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ORIGINAL

# Scholarly Output on Computer Networks and Communication: A Ten-Year Bibliometric Analysis in Scopus (2013-2022)

# Producción científica sobre redes informáticas y comunicación: un análisis bibliométrico de 10 años en Scopus (2013-2022)

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**ABSTRACT**

**Introduction:** bibliometrics measure the production and dissemination of scholarly scientific communication. It has been applied to analyze trends and research output in computer networking and communication.
**Objective:** to examine the global academic publications on computer networks and communications within the Scopus database during the timeframe 2013-2022.
**Method:** a descriptive observational bibliometric study was undertaken. Through the utilization of SciVal (Scopus), 1 260 446 documents were identified. The following variables were studied: number of documents (Ndoc), year of publication, annual variation rate (AVR) of the scholarly output, number of citations (Ncit), field-weighted citation impact (FWCI), type of document, author, institution, country, source, type of collaboration, subject area, and keyphrases. All data were sourced from SciVal.
**Results:** a steady increase in global scientific production was observed, with a slight decline in 2020. The five-year period 2016-2020 concentrated the highest Ncit, but the highest Ncit per document, FWCI and top 1 % most cited documents corresponded to 2013. The scholarly output studied mainly consisted of conference papers (72,9 %). Zhu Han, the French National Centre for Scientific Research (CNRS), the United States and ACM International Conference Proceeding Series were, respectively, the most active author, institution, country, and source. More than 90 % of the documents had some form of collaboration. Computer Science and Engineering were the most recurrent subject areas.
**Conclusions:** the study highlights a consistent global increase in scientific production, with distinct variations in citation metrics across years. The scholarly output was diverse in terms of document type. Collaboration, particularly international, played a pivotal role.

**Keywords:** Computer Networks; Communication; Bibliometrics; Scientific Publication Indicators.

**RESUMEN**

**Introducción:** la bibliometría mide la producción y difusión de la comunicación científica académica. Se ha aplicado para analizar las tendencias y la producción de la investigación en redes informáticas y comunicaciones.
**Objetivo:** examinar las publicaciones académicas mundiales sobre redes y comunicaciones informáticas dentro de la base de datos Scopus durante el periodo 2013-2022.
**Método:** se realizó un estudio bibliométrico observacional descriptivo. Mediante la utilización de SciVal (Scopus), se identificaron 1 260 446 documentos. Se estudiaron las siguientes variables: número de documentos (Ndoc), año de publicación, tasa de variación anual (TVA) de la producción académica, número de citas (Ncit), impacto de citas ponderado por campo (FWCI), tipo de documento, autor, institución, país, fuente, tipo de colaboración, área temática y frases clave. Todos los datos proceden de SciVal.
**Resultados:** se observó un aumento constante de la producción científica mundial, con un ligero descenso en 2020. El quinquenio 2016-2020 concentró el mayor Ncit, pero el mayor Ncit por documento, FWCI y el 1 % de documentos más citados correspondieron a 2013. La producción académica estudiada consistió principalmente en documentos de conferencias (72,9 %). Zhu Han, el French National Centre for Scientific Research (CNRS), Estados Unidos y ACM International Conference Proceeding Series fueron, respectivamente, el autor, la institución, el país y la fuente más activos. Más del 90 % de los documentos contaron con algún tipo de colaboración. La informática y la ingeniería fueron las áreas temáticas más recurrentes.

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**Conclusiones:** el estudio pone de relieve un aumento global constante de la producción científica, con distintas variaciones en las métricas de citas a lo largo de los años. La producción científica fue diversa en cuanto al tipo de documentos. La colaboración, sobre todo internacional, desempeñó un papel fundamental.

**Palabras clave:** Redes Informáticas; Comunicación; Bibliometría; Indicadores de Producción Científica.

## INTRODUCTION

Computer networks are collections of interconnected devices that enable communication and resource sharing.[1] They can be local or wide, wired or wireless, and use various protocols and technologies.[2] These networks allow computers to communicate with each other and access shared resources like databases and file servers.[3] They involve the interconnection of multiple devices and computers using communication channels like cables, routers, and switches. The purpose of computer networking is to establish a secure, efficient, and reliable communication infrastructure. Communication networks are closely integrated with computer networks, and their development is complementary. Communication technology, such as digital telephone switching, optical fiber communications, and satellite communications, plays a significant role in computer networks. The combination of computer networks and communication technology allows global communication and inspires further studies.[4,5] They allow devices and users to communicate, collaborate, and share resources. They improve productivity, efficiency, and security, and enable new applications and services.[1] Their development has enabled the deployment of exciting new areas such as Internet of Things and collaborative big data analysis.[6] Computer networks have been widely used in various industries, bringing convenient services, improving work efficiency, and enhancing quality of life.[7] The integration and connection between communication systems and computer networks have formed a complementary and mutual development, which will continue to deepen and become closer in the future.[3]

Bibliometrics is a research method used to measure the production and dissemination of scholarly scientific communication. It has been applied to analyze trends and research output in computer networking and communication. Studies have examined prestigious journals and conferences in the field, such as IEEE/ACM Transactions on Networking (TON), IEEE Communications Surveys and Tutorials (COMST), ACM Special Interest Group on Data Communications (SIGCOMM), and IEEE International Conference on Computer Communications (INFOCOM).[8,9] These studies have used metadata analysis, content-based analysis, and citation analysis to track trends, identify influential authors, institutes, and countries, and explore the growth and structure of scholarly communications in this domain.[9,10,11]

The aim of this study was to examine the global academic publications on computer networks and communications within the Scopus database during the timeframe 2013-2022.

## METHOD

A descriptive observational bibliometric study was undertaken to examine the scholarly output worldwide concerning computer networks and communications in Scopus between 2013 and 2022. Through the utilization of SciVal (Scopus), 1 260 446 documents falling within the research domain of "Computer Network and Communications" during the mentioned period were identified. This corpus of documents served as the study population. The following variables were studied: number of documents (Ndoc), year of publication, annual variation rate (AVR) of the scholarly output, number of citations (Ncit), field-weighted citation impact (FWCI), type of document, author, institution, country, source, type of collaboration, subject area, and keyphrases. All data were sourced from SciVal. The AVR was defined as the percentage increase or decrease in the Ndoc relative to the initial year of the analyzed period. It was calculated using the equation AVR = $[(Ndoc_f - Ndoc_i) / Ndoc_f * 100]$, where $Ndoc_f$ and $Ndoc_i$ represent the number of documents for the final and initial years of the analysis period, respectively.

## RESULTS

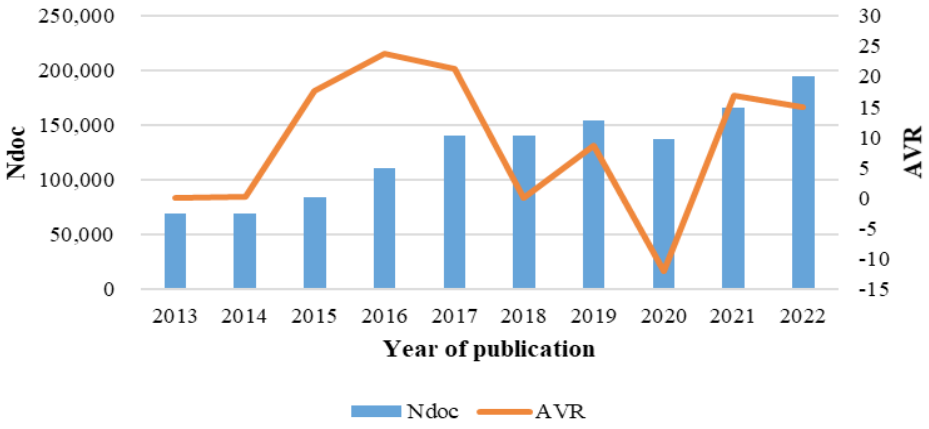



**Figure 1.** Ndoc and AVR by year of publication

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A steady increase in global scientific production was observed over the study period, with a slight decline in 2020 (figure 1).

The five-year period 2016-2020 concentrated the highest Ncit, but the highest Ncit per document, FWCI and top 1 % most cited documents corresponded to 2013. For the latter indicator, 2015 also stands out (table 1).

**Table 1.** Citation-based metrics by year of publication

| Year of publication | Ncit | Ncit per document | FWCI | Top 1 % most cited documents |
|---|---|---|---|---|
| 2013 | 757 531 | 12,2 | 1,05 | 1,4 |
| 2014 | 901 238 | 13,0 | 1,04 | 1,3 |
| 2015 | 994,847 | 11,8 | 1,04 | 1,4 |
| 2016 | 1 156 281 | 10,5 | 0,99 | 1,1 |
| 2017 | 1 402 190 | 10,0 | 0,96 | 1,1 |
| 2018 | 1 238 553 | 8,8 | 0,97 | 1,2 |
| 2019 | 1 228 456 | 8,0 | 0,96 | 1,2 |
| 2020 | 1 015 656 | 7,4 | 0,98 | 1,1 |
| 2021 | 735,042 | 4,4 | 0,93 | 1,1 |
| 2022 | 395 567 | 2,0 | 0,92 | 1,1 |

The scholarly output studied consisted of conference papers (Ndoc= 918,346; 72,9 %), articles (Ndoc= 273,312; 21,7 %), chapters (Ndoc= 21,990; 1,7 %), editorials (Ndoc= 20,762; 1,6 %), and conference reviews (Ndoc= 12,283; 1 %).

Table 2 shows the most active authors, institutions, countries, and sources.

**Table 2.** Top 5 most active authors, institutions, countries, and sources

| Name | Ndoc | Ncit | FWCI |
|---|---|---|---|
| Authors | | | |
| Han, Zhu | 658 | 14 178 | 2,30 |
| Barolli, Leonard | 583 | 2 979 | 1,04 |
| Guizani, Mohsen Mokhtar | 578 | 14,213 | 2,61 |
| Shen, Xuemin Sherman | 543 | 17 273 | 2,47 |
| Leung, Victor CM | 508 | 13 576 | 2,57 |
| Institutions | | | |
| French National Centre for Scientific Research (CNRS) | 18 180 | 159 292 | 1,03 |
| Chinese Academy of Sciences | 14 754 | 150 066 | 1,01 |
| Anna University | 14 326 | 75 375 | 0,97 |
| Beijing University of Posts and Telecommunications | 14 004 | 114 807 | 0,93 |
| Tsinghua University | 11 081 | 153 140 | 1,57 |
| Countries | | | |
| United States | 174 161 | 2 958 655 | 1,84 |
| China | 310 207 | 2 181 481 | 0,78 |
| India | 169 652 | 967 869 | 0,91 |
| United Kingdom | 52 293 | 731 166 | 1,58 |
| Canada | 33 264 | 540 566 | 1,57 |
| Sources | | | |
| ACM International Conference Proceeding Series | 82 395 | 264 085 | 0,38 |
| Sustainability | 31 582 | 353 681 | 1,03 |
| Lecture Notes in Networks and Systems | 28 151 | 38 574 | 0,76 |
| Multimedia Tools and Applications | 12 053 | 149 308 | 0,96 |
| Advances in Neural Information Processing Systems | 11 964 | 778 027 | 6,10 |

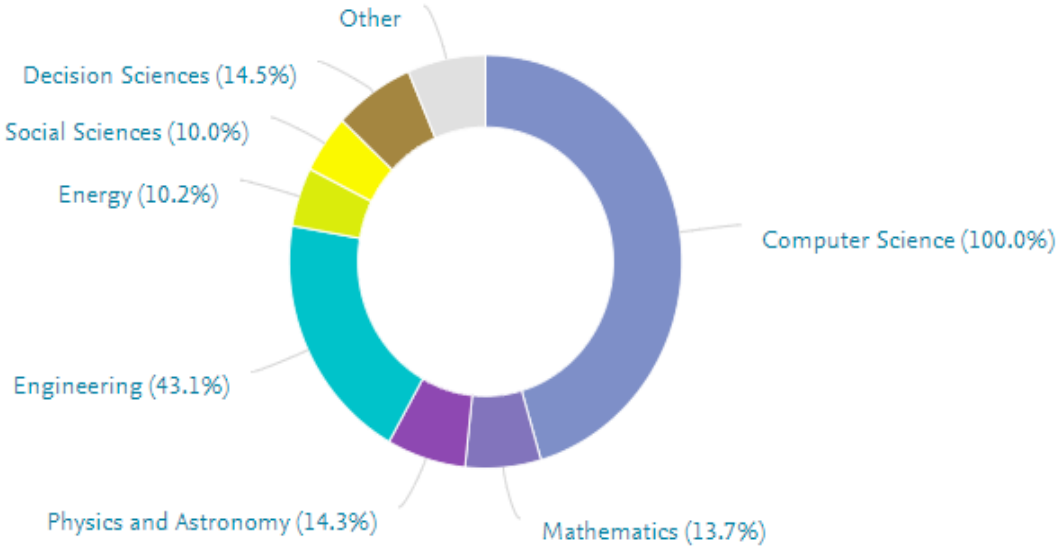
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More than 90 % of the documents had some form of collaboration. Institutional collaboration had higher Ncit and Ndoc, but was surpassed by international collaboration in terms of Ncit per document and FWCI (table 3).

**Table 3.** Types of collaboration

| Type of collaboration | % | Ndoc | Ncit | Ncit per document | FWCI |
|---|---|---|---|---|---|
| International collaboration | 17,7 | 223 373 | 3 180 659 | 14,2 | 1,55 |
| Only national collaboration | 27,1 | 342 161 | 2 549 491 | 7,4 | 0,95 |
| Only institutional collaboration | 46,9 | 591 044 | 3 732 096 | 6,3 | 0,85 |
| No collaboration | 8,2 | 103 868 | 364 115 | 3,5 | 0,47 |

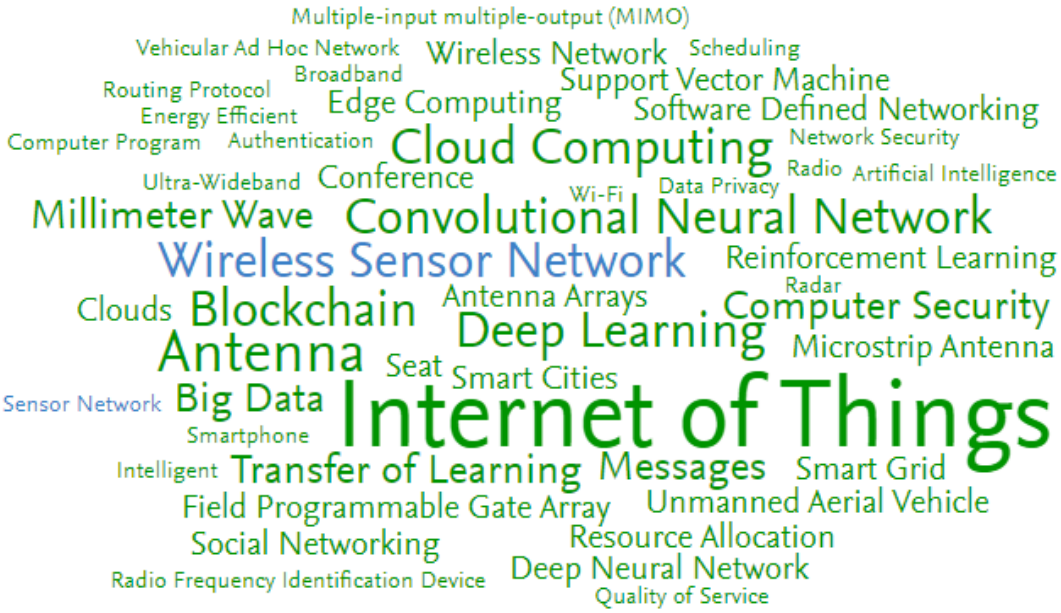
Computer Science and Engineering were the most recurrent subject areas (figure 2).




**Source**: SciVal

**Figure 2.** Ndoc by subject area

The word cloud (figure 3) depicts “Internet of Things”, “Antenna” and “Wireless Sensor Network” as the main keyphrases.




**Source**: SciVal

**Figure 3.** Keyphrase cloud according to relevance

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## DISCUSSION

Worldwide research indicates a growing output on computer networks and communication. Studies that have analyzed the growth rate, areas of research concentration, author productivity, and authorship patterns in this field demonstrate it.[12,13,14] The present study shows results that are in line with this trend.

The year 2020, which was strongly influenced by the COVID-19 pandemic, showed a decrease in scientific production. However, it is important to note that the impact of COVID-19 on scientific productivity is not binary, with differing opinions and outcomes observed. Some studies have found that the pandemic has led to delays and restrictions on research activities, as well as increased workloads from adapting to online teaching environments, which may have affected productivity.[15] On the other hand, there are reports of advantages during the pandemic, such as the efficiency of online teaching and increased funding for COVID-related research.[16] Overall, more research is needed to understand the specific conditions and outcomes related to scientific production on computer networks and communication during the COVID-19 pandemic.

Citation-based bibliometric indicators are important for assessing the quality of research activity.[17] These indicators provide quantitative measures of the impact and influence of scholarly work. They help in evaluating the visibility and significance of research outputs, both at the individual and organizational levels.[18] By analyzing citations, researchers can identify the most influential papers, authors, countries, institutions and journals in a particular field.

The CNRS (Centre national de la recherche scientifique), for instance, is a key state research organization in France that is among the world's leading national research centers. Overall, the CNRS plays a significant role in advancing scientific knowledge and addressing societal issues through research and collaboration,[19,20] and therefore its prominence in the results of the present investigation can be understood. China and the United States of America (USA) are the leading countries in scientific output, according to multiple studies. In a granular view of global scientific research, the United States and China together dominate almost two-thirds of the research publication output, with the rest of the world leading in more than one-third of publication output.[21] A scientometric study of Scopus co-publications also demonstrates a continuous rise of bilateral collaboration between the two countries, with China playing a leading role in USA-China research collaboration.[22] Additionally, China has already overtaken the USA and been the largest producer of SCI-indexed original research articles since 2018.[23] Furthermore, China-USA research outputs are mostly bilateral, with the US being more dependent on China in terms of finance and research leadership.[24] These findings suggest that both China and the USA are major contributors to global science and research collaboration. Conference papers, which were initially showcased at conferences and later modified for journal publication, differ from articles in that they typically offer original research results and undergo a more rigorous review process.[25] While it's commonly asserted that articles hold greater significance in scientific journals, the prevalence of conference papers in this study might be attributed to the prominence of sources such as *ACM International Conference Proceeding Series* (the most productive) and *Advances in Neural Information Processing Systems* (the Ncit and FWCI are higher than that of the other four sources combined).

Although international collaboration did not have the highest Ndoc, it led in terms of Ncit and FWCI. International collaboration plays a crucial role in scientific production on networks and communications. It allows for the exchange of knowledge, resources, and expertise among researchers from different countries, leading to increased quantity, quality, and impact of research activities. Collaborative efforts transcend borders and result in the formation of highly interconnected and collaborative networks, known as "invisible colleges".[26] These networks facilitate the production and diffusion of knowledge, as well as the transfer and appropriation of scientific concepts, methodologies, and theories.[27] Moreover, international collaboration enhances the centrality of scientists within their local collaboration networks, indicating their importance and influence within their respective fields.[28] Overall, international collaboration fosters innovation, promotes interdisciplinary research, and strengthens national capabilities for producing and absorbing scientific knowledge.[29]

## CONCLUSIONS

The study highlights a consistent global increase in scientific production from 2013 to 2022, with distinct variations in citation metrics across years. The diverse scholarly output, encompassing conference papers, articles, chapters, editorials, and conference reviews, emphasizes the multifaceted nature of research contributions in computer network and communications. Collaboration, particularly international, plays a pivotal role, impacting citation metrics differently. Computer Science and Engineering were dominant subject areas.

## FINANCING

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## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

## AUTHORSHIP CONTRIBUTION

*Conceptualization:* Carlos Alberto Gómez Cano, Verenice Sánchez Castillo.
*Research:* Carlos Alberto Gómez Cano, Verenice Sánchez Castillo.
*Methodology:* Carlos Alberto Gómez Cano, Verenice Sánchez Castillo.
*Writing - original draft:* Carlos Alberto Gómez Cano, Verenice Sánchez Castillo.
*Writing - proofreading and editing:* Carlos Alberto Gómez Cano, Verenice Sánchez Castillo.

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