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Intellectual Property and the Internet of Things: A Bibliometric Search

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Abstract: In recent years, there has been a significant growth in the use of embedded and nonembedded software, from the simplest to the most complex and its adoption adds benefits to innovation. Embedded systems are part of an information processor element that performs pre-programmed tasks. The objective of this study was to verify the framework of the Internet of Things (IoT) in the intellectual property. The bibliometry performed relied on the advanced consultation at Scopus and Web of Science, achieving the following results: China, United States, besides South Korea, Taiwan and Japan stood out in the production of articles to the internet of things as well as the first two were the most cited in the articles as the largest publishers of patents to IoT; there was a greater concentration of works the Engineering and Computer Science involving the technological sector. The conclusion is that China was the country that stood out when the two databases were evaluated, being ahead of the other countries in terms of technology related to IoT.

INTRODUCTION

The world is following the evolution of technology at an intense speed in several areas which results in new adaptations[1] stated that the relationship between knowledge-sharing behaviour and innovation suggests being mediated in part by absorption capacity.

The Internet of Things (IoT) can be an example of this evolution and has been enabling the communication between machines, dispensing with the direct action of man with the objective of obtaining better results as the process of automation of the stages of rural production that aims to expand the market competitiveness[2]. Other examples of Technology (IoT) can be seen in various areas and with various functions such as in the household appliances sector, means of transportation, toys, clothing (bracelets and sneakers that monitor the user's physical activity and smart watches and glasses)[3].

What is noticeable is that IoT can increasingly bring several benefits to consumers and its definition is related to how computers, sensors and objects interact with each other, processing the information in a hyperconnectivity scenario. This in turn is related to the state of communication availability of individuals at any time, a fact that results in 3 communication concepts: between individuals (P2P), between individuals and machines (H2M) and between Machines (M2M).

The use of these Internet tools will still grow a lot in the coming years, impacting on business and the paradigm shift that involves them which will require attention from

users in relation to the consequences of this new way of data processing. In this context, Brazil has been increasing the National Plan for the Internet of Things (Decree 9,854/2019) with the objective of participating more and more in this movement of connected objects, demanding actions beyond the regulation in the legal system[4].

It should be considered that a software that allows communication between the components in IoT is necessary and depending on some specific aspects, Intellectual Property allows two options: to be registered as a copyright or deposited as a patent.

Based on the above, this study aims to verify the interlacing between intellectual property and the Internet of things through a scientific bibliometry in the Scopus and Web of Science databases, besides the Brazilian Digital Library of Theses and Dissertations. It is worth mentioning that the databases used in this search are metabuscadors with thousands of indexed journals, besides books and annals of events.

Literature review

Intellectual property: Intellectual property can be defined as a set of protection rules that protect creations (copyright) and inventions (industrial law) and can be considered a genus that has species such as copyright, sub-branch of civil law and industrial property, sub-branch of business law. The rights of the author and the inventor have differences, mainly of a legal nature, since copyright protects the work itself and industrial property law protects the technique. The need to protect an invention, besides seeking to ensure economic return to its inventor or creator, stimulates innovation.

WIPO (World Intellectual Property Organization) is a United Nations agency, created in 1967 with headquarters in Geneva, Switzerland and its main mission is to enable a balanced international system of intellectual property, allowing innovation and creativity for the benefit of all.

In Brazil, the agency responsible for the protection of intellectual property is the National Institute of Industrial Property-INPI which has several attributions, among them, granting of patents, registration of computer programs, industrial designs and its mission is to stimulate innovation and competitiveness aiming at the technological and economic development of Brazil.

The legal regime for the protection of Intellectual Property at the national level is provided for by Laws No. 9.279/96 (Industrial Property), No. 9.456/97 (Cultivars), No. 9.609/98 (Software), No. 9.610/98 (Copyright and Related Rights) and No. 13.123/2015 (Biodiversity Law).

For[5], the understanding and correct use of the intellectual property system is necessary for a country, such as Brazil to be innovative. It presents the division of IP in Brazil under three axes: Copyright, Industrial Property, Sui Generis Protection, duly supported by its specific legislation.

Industrial property: Subparagraph V, of Article 10 of the Industrial Property Law (LPI) Law 9.279/96 which relates the computer program (software) itself, refers to the literal elements of its creation (source code) which are the instructions written in computer language, not being considered an invention and therefore cannot be patented.

The protection regime granted to software in Brazil is the same as that granted to literary works, i.e., registration of authorial work (Copyright Law) but in this way it is incomplete for the protection of the technologies in their entirety, since they can be easily copied through a simple change in their source code. Only programs that are created to work internally on equipment can be protected by patents that is the equipment created is the real target of the linked patent[6].

The fact that the computer program is then shipped is an indication to be considered an invention because it is associated with a product, producing technical effects of relevance to the product or good.

It should be noted that embedded systems are computer systems embedded in a complete device that are being used both in industrial applications and also in end-customer applications. This way, the embedded systems are incorporating the Internet of things.

Figure 1 presents the relationship of intellectual property for internet of things in 2 situations: embedded software, resulting in patent registration, under the tutelage of Industrial Property, provided it meets the three fundamental requirements for an invention (novelty, inventive activity and industrial application-art. 8 of LPI) and software under the tutelage of the Copyright Law.

Internet of things: IoT has presented itself as an important technology in several sectors because it provides an unprecedented change in the interaction of humans with machines[7].

The Internet of Things is a complex multi-network system, consisting of a power system combined with intelligent sensors, communication networks, artificial intelligence and cloud platform technologies[8].

Several examples of the use of IoT can be seen: Companies that can integrate processes, reduce errors and expenses, obtaining greater efficiency in their tasks[9]:

- Smart cities require reliable IoT applications as they need to operate in environments with some challenges such as hardware malfunction, battery depletion and environmental conditions[10]

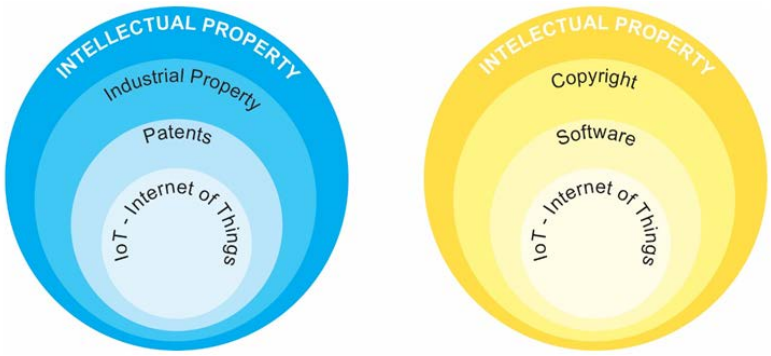

Fig. 1: Illustration of the relation of intellectual property for internet of things in 2 situations: embedded software (patents) and computer program (authorial work); researcher's illustration

- Wearable (smartphones, watches), Beacons (geolocation devices), Healthcare (Intelligent Hospitals), Energy Management, Agriculture, connected cars, supply chain and logistics

MATERIALS AND METHODS

Bibliometry was used as an instrument to evaluate and understand the performance of academic scientific production activities, extracting data limited to the period of interest, so that with its previously filtered results could be used the information perceived as necessary. The[24]presented the main criteria considered for the performance evaluation of periodicals production:

- Indicators used in the research under analysis and their origin in national or international databases
- Presence in relevant index databases
- Application of quantitative, natural and qualitative techniques

Bibliometry is a method that data can be both from the text that composes the publication and from the elements that appear "in records on publications extracted from the bibliographic database such as researcher's names, titles, sources, languages, keywords, classification and citations[11]".

The bases selected for bibliometry were Scopus and Web of Science due to their relevance in significant terms of peer indexed journals that together add a vast quantity of academic research documents, present qualitative indexes of the respective papers.

In order to complement assertives in the theoretical reference, we also used documents available from the Brazilian Digital Library of Theses and Dissertations and Google Scholar.

Search strategy at the grassroots: The same combination of keywords for Scopus and Web of Science bases was used in the "advanced search" field: ('Iot' or 'internet of thing*') and ('industrial propert*' or 'intellect* propert* or patent*) with filter for document summary. It should be noted that the asterisk (*) is a truncation character and according to its use allows the return of results with zero or with other additional characters.

Table 1: Quantitative of scientific references in Scopus databases (2009-2018) and Web of Science (2014-2020)

Database	Quantity
Scopus	169
Web of Science	21

Survey data (2020)

The information was collected on January, 21, 2020. For Scopus, the initial cut-off proposed whose period is from 2009-2018 was considered and for the Web of Science, the same period used in the previous base did not result in findings in the period from 2009-2013, so it was decided to extend the research until 2020, observing results from 2014-2020.

Outcomes: In the Web of Science database were found 21 references on the Internet of things and intellectual property (2014-2020) while at Scopus base, 169 (2009-2018), referring to the area of activity and sectors (Table 1). It can be observed that even with the amplitude of the searched period for the Web of Science database, the result was small, about 8 times less when compared to that found in Scopus.

Scopus database: The Scopus database recovered 169 scientific references related to the Internet of Things between the years 2009 and 2018. The articles analyzed data related to IoT: number of publications per year; institutes, researchers, countries, journals that have published the most; profile of the documents; institutions that financed the most publications; thematic areas that publish the most scientific articles.

Figure 2 shows the temporal evolution of scientific publications on the Internet of Things. A discrete growth

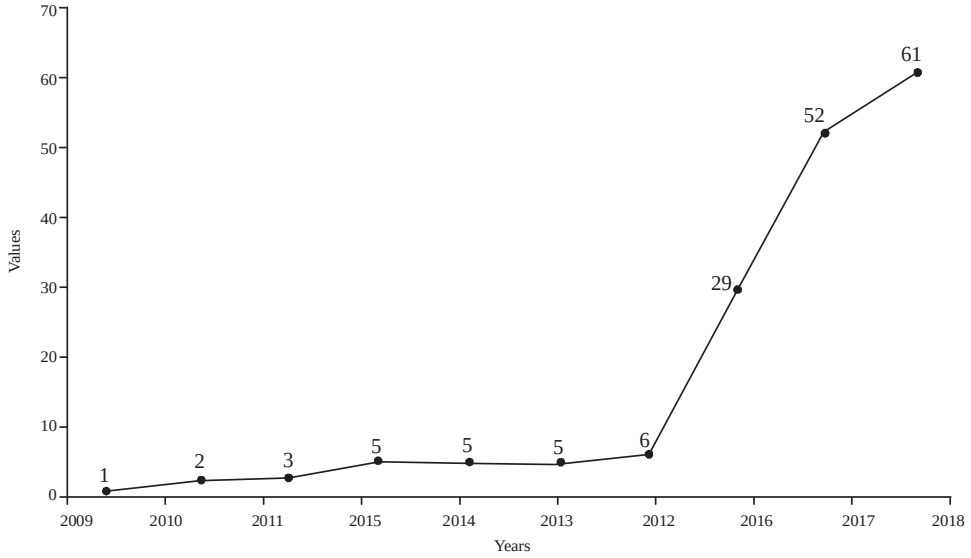

Fig. 2: Time evolution of scientific publications on the Internet of things in the period between 2009 and 2018 at Scopus. Adapted Scopus

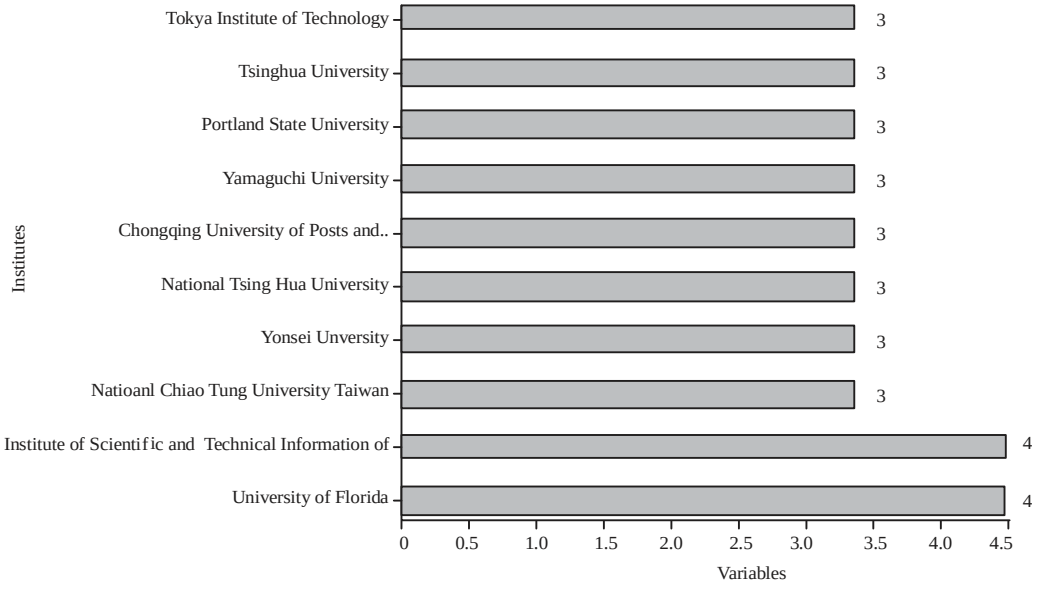

Fig. 3: Institutes that have published the most scientific documents related to IoT-Scopus (2009-2018). Adapted Scopus

is observed from 2009-2012 but from this last year there was a considerable increase, reaching 61 publications in 2018 which is equivalent to 10 times more than there was in 2012.

Figure 3 shows the institutes that publish most scientific documents related to IoT over the selected period: Tokyo Institute of Technology, Tsinghua University, Portland State University, Yamaguchi University, Chongqing University of Posts and Telecommunications, National Tsing Hua University and Yonsei University with 3 each; Institute of Scientific and Technical Information of China University of Florida with 4. The researchers who published most were: T. Daim, D. Cao and C. Bakirtzis, 2 patents each while the rest, composed by C.V. Trappey, A.J.C Trappey, Y. Takano, M. Takahasi, N.J. Sheikh, Y. Ohtsuka and Y. Kajikawa, 3 which shows that there is not much prominence among them (Fig. 4).

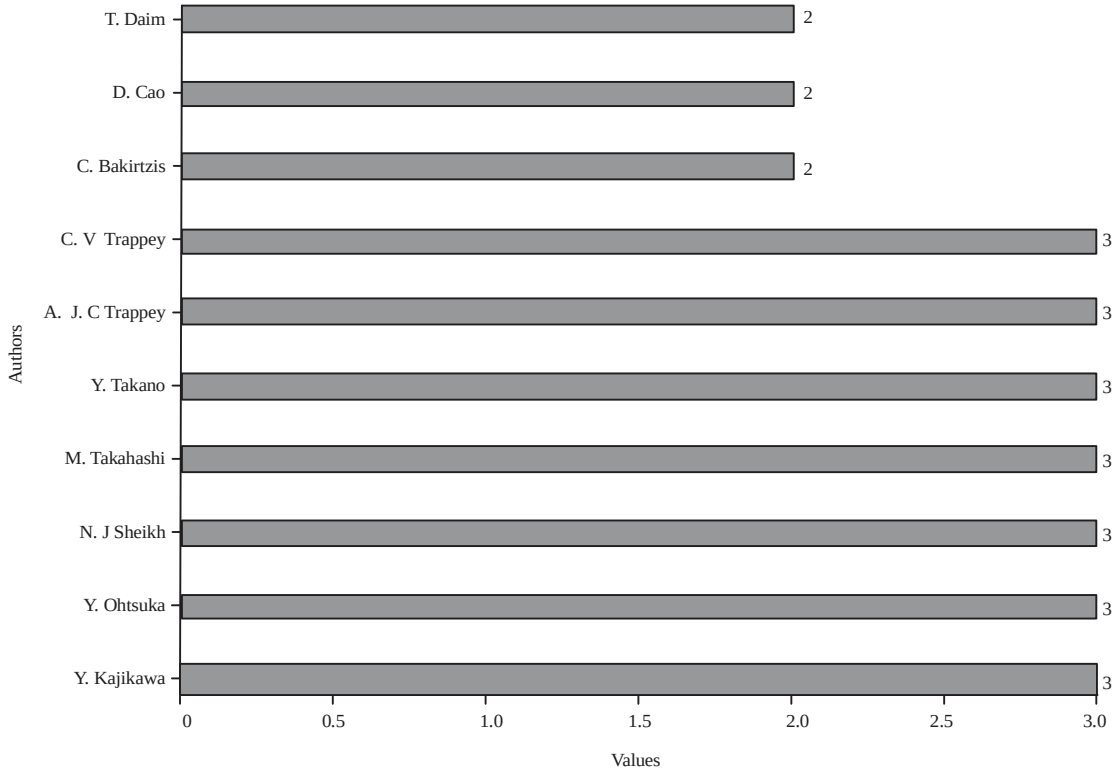

Fig. 4: Researchers who have published more scientific documents-Scopus (2009-2018). Adapted Scopus

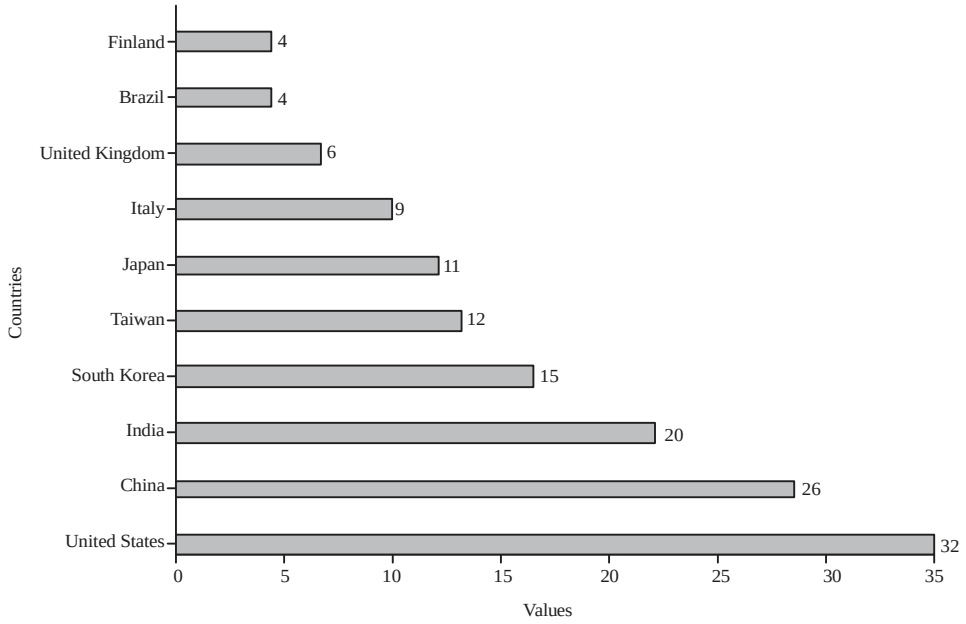

Fig. 5: Countries that have more published documents-Scopus (2009-2018); Adapted Scopus

Figure 5 shows the most published countries: Finland and Brazil (4), United Kingdom (6), Italy (9), Japan (11), Taiwan (12), South Korea (15), India (20), China (26) and the United States (32). The most used document profiles for publishing the articles were in book format with 3

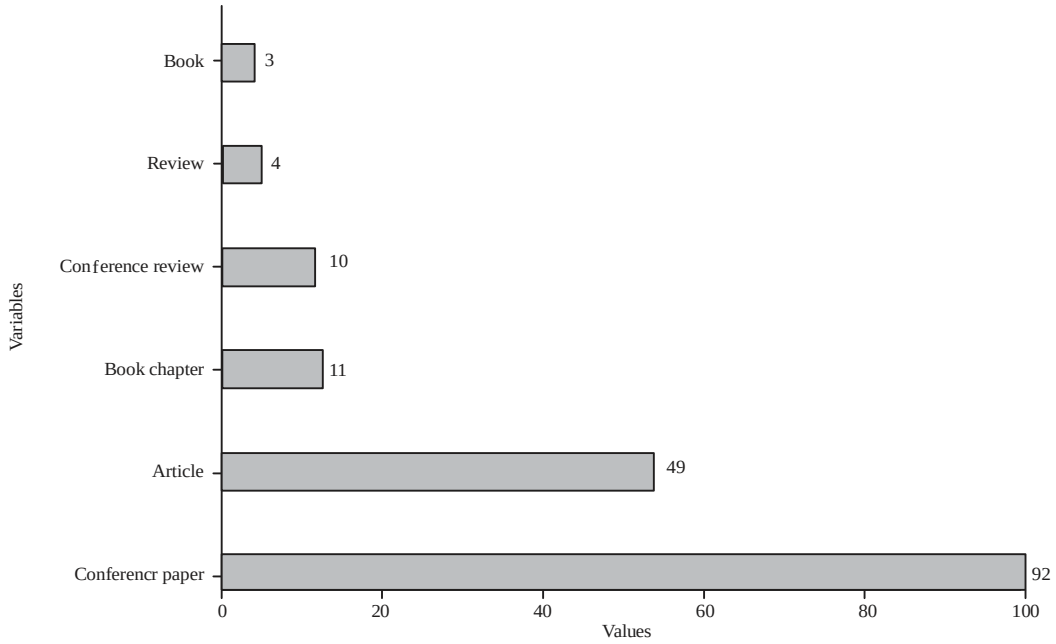

Fig. 6: Profile of the most used documents to publish articles in IoT-Scopus (2009-2018); Adapted Scopus

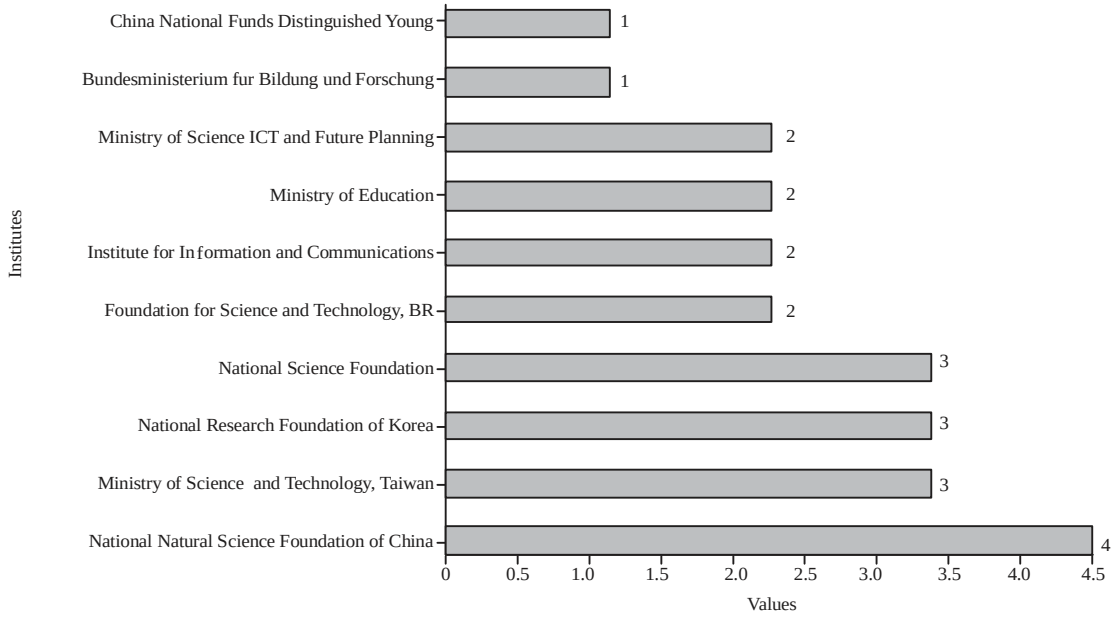

Fig. 7: Most Funding Institutions for Scientific Documents-Scopus (2009-2018); Adapted Scopus

quantities, revision (4), conference revision (10), book chapter (11), articles (49) and conference articles (92) (Fig. 6).

Figure 7 shows the institutions that have funded the most scientific documents: China National Funds for Distinguished Young Scientists and Bundes ministerium für Bildung und Forschung (1 each); Ministry of Science ICT and Future Planning, Ministry of Education, Institute for Information and Communications Technology Promotion and Foundation for Science and Technology (2 each), National Science Foundation, National Research Foundation of Korea and Ministry of Science and Technology, Taiwan (3 each) and finally, National Natural Science Foundation of China with 4 financed documents.

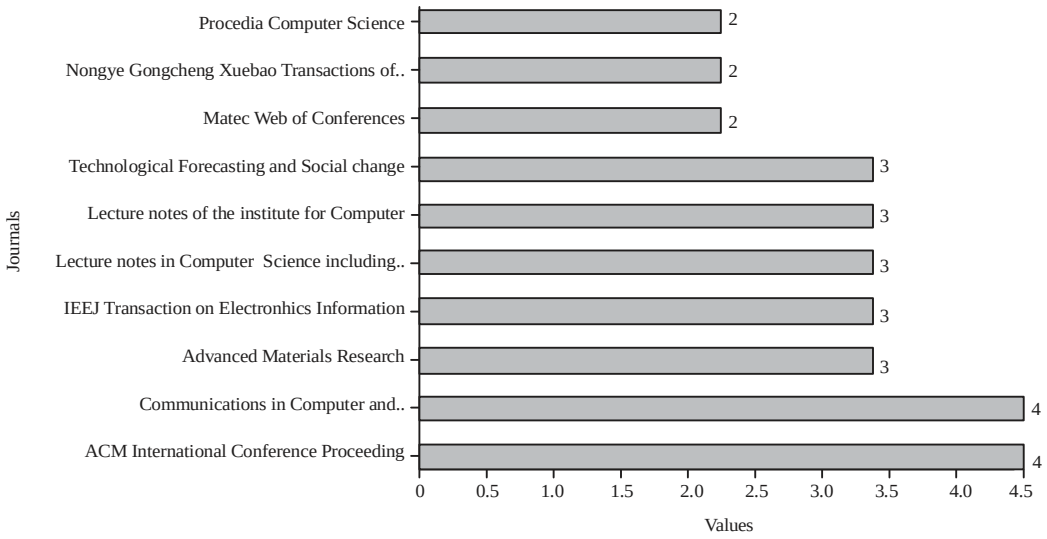

Fig. 8: Journals that have published the most scientific documents-Scopus (2009 a 2018); Adapted Scopus

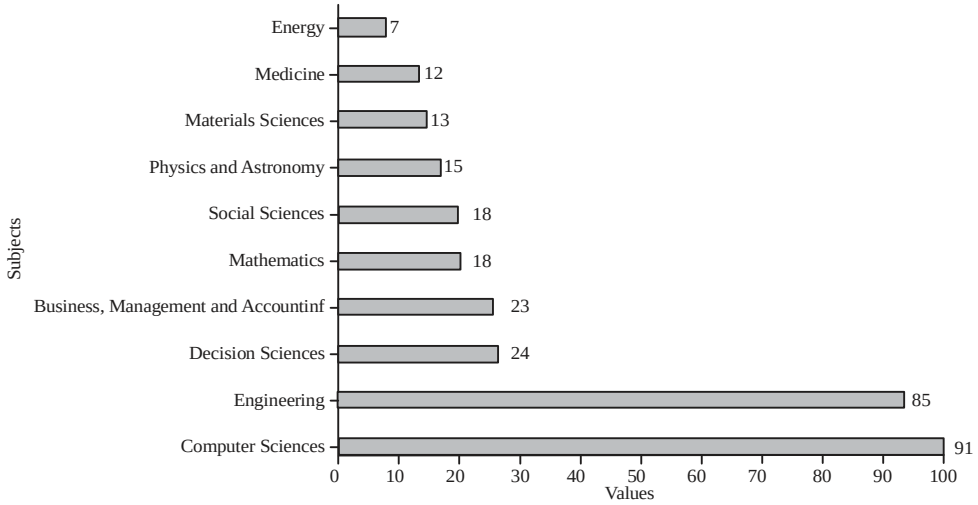

Fig. 9: Thematic areas most used for patent filing-Scopus (2009-2018); Adapted Scopus

The institutions that published the most periodicals in the Scopus database from 2009-2018 carried between 2 and 4 publications (Fig. 8): Proceeded Computer Science, Nongye Concheng Xuebao Transactions Of The Chinese Society Of Agricultural Engineering and Matec Web of Conferences with 2 publications each, followed by Technological Forecasting And Social Change, Lecture Notes Of The Institue For Computer Sciences Social Informatics And Telecommunications Engineering Lnicst, Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics e IEEJ Transactions On Electronics Information and Systems (3 each), Communications In Computer And Information Science and ACM International Conference Proceeding Series (4 each).

Figure 9 shows the most widely used subject areas for scientific publications in the area of IoT: Energy (7); Medicine (12); Material Sciences (13); Physics and Astronomy (15); Social Sciences (18); Mathematics (18); Business, Management and Accounting (23); Decision Sciences (24); Engineering (85) and finally, Computer Sciences (91).

Web of science database: Web of Science is a multidisciplinary basis developed by Thomson Scientific-Institute for Science Information (ISI). It is a source of bibliographic data to assess the relationship between researchers, institutions, states, areas of knowledge and countries of selected articles.

Figure 10 shows the categories with the most publications: Probability Statistics, Regional Urban

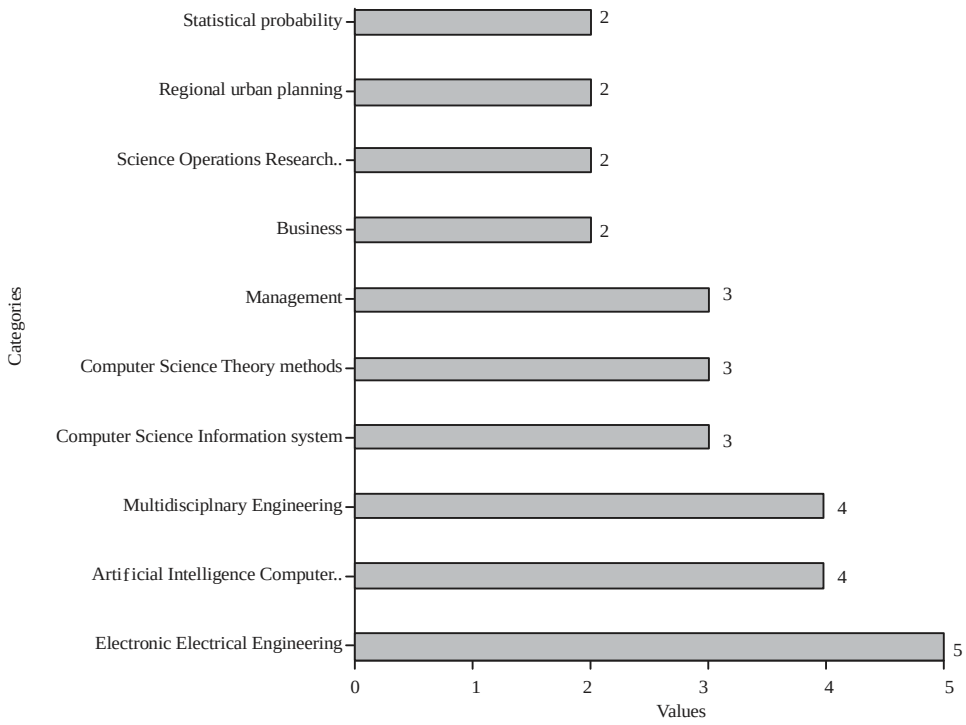

Fig. 10: Categories with more publications-Web of Science (2014-2020); Adapted Web of Science

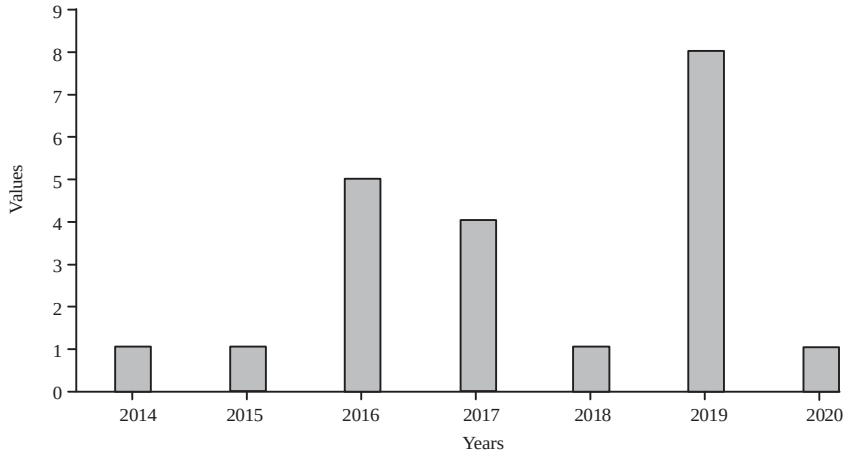

Fig. 11: Documents published per year-Web of Science (2014-2020); Adapted Web of Science

Planning, Operations and Business Research Management with 2 publications each; Management, Computer Science Theory Methods, Computer Science Information Systems (3 each); Multidisciplinary Engineering and Artificial Intelligence of Computer Science (4 each); Electronic Electrical Engineering is the area with most publications, 5.

The years 2014 and 2015 had the lowest level of documents published per year on the Web of Science: 1 document; however, in 2016, 5 documents were registered, a pace that was followed the following year, despite a drop to 4 documents. However, in 2018 only 1 publication was registered but in the following year, in 2019, there was a significant increase in document registrations, being the year with the highest number of published documents, 8. In 2020, for the time being, there is only 1 document published (Fig. 11-14).

Figure 12 shows the most commonly used types of documents: Review (1), Article in press (2), Conference Papers (6), Article (14).

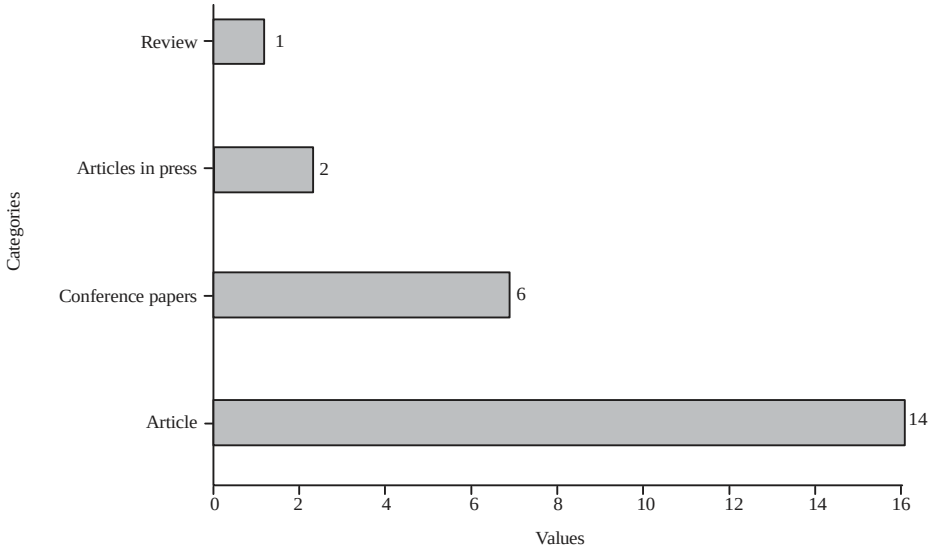

Fig. 12: Most used document types-Web of Science (2014-2020); Adapted Web of Science

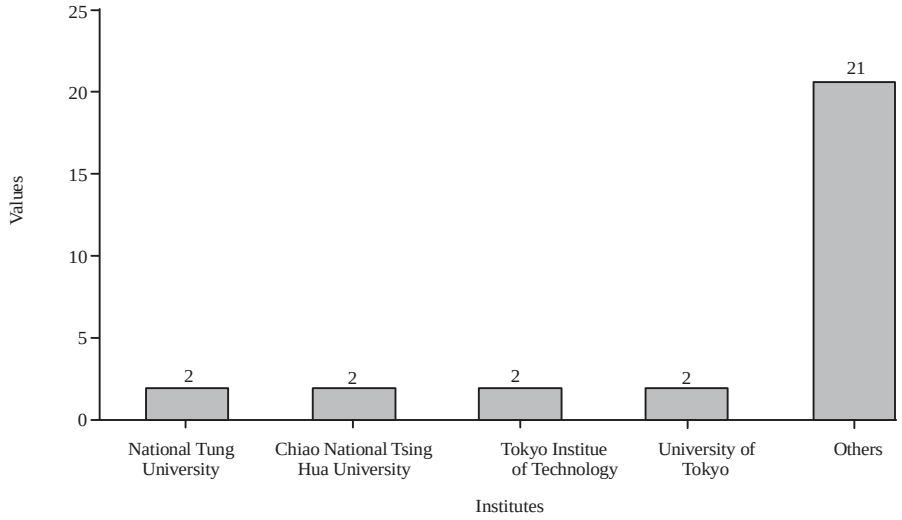

Fig. 13: Publishing organizations-Web of Science (2014-2020); Adapted Web of Science

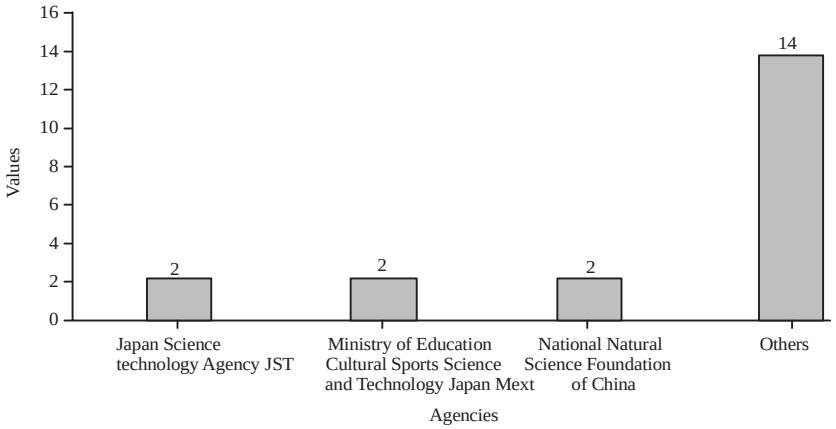

Fig. 14: Financing Agencies -Web of Science (2014-2020); Adapted Web of Science

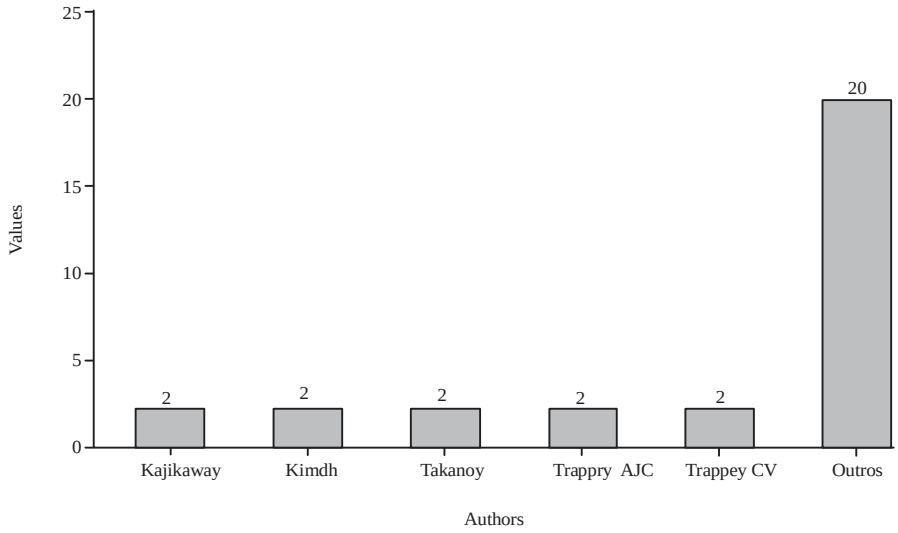

Fig. 15: Most cited researchers-Web of Science (2014-2020); Adapted Web of Science

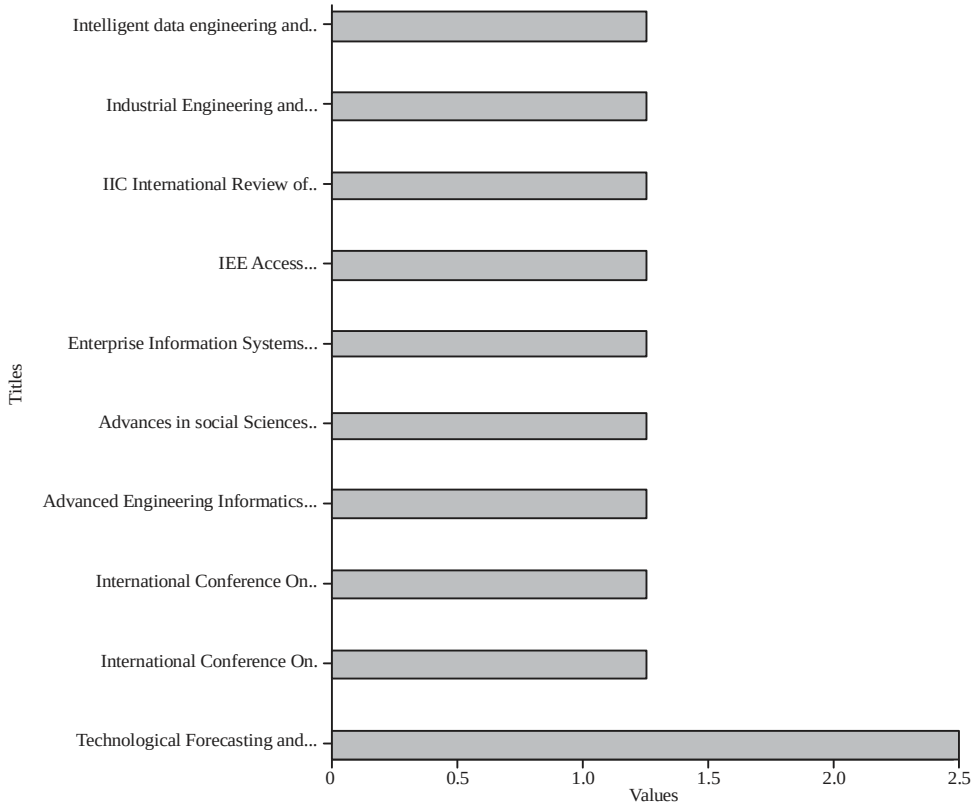

Fig. 16: Source Titles-Web of Science (2014-2020); Adapted Web of Science

National Chiao Tung University, National Tsing Hua University, Tokyo Institute of Technology and University of Tokyo, each organization has 2 published articles but it can be observed that there are other institutions, not informed with a total of 21 published articles (Fig. 13-17).

Figure 14 presents the most prominent funding agencies: Japan Science Technology Agency JST, Ministry of Education Culture Sports Science And Technology Japan Mext, e National Natural Science Foundation of China, each one financed 2 articles. The other funding agencies, 14 articles.

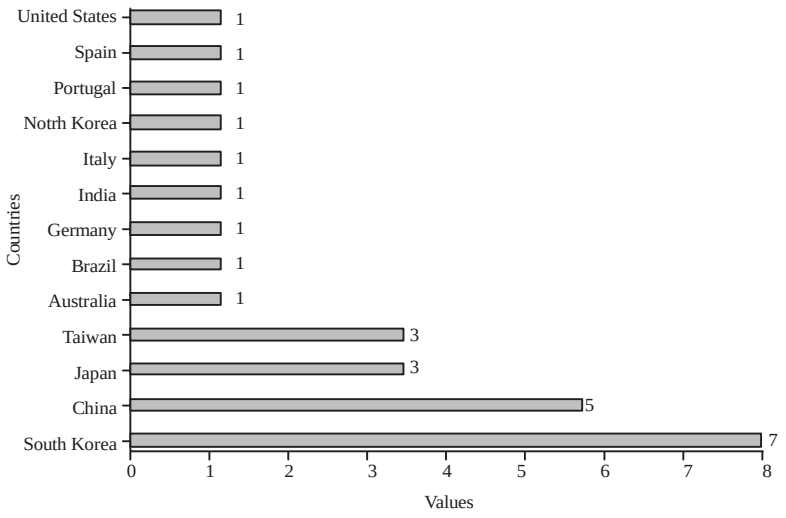

Fig. 17: Countries leading in article publications-Web of Science (2014-2020); Adapted Web of Science

The most cited researchers on the Web of Science in relation to the research conducted are presented in Fig. 16: Y. Kajikawa, D.H. Kim, Y. Takano, A. J .C. Trappey and C.V. Trappey, 2 citations each. The other quotations were not identified (20).

Figure 15 presents the titles of the most cited sources: Technological Forecasting and Social Change leads as source of 2 titles. The rest has only titles with 1 source.

The countries on the Asian side lead in the article publications, South Korea with 7 publications; China, 5; Taiwan and Japan, each with 3. The rest of the countries have only 1 publication each (Fig. 17).

RESULTS AND DISCUSSION

Comparing and analyzing the two databases, Scopus and Web of Science, one can notice a growing evolution of scientific publications regarding the Internet of Things over the years with emphasis on 2018 and 2019, respectively, despite the different quantity of scientific documents in each one (Table 2 and 3).

Among the Institutes that have published the most documents by country, China is common for both bases, but the United States also appears in Scopus and South Korea for Web of Science. In the category of authors, China has published the most (Scopus) and the most cited (Web of Science).

The study was the most used type of document for publication in both bases as well as the areas that published most, Engineering and Computing[5] stress that in an increasingly connected society, technologies are emerging that have an impact on all areas of knowledge. Among the inventors who publish the most articles about IoT, the Chinese are in the top positions worldwide. This position is likely to result in financial investments in education and technology for education, based on the understanding that technological means enable more creative and disruptive modes of learning.

As for the origin of the periodicals that publish the most articles on the subject are from the United States (ACM International Conference Proceeding Series) and Germany (Communications In Computer And Information Science).

Final considerations: Based on the two bibliometric surveys, the main centres originating from IoT-related technologies were identified with the United States, China, South Korea and investment in R&D standing out. Brazil does not present a relevant number of articles and IoT technologies, considering the limitations of the research, but it demonstrates that it has begun to establish important regulatory measures that bind the country to this technological agenda such as Decree No. 9,854/2019, which establishes the National Plan for the Internet of Things.

Among the technological areas in which there are more publications, the exact sciences, Engineering and Computing, prioritizing machine-machine communication with systemic and intelligent interaction and with little or no human interference, stand out. This is also related to the connectivity aspect which is an essential factor for IoT.

The possible emergence of an independent embedded software market could happen more quickly in sectors where standardization occurs most effectively. In this scenario the Internet of things is already present in embedded systems in the form of industrial property.

Table 2: Summary of results found in Scopus database in relation to the internet of things

Descriptions	Results
Number of references	169
Annual evolution of the number of publications	Most in 2018
Most published institutes/country	China and USA
Most published authors/country	China
Countries that have published the most	USA and China
Mostused documents	Conference article
Most funding institutions/country	China
Most published periodicals	ACM International Conference Proceeding Series (USA) and Communications In Computer And Information Science (Germany)
Areas that have deposited most Researchers	Computing and Engineering

Table 3: Summary of results found in the web of science base in relation to the internet of things

Descriptions	Results
Number of references	21
Categories with more publications	Engineering and Computing
Number of documents published per year	Most in 2019c
Most used documents	Article
Publishing organization/country	China and Japao
Financial Agencies	China and Japao
Most cited authors	China
Top Publishers/Country Authors	South Koreaand China

CONCLUSION

The results presented in this study contribute to the knowledge and direction of future research to the journals that obtained more articles on the subject of intellectual property and the Internet of things, favoring the understanding and improvement of scientific production in the area.

LIMITATIONS

This study is limited to the databases analysed and their temporality. Further, studies on the subject are suggested with greater amplitude in other databases for the verification of a new scenario or confirmation of this one.

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