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CLOUD COMPUTING AND FIRM PERFORMANCE: A BIBLIOMETRIC ANALYSIS

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Abstract

The emergence of Cloud Computing has led to a revolution within the field of Information Systems due to the benefits of the pay-per-use model as a powerful source of increased competitiveness. One of the factors that have conferred the most impetus to this type of Cloud service is the reduction of costs. The aim of this study is to compile information on the most relevant studies considering the other key factor in the development of these solutions: the impact that Cloud Computing has had on Firm Performance wherever it has been implemented. For this purpose, the most productive and influential sources were identified, analyzing data from the general Web of Science Database until the year 2023. In this way, authors, countries, entities, and journals with the highest levels of productivity and influence were identified, and the most relevant and influential papers were determined. The final objective of this study was to open a line of research that is built from the conclusions of the most relevant and influential sources of information in this field of study. The main takeaway of this study is the increasing interest that researchers have in the interrelation between Cloud Computing and Firm Performance, identifying the most relevant and influential sources of information that may help future researchers develop this research line. As a general conclusion, this study shows that the most productive and influential authors, institutions and sources are based in India, China and the United States

Keywords: Cloud Computing; Firm Performance; Bibliometrics.

JEL Classification: L86, M00, M15

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1. INTRODUCTION

The research carried out in this study is based on a motivation to delve deeper into the effect that the use of Cloud Computing can have on Firm Performance. One of the drivers of company productivity is Innovation and the development of resources that improve Firm Performance. In the search for sustainable paths to achieve this, it is understood that Cloud Computing technologies may be the most efficient method. In a world immersed in an unstoppable process of digital transformation, where competitiveness is key to survival (Stankovic et al., 2021), it is key for companies and countries to adapt their main productive and administrative processes to digitalization, in which Cloud Computing provides a considerable competitive advantage (Gupta et al., 2023). This line of research aims to begin, through the present work, with the identification, through a bibliometric study, of the most relevant research focuses in this subject.

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1.1. Cloud Computing

Cloud Computing is a model for using Information Technologies (IT) as a service that is increasingly accepted by IT professionals and functional users. Cloud Computing is defined as "a model that allows on-demand access over the network to a set of shared and configurable resources (such as networks, servers, storage capacity, applications and services) that can be quickly allocated and released with minimum management by the service provider" (De Parga, 2011). This system, based on pay-per-use, does not require an initial investment in fixed assets (which would later have to be amortized) with the consequential savings in costs and the elimination of entry barriers to the IT necessary for the performance of the activity/ business. In addition, it provides companies with a scalability that allows them to add/reduce usage capabilities based on the requirements of each moment (Srinivas et al., 2012). Cloud Computing has become one of the services in Information and Communication Technologies (ICT) with the greatest degree of penetration, not only in the field of domestic use, but also and in a key way in the business field (Gupta et al., 2023). The use of technology provides the necessary power for Information Systems (IS) to have the capacity to provide decision makers with the relevant information they need in a timely and reliable manner (Berman et al., 2012). Technology has quickly and powerfully adopted a management model based on Cloud services (Malik et al., 2018). Hung (2019) demonstrates that although this technology seems to be exclusive to highly technological and technical companies, there are certain industries that have taken advantage of it to modernize and deal with the challenge of digital transformation. Specifically, the sectors with the greatest penetration have been education as a service (EaaS), logistics as a service (LaaS), and manufacturing as a service (MaaS).

1.2. Innovation

From a business point of view, any company that wants to survive in the market is obliged to invest in management models that improve productivity and innovation in its five dimensions (processes, products, marketing, administration and services), which is key to improving Firm Performance (Gil-Gomez et al., 2020). Abbaset al. (2024) establish a clear link between technology, innovation and firm performance through the mutual relationship that each of these variables has with productivity, constituting the fundamental pillars for the success of production and management processes in the search for business excellence and the achievement and improvement of competitive advantage. As seems to be intuitive, a priori the use of technologies based on the Cloud Computing model should induce improvements in the Firm Performance of the companies that put it into practice (Malallah et al., 2023). However, it has been demonstrated on many occasions that the impact of using certain business management systems does not necessarily lead to improvements in performance, which depends on certain success factors (Vicedo et al., 2020).

1.3. Object and scope

The present bibliometric study aims, given the rise in the use of Cloud Computing in all areas but especially in the business sector, to identify the most relevant studies on the relationship that Cloud Computing has with the improvements in Firm Performance that companies require to be successful in an increasingly dynamic, changing, technical, and

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competitive business world. In order to obtain the maximum possible information, the entire available period of data regarding reference publications was analyzed, specifically for the years 1900-2023, using proven reference methodologies (Lazarides et al., 2023). The objective of this study is to locate and quantify the productive relevance (measured in number of publications) and influence (measured in number of citations) that each author, entity, journal, etc. has had since the beginning of publications related to this topic until the present (year 2023 completed).

The following sections present a review of the most relevant previous studies regarding Cloud Computing and Firm Performance, as the basic variables of this study. Likewise, a review of the literature on the basic concepts of the bibliometric analysis technique is presented. After a description of the methodology used, the results and conclusions of the study are presented.

2. THEORETICAL BACKGROUND

In the phase prior to carrying out the study, it was essential to contextualize the key factors. In this case, the most relevant, recent literature was reviewed considering the two main factors of the study (Cloud Computing and Firm Performance), as well as the methodology used in the study (Bibliometrics). Following a thorough initial investigation, no studies were found in which the two proposed variables (Cloud Computing and Firm Performance) were part of the core of the research, specifically in the field of how the adoption and use of this type of computing impacts the results and performance of companies. Therefore, the main contributions in both areas were reviewed separately. The best support for research starts from the effective and crucial point of contextualizing both factors. Therefore the most relevant key points obtained from the literature review carried out in both areas are presented below.

2.1. Cloud Computing

Srinivas et al. (2012) defines, in terms of the basic concepts of what Cloud Computing is, how this type of management and use of technology is based on the concept of a service provider for the use of management technologies, typically Information Technologies and Communications (ICT), which users access through remote connections and usually on a pay-per-use basis. Bokhari et al. (2016) defines three types of Cloud service, which are defined, in increasing order of available functionality for the user, as: Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS).

Among the most relevant advantages provided by the ICT Cloud management system is the absence of a need for initial investment in fixed assets (with the consequent elimination of entry barriers to the use of these technologies) and the scalability and flexibility of adaptation of the contracted resources to the circumstances and needs of the user (Srinivas et al., 2012). Access to this type of use of ICT has become widespread in recent decades in areas of both domestic use (for office applications and entertainment) and for professional areas, not only in the business production area but also in education and corporate in general (Gupta et al., 2023).

Kaur & Singh (2015) raise certain challenges that may lead to reluctance when adopting this model of process automation, among them, those that could lead to a decrease in the

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security of data management, the psychological factor of loss of trust in control over the company's internal management system, and finally, adaptation to the legislation on intellectual property, data protection and legal custody of sensitive company information. In this sense, Saini et al. 2022 reflect on how legislation has been adapting to this computing model, whose benefits in terms of accessibility, scalability, and performance improvements make this model key in improving the competitiveness of companies. Likewise, the cultural factor is no longer an obstacle to the adoption of this management model, from the moment that those responsible for the processes that are automated in the Cloud verify that not only is there no loss of control, but that instead, security and reliability are gained by delegating the management of versions and security patches of the applications hosted in the Cloud, which are provided by the manufacturers.

The most recent studies, given the growing adoption rate of this type of access to technology, no longer only analyze the computing power and ease of access to this type of solution, but also address the benefits of using them in terms of improvements in the performance and therefore in the productivity of ICT solutions hosted in the Cloud (Malallah et al., 2023). These studies also predict that this trend is not only consolidated in the present, but that it shows clear signs of continuing to grow in coming years, both in capacity of use, and in the diversification of areas and types of services, as well as in security, and the reliability of the systems made available to users (Taleb & Mohamed, 2020).

2.2. Firm Performance

De Loecker & Goldberg (2014) established that the development of resources to improve Firm Performance is one of the key factors in the competitiveness of companies in today's business world. This is because the globalized market permits customers and companies universal access to information and entry to delocalized and highly dynamic markets, causing companies to constantly strive to find new ways to maintain their competitive advantage, which cannot be achieved without investing in innovation and improvements in productivity and efficiency in all areas, both internal and external. Technology is key to improving firm performance through innovation in all its dimensions (Gil-Gomez et al., 2020).

Huang and Lin (2005) determined that the variables that influence the calculation and estimation of the Firm Performance variable in study models are highly complex due to the difficulty of generalization to different business areas, but it does give rise to, in line with relationship marketing theories, establishing some basic principles to outline this concept of business efficiency: increased customer loyalty, more effective marketing, improved customer service and support, and greater efficiency and cost reduction.

The development of actions in search of better Firm Performance is therefore one of the most efficient ways to guarantee the sustainability of a company's productive model, not only in terms of permanence in the market (through the maintenance and improvement of its competitive advantages) but also in terms of environmentally sustainable production and service models (Ramos et al., 2022; Wang et al., 2023b).

2.3. Bibliometrics

We can find the first definition of bibliometrics focusing on the use of this discipline in the 1980s, leaving the concept open for further development (Broadus, 1987). This initial

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concept was updated by Bar-Ilan (2008) from the general perspective of informatics, reporting that the Internet improved the scope of these studies. Recently, Lazarides et al. (2023) established that bibliometric analysis "represents a new tool for classifying and quantitatively assessing bibliographic material (publications, citations, authors, institutions, etc.) of a scientific discipline", adding that "these analyzes are increasingly accepted in the medical literature to identify the most influential papers/authors/institutions on a given topic". In the past decade, there has been a remarkable increase in the number of published bibliometric analysis articles, being one of the first stages in the opening of new lines of research, even more so in the field of research related to the use of new technologies whose development is so dynamic that locating the foci of greatest interest and influence is essential (Kalantari et al., 2017).

Bibliometric studies have been used in multiple areas of scientific research, with a large initial deployment in the area of accounting, but with multiple derivatives and new areas, especially technological (Guerola-Navarro et al., 2020) and also in areas related to economic themes highly linked to sustainability and new forms of financing in increasingly dynamic and complex environments (Gil-Gomez et al., 2021). Bibliometric studies have also had a widely recognized focus on enterprise information management (Donthu et al., 2022), which is one of the management areas with the greatest relevance in the search for improvements in the performance of companies that are successful in today's changing and challenging business world. Ribeiro-Navarrete et al. (2021) clearly show the relevance of bibliometric studies that combine the relevance of factors such as information management (Donthu et al., 2022), with new ways of managing financing and entrepreneurship such as crowdfunding (Gil-Gomez et al., 2021), all aimed at improving firm performance.

Wang et al. (2023a) establish that bibliometric studies are generally facing more and more challenges in the assessment of sustainability factors, which are key in the environment of social and business awareness about the Sustainable Development Goals (SDGs) of the United Nations (UN) in its 2023 agenda (Mori et al., 2019). In this line, the study of technologies such as Cloud Computing emerges as an anchor for companies that have in mind the reduction of the use of physical and logistical components in the field of their own technological management (Kumar & Buyya, 2012), greatly justifying measuring the usefulness of the study carried out here.

3. RESEARCH OBJECTIVE, METHODOLOGY AND DATA

Lazarides et al. (2023) define bibliometric analysis as "a new tool for classifying and quantitatively assessing bibliographic material (publications, citations, authors, institutions, etc.) in a scientific discipline", focusing on the use of this type of study as the basis on which to develop new lines of research. The identification of the authors, institutions, etc. that are most productive and influential in a certain area, means that researchers can create a specific knowledge database of the most relevant and influential studies on which to build their new line of research.

With this bibliometric study, a quantitative analysis was developed to identify where the most active and influential research focus is located related to the relationship between the use and deployment of Cloud Computing solutions and the Firm Performance of the company or entity where the Cloud solution is located. This type of quantitative analysis

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is based on the quantification of the number of publications, the number of citations and the "h" impact index associated with the authors, sources, institutions and countries that have published scientific articles closely related to this topic. The present study uses the quantitative analysis method described in the literature review section corresponding to Bibliometrics as well as in this Methodology section. This is a literature review quantified in terms of the number of publications, the number of citations, and the impact indices (h-index and 5 year impact factor) most recognized in scientific literature as quality indices. The research structure is therefore as follows: after an initial selection of the database (the Web Of Science in the All Databases category in this case) and the search filters, the productivity and influence of each source was quantified according to knowledge related to the field under study (in this case "Cloud Computing" and "Firm Performance"). Below are a series of reference tables with this information, which is discussed in order to obtain executive conclusions.

Regarding the parameters that determine whether a bibliometric study is of sufficient quality to be representative, there is some agreement that the most relevant are (Podsakoff et al., 2008):

- the productivity of each research source, estimated from the number of publications by the authors, institutions and countries.
- the influence of authors, institutions and countries, estimated from the number of citations they have.
- the third index used is the "h" index, which combines the number of citations with the number of publications (Hirsch, 2005).
- finally, the five-year Impact Factor is considered to determine the relevance of the publication.

In order to carry out this study, the following research structure was used (Gil-Gomez et al., 2021):

1. Initially, the topic of study, the period to be analyzed, and the key words that define the topic in all its extension, generality and particularities are chosen.
2. Subsequently, the database is chosen in which the literature is analyzed, classified and quantified based on its productivity (number of publications) and its influence (number of citations).
3. The results obtained are shown below (publications that meet the chosen criteria)
4. In the next step, the results are classified according to the criteria set by the bibliometric methodology recognized in the field of scientific research.
5. Finally, the conclusions are defined in terms of identifying the most productive approaches (with the highest number of publications) and the most influential (with the highest number of citations).

In the first phase of this study, initiating an investigation into the impact that the use of Cloud Computing has on Firm Performance, these two expressions were chosen as the key words that determine the conceptual scope of the study, and it was determined that since the use of Cloud Computing is relatively recent, the entire time period available up to now should be used.

Regarding the second point, the raw data for this study were obtained from the **Web of Science (WOS) database**, owned by Thomson and Reuters. It is one of the most recognized databases worldwide in terms of scientific publications, both in the number of publications and the number of citations and impact indices. Giving a unit to each author,

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institution, journal and country, for each publication registered in the WOS, this paper aims to give an overview of the most productive and influential authors, institutions, and countries in our field of study (the relationship between Cloud Computing and Firm Performance). In this case, trying to cover the maximum possible results related to the scope of study undertaken, the search string chosen was:

- TOPIC: cloud computing (Topic) and firm performance (Topic), which are the main axis for the intended research line to be developed
- Time span: 1900-2023, which covers all the tracking history
- Database from Web of Science (WOS): All Databases, trying to cover the maximum possible scope

With these search criteria, 344 results were obtained. To avoid duplications and documents of less scientific relevance, only the following document types: Articles, Reviews, and Letters were taken into account. Therefore, the search was refined through the refine option "DOCUMENT TYPES: (ARTICLE OR REVIEW ARTICLE OR LETTER)", a total of 273 results were thus obtained, which were those that were analyzed and quantified in terms of the productivity and influence of each research source.

In the next section, the results obtained through the use of this query based on reference data are presented, to later present the most relevant conclusions.

4. RESULTS AND DISCUSSION

In this section, the journals, articles, authors, institutions and countries are presented, organized by categories of sources, which are the most productive research focuses (with the greatest number of publications), and the most influential (with the greatest number of citations), as well as a temporal evolution in terms of interest in the topic (measured by the number of citations and publications).

4.1. Publishing Journals

Firstly, we analyzed the productivity (measured by the number of publications referring to the topic of this study) and the influence (measured by the number of citations, also referring to the topic under study) of each of the journals that have published articles in this area. These results are shown in Table 1. The rank was constructed based on the number of publications.

Table 1. Most Influential Journals. Source: own research

Rank	Name	h-index	TC	TP	TC/TP	>100	>50	>25	>10	IF (2022)	5-IF
1	SUSTAINABILITY	7	180	11	16.36	0	1	3	5	3.9	4
2	INTERNATIONAL JOURNAL OF INFORMATION MANAGEMENT	9	758	9	84.22	3	5	8	9	21	19
3	JOURNAL OF ENTERPRISE	3	109	9	12.11	0	0	2	2	6.5	6.4

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	INFORMATION MANAGEMENT										
4	INTERNATIONAL JOURNAL OF PRODUCTION ECONOMICS	5	395	8	49.38	1	2	2	3	12	11
5	ANNALS OF OPERATIONS RESEARCH	4	216	6	36.00	1	1	1	3	4.8	4.6
6	INDUSTRIAL MANAGEMENT & DATA SYSTEMS	6	120	6	20.00	0	0	2	5	5.5	6.4
7	BENCHMARKING-AN INTERNATIONAL JOURNAL	4	64	5	12.80	0	0	1	1	5.6	4.9
8	IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT	4	44	5	8.80	0	0	0	1	5.8	5.8
9	INFORMATION & MANAGEMENT	5	143	5	28.60	0	1	2	4	9.9	10.7
10	INTERNATIONAL JOURNAL OF LOGISTICS MANAGEMENT	5	465	5	93.00	2	4	4	4	7.5	7.4
11	MANAGEMENT DECISION	3	103	5	20.60	0	1	2	2	4.6	5.9
12	TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE	5	273	5	54.60	0	2	5	5	12	12

Abbreviations: R = Rank; Name = Name of the journal or source Title; h = h-index; TC = Total Citations; TP = Total Papers; TC/TP = ratio total Citations per Published Paper; >100, >50, >25, >10 = number of papers with more than 100, 50, 25, 10 citations; IF = Impact Factor 2018; 5-IF = five-year Impact Factor 2022.

To create this table of results, among the journals that have published articles meeting the parameters of this study, those that have 5 or more publications were identified (the rest of the journals, which have only 4 or fewer publications, were not included in this table).

First appears "SUSTAINABILITY", which has the most publications, which may be due to the fact that the corporate purpose and rationale of the journal is to collect studies focused on Sustainability, a key factor as an advantage of Cloud Computing (due to the use of initiatives such as those of GreenIT) and one of the dimensions of Firm Performance (as indicated in the literature). All the journals identified have a small number of publications in this area, the highest number being 11.

Regarding the number of citations, the one with the highest was "INTERNATIONAL JOURNAL OF INFORMATION MANAGEMENT", followed by "INTERNATIONAL JOURNAL OF LOGISTICS MANAGEMENT" and "INTERNATIONAL JOURNAL OF PRODUCTION ECONOMICS", the latter two with just over half the number of citations compared to the first. It was also found that there were very few articles with more than 100, 50, or 25 citations.

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Finally, it was observed that in terms of the TC/TP ratio, it was "INTERNATIONAL JOURNAL OF LOGISTICS MANAGEMENT" that had the most, followed by "INTERNATIONAL JOURNAL OF INFORMATION MANAGEMENT" and "TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE".

The last two columns show the Impact Factor of each journal in 2022 and as a more comprehensive measure the Impact Factor over five years, factors that show the relative importance of each journal in the field of research.

4.2. Evolution of published articles

The next analysis, once we reviewed which journals or sources were most relevant in this study, was that of the temporal evolution of the number of publications and the number of citations referring to this topic. Specifically, Figure 1 shows the annual number of citations, and Figure 2 shows the annual number of publications.

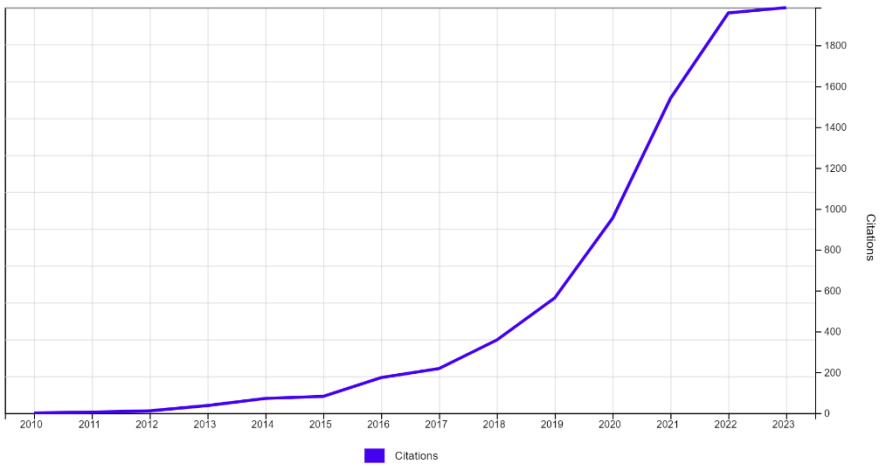

Figure 1. Number of Annual citations. Source: Web of Science.

In Figure 1, the annual evolution of citations shows a progressive growth trend, which accelerates until it becomes exponential starting in 2019. Following the trend, it can be seen that in the last year of the study (2023) a total of 2046 citations are reflected, exceeding the 1958 citations of the previous year 2022, showing a slowdown in the growth trend of previous periods.

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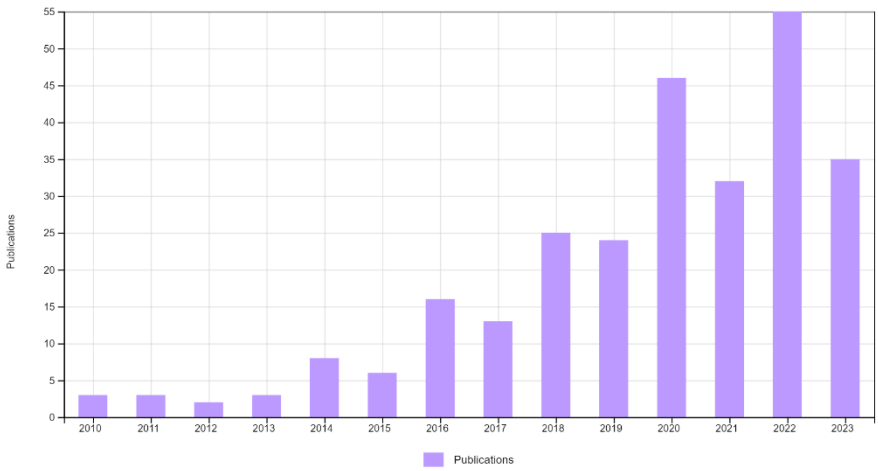

Figure 2. Number of Annual publications. Source: Web of Science.

Figure 2 shows that publications on the topic under study appear from 2010 onwards. The annual number of publications follows a very curious pattern of evolution, rising one year and falling the next, but in such a way that it remains, however, above the level of previous years (except for the immediately preceding year). The growth trend is progressive; it does not show large jumps between consecutive values. The year with the highest number of publications was 2022 with 55 publications, also with a very high number of citations (1958).

Overall, both figures show the novelty of the topic as an object of study, with the first studies being very recent and in no case having high productivity and influence metrics. The immaturity of this research area explains the progressive growth that gives it a highly positive potential derived from the always increasing trends of both graphs (with the curious up-down pattern of the number of annual publications).

Table 2. General citation structure. Source: own research

	All time		2019 - 2023	
Citations	Number of papers	% Papers	Number of papers	% Papers
> 500 citations	1	0.373	1	0.529
> 200 citations	5	1.866	1	0.529
> 100 citations	14	5.224	5	2.646
> 50 citations	38	14.179	13	6.878
<= 50 citations	215	78.358	173	89.418
Total	273	100.000	193	100.000

The study is completed with Table 2, which shows the quantitative distribution of the number of publications, classified by the range of citations obtained within the period

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considered. Two different time ranges are presented, an initial one with the entire study period (All time), and a second one considering only the last 5 years (2019-2023), which are those in which the number of citations begins to grow exponentially. The paper with the most citations (727 citations) was published in 2019 ("Building dynamic capabilities for digital transformation: An ongoing process of strategic renewal"). Another notable conclusion is that only 20 publications (about 7.4% of the total) from All Time have more than 100, 200, or 500 citations, which means that approximately 92.6% of papers have 100 or fewer citations.

4.3. The most influential articles

The bibliometric analysis that was carried out consisted of reviewing the articles under study, focusing this phase of the study on ordering these articles from greatest to least number of citations, so that the most influential articles in this field of research were identified. The objective of this analysis was to identify the articles that aroused the greatest interest among researchers, and that therefore were reviewed the highest number of times and cited the most, therefore being considered the most influential.

In this case, the first 25 papers in terms of number of citations were chosen, which represented approximately 10% of the total papers. Table 3 shows that the first article in the ranking had twice the number of citations compared to the second article, which is very close to the third and fourth, and the fifth is further away (with just over a third of the citations of the first).

Among the 25 most cited papers, two journals stand out with 3 papers: "INTERNATIONAL JOURNAL OF INFORMATION MANAGEMENT" and "INTERNATIONAL JOURNAL OF LOGISTICS MANAGEMENT" (the rest of the journals have 2 or fewer papers). At a quantitative level, among the 25 most cited papers, reviewing the years with the highest number of papers published, it is observed that there were 4 papers in 2016, 4 papers in 2018, and 5 papers in 2020.

Finally, using the relative ratio of number of citations per year, the highest ranked article appears twice as often as the fourth ranked article (which appears in second place in citations per year), and almost triple that of article rank 2 (which appears in third place).

Researchers starting any new research project in this area should begin by reviewing the articles that are considered the most influential, the identification of which is the objective of this analysis.

Table 3. The 25 most cited papers. Source: own research.

Journal	Rank	TC	Title	Author/s	Year	C/Y
LONG RANGE PLANNING	1	727	Building dynamic capabilities for digital transformation: An ongoing process of strategic renewal	Warner, KSR and Wäger, M	2019	135.80
INTERNATIONAL JOURNAL OF PRODUCTION RESEARCH	2	339	The role of digital technologies for the service transformation of industrial companies	Ardolino, M; Rapaccini, M; (...); Ruggeri, C	2018	54.00
DECISION SUPPORT SYSTEMS	3	313	Opportunities and risks of software-as-a-service: Findings from a survey of IT executives	Benlian, A and Hess, T	2011	22.15

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INTERNATIONAL JOURNAL OF PRODUCTION ECONOMICS	4	295	The impact of digital technologies on economic and environmental performance in the context of industry 4.0: A moderated mediation model	Li, Y; Dai, J and Cui, L	2020	71.25
INTERNATIONAL JOURNAL OF INFORMATION MANAGEMENT	5	281	Examining cloud computing adoption intention, pricing mechanism, and deployment model	Hsu, PF; Ray, S and Li-Hsieh, YY	2014	24.40
BUSINESS PROCESS MANAGEMENT JOURNAL	6	186	Internet of Things Applications and challenges in smart cities: a case study of IBM smart city projects	Scuotto, V; Ferraris, A and Bresciani, S	2016	22.50
ANNALS OF OPERATIONS RESEARCH	7	179	Increasing flexibility and productivity in Industry 4.0 production networks with autonomous mobile robots and smart intralogistics	Fragapane, G; Ivanov, D; (...); Strandhagen, JO	2022	42.00
EXPERT SYSTEMS WITH APPLICATIONS	8	176	Cloud computing in manufacturing: The next industrial revolution in Malaysia?	Ooi, KB; Lee, VH; (...); Hew, JJ	2018	26.50
INTERNATIONAL JOURNAL OF LOGISTICS MANAGEMENT	9	171	Adoption of cloud computing technologies in supply chains An organizational information processing theory approach	Cegielski, CG; Jones-Farmer, LA; (...); Hazen, BT	2012	12.50
INTERNATIONAL JOURNAL OF INFORMATION MANAGEMENT	10	164	The effects of IT capabilities and delivery model on cloud computing success and firm performance for cloud supported processes and operations	Garrison, G; Wakefield, RL and Kim, S	2015	14.78
COMPUTERS IN HUMAN BEHAVIOR	11	133	Understanding and predicting the determinants of cloud computing adoption: A two staged hybrid SEM - Neural networks approach	Priyadarshinee, P; Raut, RD; (...); Gardas, BB	2017	31.75
INFORMATION SYSTEMS FRONTIERS	12	132	Adoption of Software as a Service (SaaS) Enterprise Resource Planning (ERP) Systems in Small and Medium Sized Enterprises (SMEs)	Seethamraju, R	2015	17.29
INTERNATIONAL JOURNAL OF LOGISTICS MANAGEMENT	13	129	Supply chain management in the era of circular economy: the moderating effect of big data	Del Giudice, M; Chierici, R; (...); Fiano, F	2021	28.50
INTERNATIONAL JOURNAL OF INFORMATION MANAGEMENT	14	125	Big data analytics adoption: Determinants and performances among small to medium-sized enterprises	Maroufkhani, P; Tseng, ML; (...); Khalid, H	2020	11.67
TECHNOLOGY IN SOCIETY	15	100	Cloud computing adoption and its impact on SMEs' performance for cloud supported operations: A dual-stage analytical approach	Khayer, A; Talukder, MS; (...); Hossain, MN	2020	24.00
INTERNATIONAL JOURNAL OF LOGISTICS MANAGEMENT	16	95	Big Data Analytics and IoT in logistics: a case study	Hopkins, J and Hawking, P	2018	14.67

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DECISION SUPPORT SYSTEMS	17	94	Cloud computing and its impact on economic and environmental performance: A transaction cost economics perspective	Schniederjans, DG and Hales, DN	2016	21.75
INTERNATIONAL JOURNAL OF PRODUCTION RESEARCH	18	94	A big data MapReduce framework for fault diagnosis in cloud-based manufacturing	Kumar, A; Shankar, R; (...); Thakur, LS	2016	10.88
TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE	19	90	Balancing innovation and exploitation in the fourth industrial revolution: Role of intellectual capital and technology absorptive capacity	Mahmood, T and Mubarik, MS	2020	10.63
WIRELESS PERSONAL COMMUNICATIONS	20	86	A Hybrid Multi-Criteria Decision-Making Model for a Cloud Service Selection Problem Using BSC, Fuzzy Delphi Method and Fuzzy AHP	Lee, S and Seo, KK	2016	20.25
STRATEGIC MANAGEMENT JOURNAL	21	85	Mutualism and the dynamics of new platform creation: A study of cisco and fog computing	Khanagha, S; Ansari, S; (...); Oviedo, L	2022	20.00
INTERNATIONAL JOURNAL OF PRODUCTION ECONOMICS	22	84	Implementation of digital manufacturing technologies: Antecedents and consequences	Gillani, F; Chatha, KA; (...); Farooq, S	2020	9.75
CONCURRENCY AND COMPUTATION-PRACTICE & EXPERIENCE	23	77	Quantitative comparisons of the state-of-the-art data center architectures	Bilal, K; Khan, SU; (...); Zomaya, AY	2013	11.83
TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE	24	76	Analyzing the factors influencing cloud computing adoption using three stage hybrid SEM-ANN-ISM (SEANIS) approach	Raut, RD; Priyadarshinee, P; (...); Jha, MK	2018	6.80
INFORMATION & MANAGEMENT	25	76	Market perception on cloud computing initiatives in organizations: An extended resource-based view	Son, I; Lee, D; (...); Chang, YB	2014	6.18

Abbreviations are available in Table 1 except for C/Y = Citations per Year

4.4. The most prolific and influential authors

In the same way that the journals and sources were analyzed from the point of view of the number of publications and the number of citations, Table 4 presents the results of the same type of analysis applied to the authors, for the purpose of detecting which were the most productive and the most influential authors. To compile Table 4, the first ten authors were chosen in terms of number of publications. The first five authors in the ranking published 4 or 5 papers. Of the authors with three publications, which are very numerous, the five authors with the most citations (therefore most influential) were chosen. The rank was constructed based on the number of publications.

Table 4. The 10 most productive and influential authors. Source: own research.

Rank	Name	Institution	Country	TP	TC	TC/ TP	h-index	> 100	> 50	> 25	>10

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1	Gardas, Bhaskar B.	Veermata Jijabai Technological Institute (VJTI)	India	5	222	44.40	4	1	2	2	3
2	Gupta, Shivam	NEOMA Business School	France	5	195	39.00	4	0	2	4	4
3	Priyadarshinee, Pragati	Chaitanya Bharathi Institute Of Technology	India	5	269	53.80	5	1	2	3	4
4	Khayer, Abul	Huazhong Univ of Science & Technology	China	4	147	36.75	3	0	1	1	3
5	Moyano-Fuentes, Jose	Univ de Jaen	Spain	4	147	36.75	4	0	1	3	3
6	Iranmanesh, Mohammad	Edith Cowan Univ	Australia	3	146	48.67	3	1	1	2	2
7	Li, Ying	Shandong Univ	China	3	292	97.33	2	1	1	1	1
8	Maroufkhani, Parisa	Zhejiang Univ City College	China	3	187	62.33	3	1	1	3	3
9	Raut, Rakesh D	National Institute of Industrial Engineering	India	3	211	70.33	3	1	2	2	3
10	Khanagha, Saeed	Vrije Univ Amsterdam	Nether-lands	3	125	41.67	3	0	1	2	3

Abbreviations are the same as in Table 1 and Table 3, except for Univ = University

Table 4 shows that the most influential authors (with the most citations) come from China and India. Likewise, the table shows that there is no author with a large difference (compared to the others) in terms of number of publications, nor in terms of citations. The author with the highest number of citations is “Li, Ying”, followed by “Priyadarshinee, Pragati” and then “Gardas, Bhaskar B.”.

4.5. The most productive and influential institutions

Another ranking of interest is to compare publications and citations by Entities / Institutions. This ranking has the limitation that there are authors in each paper linked to different entities. Table 5 was built in order to show the results of this analysis. In this case, entities with 4 or more publications were analyzed, obtaining 11 results in total. The ranking was constructed based on the number of publications.

Table 5. The 11 most productive and influential institutions. Source: own research.

Rank	Institution	Country	TP	TC	TC/ TP	H-index	> 100	> 50	> 20	ARWU	QS
1	INDIAN INSTITUTE OF TECHNOLOGY SYSTEM IIT SYSTEM	India	7	179	25.57	6	0	1	3	-	-
2	NATIONAL INSTITUTE OF INDUSTRIAL ENGINEERING NITIE	India	7	286	40.86	6	1	2	3	-	-
3	UNIVERSITY OF JAEN	Spain	5	204	40.80	4	0	2	4	801-900	-

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4	ZHEJIANG UNIVERSITY	China	5	98	19.60	5	0	0	3	33	-
5	CHINESE ACADEMY OF SCIENCES	China	4	96	24.00	3	0	1	1	-	-
6	HUAZHONG UNIVERSITY OF SCIENCE TECHNOLOGY	China	4	147	36.75	3	0	0	2	91	275
7	MONTPELLIER BUSINESS SCHOOL	France	4	195	48.75	4	0	2	4	901-1000	29
8	TAMKANG UNIVERSITY	Taiwan	4	23	5.75	3	0	0	1	-	1201-1400
9	UNIVERSITY PUTRA MALAYSIA	Malaysia	4	4	1.00	1	0	0	0	801-900	-
10	UNIVERSITY SAINS MALAYSIA	Malaysia	4	42	10.50	4	0	0	2	-	137
11	UNIVERSITY SYSTEM OF GEORGIA	USA	4	130	32.50	4	0	1	3	301-400	514

Abbreviations are the same as in Table 1 and Table 3; ARWU and QS = Ranking in the general ARWU and QS university rankings

Table 5 shows that "INDIAN INSTITUTE OF TECHNOLOGY SYSTEM IIT SYSTEM" and "NATIONAL INSTITUTE OF INDUSTRIAL ENGINEERING NITIE" were the most productive and influential institutions, both located in India, with 7 publications each. Among the 11 entities with the most publications, China is the one with the highest proportion with 3 entities included in this ranking.

Regarding the number of citations, the entity that had the highest number of citations was "NATIONAL INSTITUTE OF INDUSTRIAL ENGINEERING NITIE", followed by "UNIVERSITY OF JAEN" and "MONTPELLIER BUSINESS SCHOOL".

Finally, the TC/TP ratio shows that in first position is "MONTPELLIER BUSINESS SCHOOL", and almost equal in second and third positions are "NATIONAL INSTITUTE OF INDUSTRIAL ENGINEERING NITIE" and "UNIVERSITY OF JAEN".

It is also very interesting to check the level of co-authorship of the authors in these studies, which at a graphic level is shown with the size of the balloon and the interaction lines between balloons in Figure 3.

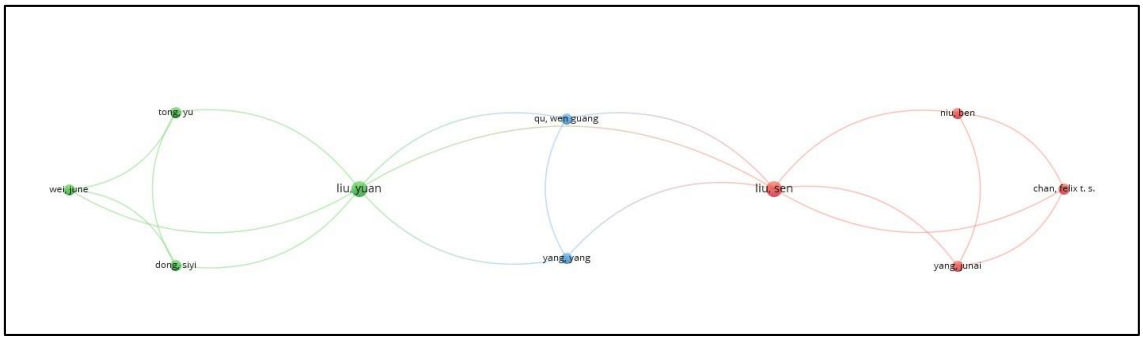

Figure 3. Co-authorship level of interactions. Source: VOSviewer.

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4.6. Country analysis

The last bibliometric analysis proposed is that of the productivity and influence that the main countries have developed in this field of study. Table 6 was built in order to show the most productive and influential countries. The countries with 10 or more publications were chosen; since the rest are very far behind (they have 7 or fewer publications). The rank was constructed based on the number of publications.

Table 6. The 12 most productive and influential countries. Source: own research.

Rank	Country	TP	TC	TC/TP	H-index	Population	TP/Pop	TC/Pop	> 100	> 50	> 20
1	PEOPLES R. CHINA	55	1,094	19.89	18	1,411,395.00	0.04	0.78	1	5	17
2	USA	42	1,230	29.29	20	333,287.18	0.13	3.69	2	8	20
3	INDIA	40	745	18.63	13	1,410,180.13	0.03	0.53	1	5	10
4	UK	23	595	25.87	15	66,058.27	0.35	9.01	0	2	11
5	MALAYSIA	22	523	23.77	10	32,804.26	0.67	15.94	2	2	7
6	SOUTH KOREA	16	442	27.63	9	51,466.20	0.31	8.59	1	3	7
7	TAIWAN	16	589	36.81	8	23,570.00	0.68	24.99	2	5	6
8	SAUDI ARABIA	15	386	25.73	8	36,408.00	0.41	10.60	1	2	6
9	AUSTRALIA	14	522	37.29	9	25,978.00	0.54	20.09	2	5	6
10	FRANCE	12	425	35.42	9	67,935.00	0.18	6.26	1	3	7
11	ITALY	11	697	63.36	5	58,856.00	0.19	11.84	3	3	4
12	SPAIN	10	270	27.00	6	47,615.00	0.21	5.67	0	2	5

Abbreviations are the same as in Table 1 and Table 3, except for Pop = Population (millions); TP/Pop = Studies per millions of population; TC/Pop = Citations per millions of population

The two most populated countries appear in first place (PEOPLES R CHINA) and in third place (INDIA) in terms of number of publications. The USA is the one with the largest H-Index, despite appearing second in number of publications the USA is prominent in terms of number of citations, and PEOPLES R CHINA is relatively close, leaving the rest far behind. Regarding the TC/TP ratio, ITALY is very prominent, with AUSTRALIA, TAIWAN and FRANCE relatively equal to each other but with almost half that of ITALY

5. CONCLUSION

The set of tables shown in this study corresponds to the catalog of results that builds a global picture that is as adjusted as possible to the reality of the most productive and influential focuses in the study of the relationship between Cloud Computing and Firm Performance. The journals, authors, institutions, and countries with the greatest number of publications and citations within the proposed scope of study were identified. The articles with the greatest number of citations were also identified, which is more influential and recommendable to use as a basis for future research. In addition, a quantitative analysis was carried out on the distribution of articles by number of citations

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received. With all these results, this study provides future researchers with the possibility of quickly locating the most relevant articles and sources to turn to when undertaking studies in this area.

After carrying out this quantitative bibliometric study, and analyzing the results, the first and main discussion prior to the conclusions is whether the research structure was appropriate. The results obtained justify the chosen methodology, since the objective of the study (to locate the most productive and/or influential research focuses) was satisfied. However, based on the results themselves and as a general conclusion, it is recommended that future studies carry out an in-depth literature review following a systematic methodology, which complements this study and provides researchers with a complete contextual framework in itself as a sum of both studies.

As the main asset resulting from this study, it was possible to verify the growing relevance of studies referring to the use of Cloud Computing in relation to the measurement and improvement of Firm Performance. It is also clearly observed in the studies analyzed that cloud computing seems to be strongly related to firm performance and competitiveness, a relationship that should be confirmed by empirical statistical studies as future lines of research. After the first publications in 2010, there was a strong growth in the citations of these articles entering the year 2019, which have only increased from then to the present. It is curious, however, to see the gradual evolution of the number of publications, with continuous growth and decrease, but with a clearly ascending general trend (in line with the conclusion obtained regarding the evolution of citations).

Related to the previous reasoning, the continuous growth of the production and relevance of citations in this area of knowledge is an indicator of the novelty of this topic of study. This means that it is a topic in the initial phase of growth, with a high development potential, and from which important outputs can still be obtained applicable to theoretical reasoning and the evolutionary praxis of key technologies in the improvement of firm performance.

The results have identified the most influential research articles, as well as the most productive and/or influential authors, entities, journals and countries, which represents a quantitative analysis (in number of publications and citations) but at the same time qualitative (as a structured knowledge base of the main research sources). This knowledge base is postulated as the first step that any researcher who wants to carry out some type of in-depth study on this topic related to the use of Cloud Computing and the impact on Firm Performance should take.

As to specific conclusions, the paper "Building dynamic capabilities for digital transformation: An ongoing process of strategic renewal" can be highlighted, with more than twice as many citations as the next one, and with even more citations than the second and third papers combined. However, no great dominants were observed in the number of publications or citations in terms of authors, journals, countries and entities related to these studies, although as a general conclusion it can be said that considering the countries and the origin of authors and entities, China and India are the most influential in this area of knowledge.

As future research, two possible lines are proposed, the first of which would be to check if there is any variable closely related to Cloud Computing and Firm Performance that could expand the relevant knowledge of this study, and the second to address a complete

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line of research on how the use of Cloud Computing can improve Firm Performance in companies that use it.

This study has a clear limitation, which is the extremely short life cycle that technologies usually have, and which could mean that despite being a subject in growth and development, it may have an earlier decline than expected.

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