latin American philosophy. It is possible to state that in the Latin American regional context, the tools and knowledge neutrosophic are used for the identification, analysis and resolution of social problems which has unique approaches or distinctive contributions to the field of neutrosophy, possibly influenced by its cultural and philosophical context.

**3.2 Source analysis**

There were 10 scientific journals where Latin American production on Neutrosophia was distributed, as shown in Table 2. 27.27% of the journals are ranked in Q1, also with the same percentage in the case of Q2 and Q3 and to a lesser extent Q4 with 9,09%.

Table 2: Distribution and impact of scientific production according to source of publication.

| Source | Ndoc | %Ndoc | Q | Cit | H-Index |
|---|---|---|---|---|---|
| Neutrosophic Sets and Systems | 241 | 66,7 | Q2 | 1202 | 33 |
| International Journal of Neutrosophic Science | 56 | 15,5 | Q1 | 100 | 23 |
| Investigacion Operacional | 31 | 8,5 | Q4 | 128 | 16 |
| Universidad y Sociedad | 12 | 3,3 | S/Q | 24 | 11 |
| Journal of Intelligent and Fuzzy Systems | 2 | 0,5 | Q2 | 2 | 82 |
| International Journal of Fuzzy Systems | 2 | 0,5 | Q2 | 1 | 60 |
| Advances in the Theory of Nonlinear Analysis and its Applications | 2 | 0,5 | Q2 | 1 | 13 |
| Management Decision | 1 | 0,2 | Q1 | 1 | 126 |
| Sustainability (Switzerland) | 1 | 0,2 | Q1 | 1 | 169 |
| Process Integration and Optimization for Sustainability | 1 | 0,2 | Q2 | 1 | 18 |
| Computers and Industrial Engineering | 1 | 0,2 | Q1 | 1 | 161 |
| Gulf Journal of Mathematics | 1 | 0,2 | Q3 | 1 | 5 |

| | | | | | |
|---|---|---|---|---|---|
| Annals of the University of Craiova, Mathematics and Computer Science Series | 1 | 0,2 | Q3 | 0 | 14 |
| Asian-European Journal of Mathematics | 1 | 0,2 | Q3 | 0 | 20 |
| Yugoslav Journal of Operations Research | 1 | 0,2 | Q3 | 1 | 24 |
| Revista Cubana de Obstetricia y Ginecologia | 1 | 0,2 | Q4 | 1 | 10 |
| Axioms | 1 | 0,2 | S/Q | 0 | 33 |
| Symmetry | 1 | 0,2 | Q2 | 1 | 90 |
| Journal of Cloud Computing | 1 | 0,2 | Q1 | 1 | 44 |
| Hacettepe Journal of Mathematics and Statistics | 1 | 0,2 | Q3 | 1 | 36 |
| Expert Systems with Applications | 1 | 0,2 | Q1 | 1 | 271 |
| Iraqi Journal of Science | 1 | 0,2 | Q3 | 0 | 16 |

Concerning the impact indicators of journals, a well-known presence of sources that stand out for a higher level of quality and prestige in their areas of expertise is appreciable. This impact is seen through their H-Index where we can observe in at least 4 cases that rise to 3 digits. However, as mentioned in previous lines, sources of lower performance were also found, including two that were removed from Scopus.

The application of the Bradford Law allows for the delineation of the most quoted journals within the analyzed domain, effectively separating them from others that have had a relatively minor impact. [11,21] Its use enables a relational analysis on the dispersion between journals, articles and quotes that classifies the sources into 3 categories according to the number of published articles. Because of this, the application of this law to the set of sources obtained resulted in the core journal of the scientific production on Neutrosophy in Latin America is Neutrosophic Set and Systems(NSS). The other journals that stand out, but to a lesser extent, are the International Journal of Neutrosophic Science (IJNS) and Operational Research (IO in Spanish).

Precisely, it is remarkable that the dispersion of quotes received is concentrated mainly in NSS representing 81.8% of the total. The journal NSS from its inception emerged as a specialized journal on the subject of neutrosophy and its application in the various sciences, it focuses on the publication of original articles, has in its editorial team with the eminent pioneer professor of neutrosophy Florentin Smarandache and presents a strong revision process to its articles, all these constitute factors that favor the excellent position that the journal holds. This highlights the importance of this journal as the organ of dissemination and reference of neutrosophic thought in Latin America.

In this sense, the analysis of these sources is crucial to understanding the behavior of the publication trends and performance of the field studied. Figure 6 shows a comparison of the evolution of the annual growth of these journals and other indicators associated with impact and visibility.

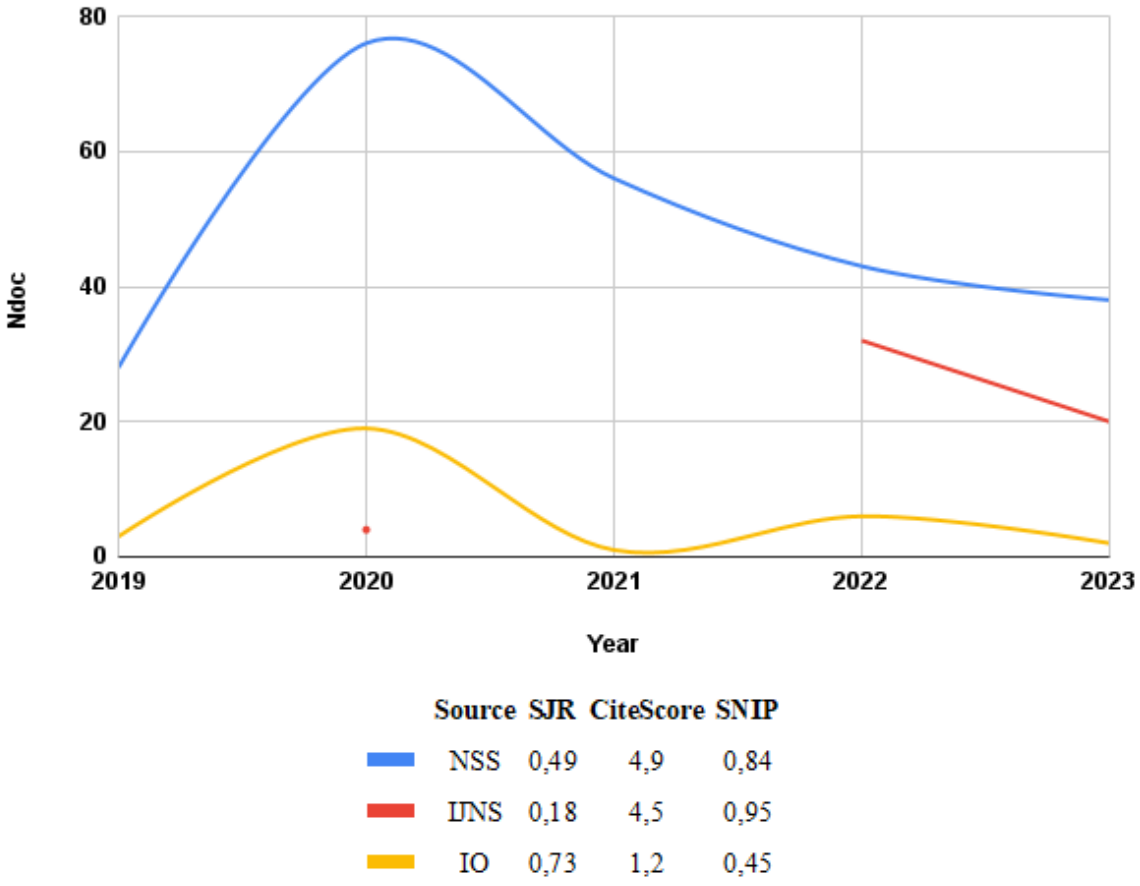


Figure 6: Annual growth of journals and other indicators associated with impact and visibility (2019–2023).

The 3 journals assume different publishing patterns in terms of volume, being notable in the image a peak of productivity in 2020 for NSS and IO however the peak in IJNS was presented in the year 2022. We can also appreciate that the IJNS starts to stand out in the same year 2022 where it assumes a greater number of articles.

As far as the impact values are concerned, we can see that there is a distribution among the journals as to the highest indicators. IO has the highest SJR, IJNS stands out as SNIP and NSS has the higher CiteScore. This not only demonstrates that the quality of the publications is internationally recognized, but can vary depending on the perspective of how it is measured.

These analyses allow us to state that the core of the production is published in sources with a medium to high impact and a high level of international prestige in their respective themes. Through this impact, the dissemination and progressive recognition of neutrosophic knowledge conceived from the Latin American region is possible.

### 3.3 Author analysis

A total of 882 authors were counted for the 361 articles found, distributed according to the number of published articles as shown in Figure 7. Similarly, authors were counted by paper resulting in a greater distribution of documents with multiple authorships. Figure 8.

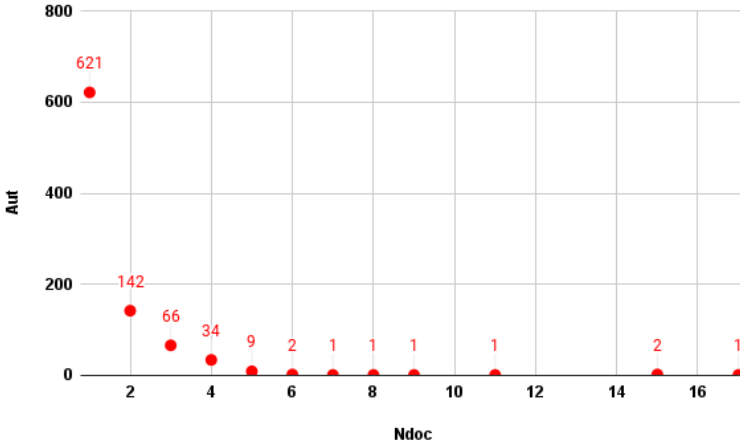


Figure 7: Document per author

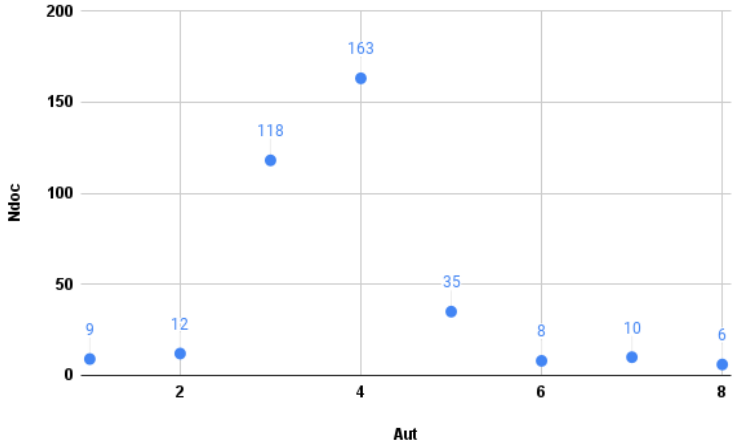


Figure 8: Author per document

Chamorro (2021) highlights in his research that multiple authorship is not condemnable and maybe the future behavior in scientific research due to this high trend in recent years. Similarly, the number of authors per document may vary depending on various factors such as the scientific discipline being investigated. [22] In that sense, and given that we have identified in this study a strong tendency towards multidisciplinary publication, it is justifiable the behavior of the author in the documentary set analyzed.

To analyze the distribution of authors according to their productivity, the Lotka Law was applied. This suggests that the number of authors (An), who publish (n) works on a subject is inversely proportional to (n2).[21, 23] On the basis of the Lotka Index, it is possible to distribute authors into three levels of productivity: small producers (with a single job or productiveness index equal to 0), medium producers (2 to 9 jobs with a productive index greater than 0 and less than 1) and large producers (10 or more jobs and productive Index equal or higher than 1) [23].

The authors were divided by productivity as follows: 4 large producers, 257 medium-sized producers, and 621 small producers. As is obvious, it highlights a group of authors who have led the production of articles in the region, and not only in terms of productivity but also regarding impact. These authors can be found in Table 3 and Table 4.

Table 3: Top 5 Latin-American authors based on number of documents and citations.

| Author | Country | Ndoc | Cit | H-Index | FWCI |
|---|---|---|---|---|---|
| Carlos Granados | Colombia | 17 | 127 | 8 | 1,29 |
| Maykel Y. Leyva Vázquez | Ecuador | 15 | 114 | 18 | 1,47 |
| Jesús Estupiñan Ricardo | Ecuador | 15 | 322 | 14 | 3,19 |
| Ariel Romero Fernández | Ecuador | 11 | 64 | 5 | 1,54 |
| Noel Batista Hernández | Ecuador | 6 | 179 | 9 | 2,68 |

Table 4: Top 5 Latin-American leading-authors

| Author | Country | Ndoc(lead) | %Ndoc(lead) |
|---|---|---|---|
| Carlos Granados | Colombia | 6 | 35,2 |

| | | | |
|---|---|---|---|
| Jesús Estupiñan Ricardo | Ecuador | 4 | 26,6 |
| Maykel Y. Leyva Vázquez | Ecuador | 4 | 26,6 |
| Noel Batista Hernández | Ecuador | 4 | 66,6 |
| Ariel Romero Fernández | Ecuador | 3 | 27,2 |

The first table shows the 5 most productive regional authors and the second table the 5 authors leading research on the subject. It is no coincidence that these names coincide in the two tables, nor is it that most of these names are associated with the ALCN. Before analyzing this relationship with this organization, it is worth noting that the above-mentioned authors present mostly very favorable indicators in terms of their levels of scientific performance.

First identified Colombian mathematician Carlos Granados who has based his production on the analysis and application of neutrosophic and mathematical methods for decision-making. This scientist also stands out in terms of leadership in the research carried out with a 35.2% performance as the lead author.

Furthermore, the rest of the researchers are closely linked to the leading and representative organization of Neutrosophic Science in the region. Based on the promotion of research and technological development from Neutrosophic theories and their applications, this partnership has been building strong academic relationships with research institutions throughout the region. Its objective is the dissemination of neutrosophic thinking but also the solution of social problems that affect the region from the science itself. Because of this, it is to be expected that the main exponents of research in this branch will be part of or linked to the ALCN as is the case of the prominent Ecuadorian researcher Ariel Romero Fernández who is acting as Research Director at a prestigious Andean university.

A co-authorship network was also developed to determine the levels of relationship between authors, enabling the identification of major associations. This map can be seen in Figure 9.

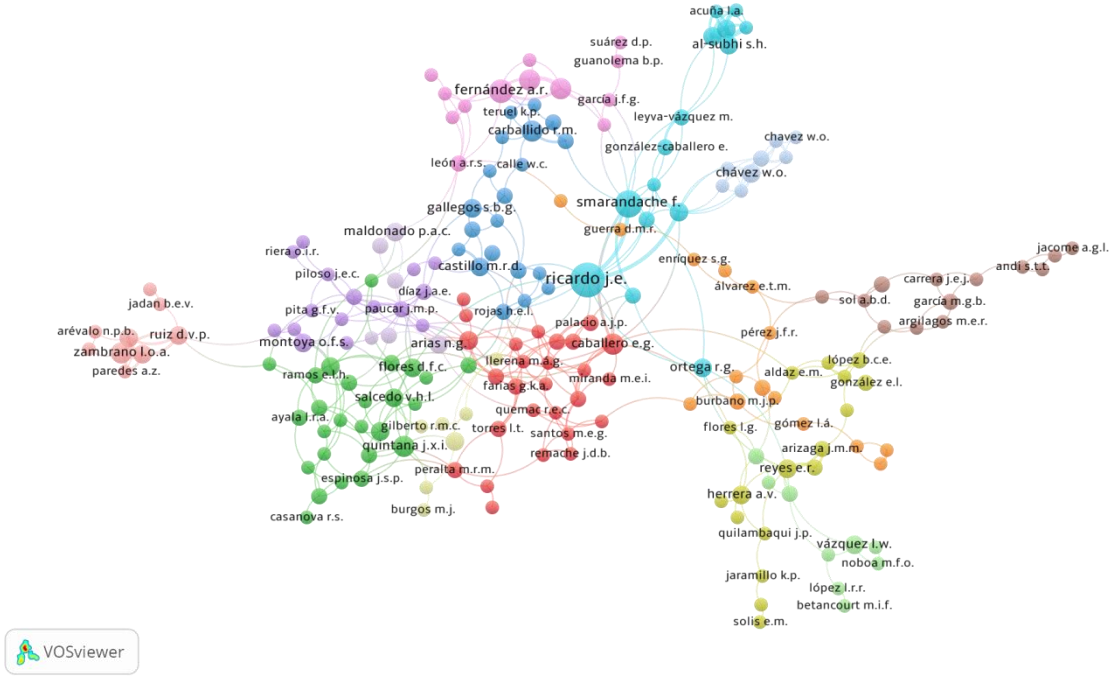


Figure 9: Co-authorship analysis network.

The group consisted of 261 authors, after which researchers with less than 2 papers and those who did not submit links with others were excluded. The final result was distributed among 14 collaborative clusters, 415 links, and 476 total link strength. The collaborative density rests with the above-mentioned researchers, reinforcing the key role played by ALCN in the region.

It is also interesting that the leading author in this branch, Smarandache F., and some other prominent exponents of Neutrosophy worldwide [11] have participated in collaborative research with Latin American authors. This shows the linkage and positioning of this discipline in the region by the international scientific community. It also shows the acceptance of the diversity of trends and fields of Neutrosophy research, and how, unlike the international context, in Latin America its study is applied primarily for social benefit. This diversity, rather than becoming a limitation to the development of science, according to the levels of relationship between authors has proven to be one of the most influential components in the substantial progress of Neutrosophic Science and their global positioning.

In this respect, Figure 9 shows the collaboration between countries according to the authors of the documents. All countries were taken into account and there were no restrictions on the presentation of these data. The network was formed as follows: 33 Items were found, grouped into 5 Clusters, and associated with 56 Link. The total link strength was 143.

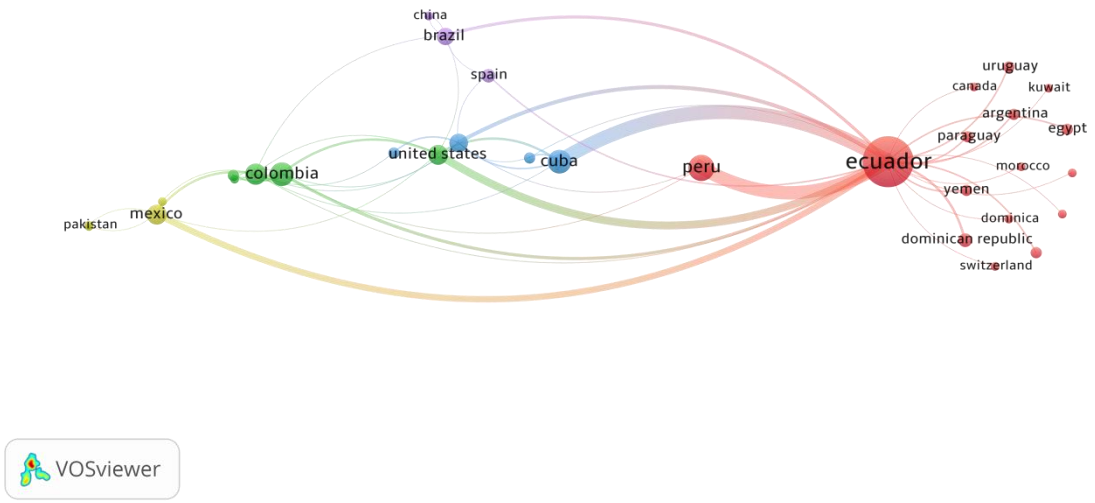


Figure 9: Country collaboration network.

The leading country in terms of documents and collaborations is Ecuador with a total of 312 articles. Ecuador acts as the "embassy" of Neutrosophy in Latin America due to the ALCN's roots in that territory. But other relevant countries could also be identified, such as Peru with 33 articles and Colombia and Cuba with 23 in each case. Collaborative links were not only detected between Latin American countries but from other latitudes, as we mentioned earlier, joint efforts were made, such as India, the United States and Spain.

These collaborations can be translated into values if %Icol measurement is applied. It is possible to calculate the annual percentage of this phenomenon which is summarized in a 31.3% overall as shown in Figure 10.

The collaboration a pattern of growth, except in 2022 when its percentage decreased considerably but recovered rapidly in the following year marking the highest value of the period analyzed. It is possible to associate this phenomenon with other results, as the levels of quotations seen earlier also declined in that same year, which may well be justified to a lesser extent by the lack of international collaboration.

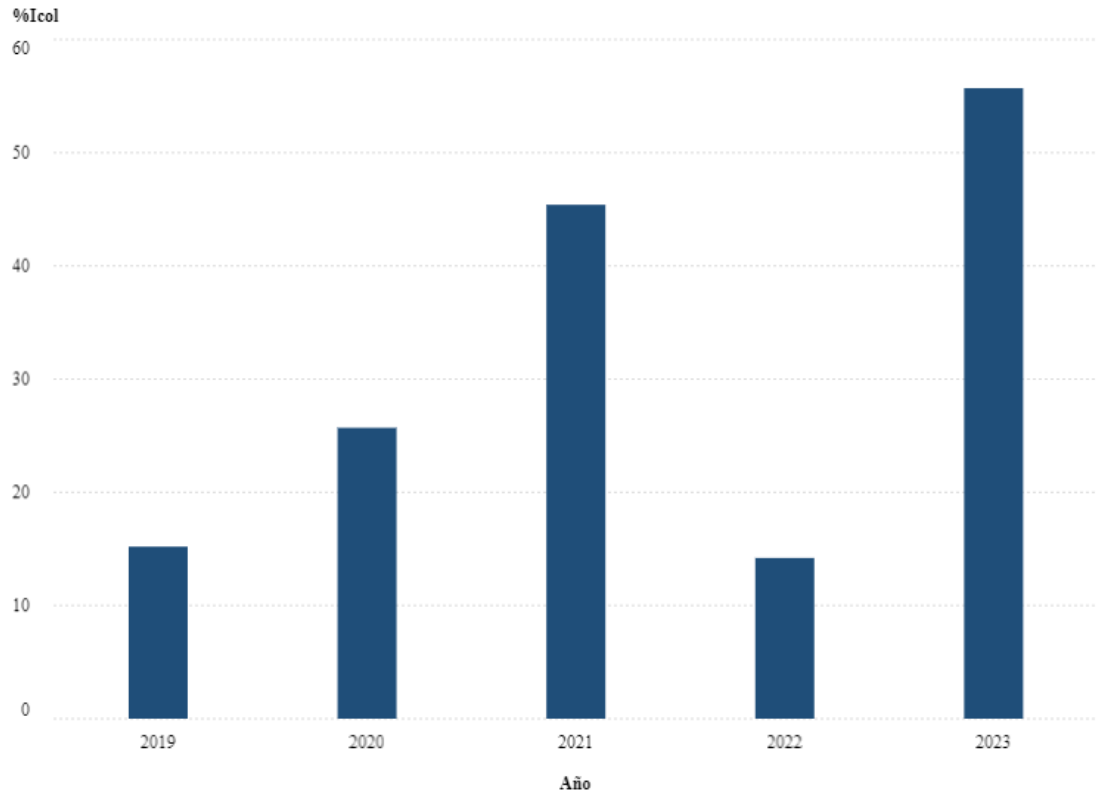


Figure 10: Evolution of annual %Icol (2019-2023).

As we explained earlier lines, Ecuador stands out for the largest share in the volume of production because it is where the ALCN officially lies. It is precisely the institutions in this country that have the highest performance in terms of research contribution, as described in Table 5.

Table 5: Top 10 Latin-American institutions based on number of documents (2019 – 2023)

| Affiliation | Country | Ndoc | %Ndoc | Cit |
|---|---|---|---|---|
| Universidad Regional Autónoma de los Andes | Ecuador | 269 | 74,5 | 1014 |
| Universidad Nacional Mayor de San Marcos | Peru | 14 | 3,9 | 28 |
| Universidad de Guayaquil | Ecuador | 13 | 3,6 | 167 |
| Universidad de Antioquia | Colombia | 10 | 2,77 | 51 |
| Universidad Técnica de Babahoyo | Ecuador | 9 | 2,4 | 111 |
| Universidad Nacional Intercultural de la Amazonìa | Ecuador | 8 | 2,2 | 4 |
| Universidad de La Habana | Cuba | 7 | 1,9 | 46 |
| Universidad Catolica de Santiago de Guayaquil | Ecuador | 7 | 1,9 | 65 |
| Universidad Politécnica Salesiana, Cuenca | Ecuador | 5 | 1,3 | 99 |
| Universidad Nacional del Centro del Perú | Peru | 5 | 1,3 | 0 |

The Regional Autonomous University of the Andes (UNIANDES) accounts for 74.5% of the total output. UNIANDES has emerged as one of the top 20 universities in Ecuador in terms of scientific impact.[24] Therefore, the commitment of this university as one of the main institutions sponsoring

Neutrosophy in the region has a positive impact on this outcome. It is also the leading institution in quotation values. As members of the ALCN the teachers and students of this house of higher studies have developed this theme in their research.

Other prestigious Latin American universities include the National University of San Marcos (UNMSM), the University of Guayaquil (UG), University of Antioquia (UDEA) and University of Havana (UH).

While the spread of neutrosophic thinking in the region is recognized, research in this field in institutions outside Ecuador is still limited, which poses a challenge to the scientific community.

## 5. Conclusions

In conclusion, we can say that the scientific production in Neutrosophy assumes patterns of behavior that vary from the international pattern associated with this topic. Mainly, it distinguishes the Latin American branch with a marked approach to the social. The application of these methods has enabled us to understand from a new perspective the individual and collective context of the region, based on neutrosophic knowledge for the identification, analysis, and resolution of social problems which is reflected in scientific research.

Although productivity levels have not increased in recent years, the impact and recognition from the international community have grown significantly, meaning the evolution of a process of transformation. The quality in the sources where these new contributions are shared is outstanding, with the publication concentrating on the main impact quarters and focusing mainly on the NSS magazine. International collaboration played a key role in the production and countries such as Ecuador, Peru, Colombia, and Cuba stand out.

ALCN is a key factor that positively influences the behavior of scientific production on Neutrsofia in the Latin American region. It has served as a means of dissemination for research in this discipline and has emerged as an agent of social change in the academic and scientific spheres. It has also contributed to the development of collaboration between the main international core of the branch and the emerging elements that are forming around the study and application of this science in the region.

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