The Scientific Production of the Moroccan Researchers in Computer Science from 2007 to 2016: Analysis and Assessment

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Abstract—The main purpose of this research is to examine the state of scientific research in the field of Computer Science in Morocco during the last decade and compare the scientific production in this field among the 3 North African countries.

Based on a bibliometric study - carried out by searching the Scopus database with a combined search strategy based on the keywords listed - and on an analysis of the data collected, this study evaluated the number of publications, co-authorship and scientific collaboration networks locally in Morocco and regionally with Algeria and Tunisia.

There is a lack of communication and collaboration between universities in neighboring countries or sometimes between the universities of the same country.

Finally, for conclude, our study presents recommendations for improving the visibility and ranking of the Moroccan university and the Moroccan researcher within its global scientific community.

Keywords—scientific research, computing science, bibliometrics, Morocco, North African countries, co-authorship.

1 Introduction

Scientific production is, since always, a reflection of scientific activity and productivity in terms of research. In addition, publications are the most widely reported form of transmission of scientific research results.

As a result, publications in scientific journals are one of the main methods of validation and dissemination for researchers' work. Records describing these publications are stored in bibliographic databases, which include information on sources (journal, authors, laboratories and their institutional affiliations), scientific content (title, keywords, abstract), and links to scientific content with other publications (references or citations) [1].

Primarily, these publications are considered as the privileged criteria for evaluation, peer recognition and researcher positioning in a disciplinary field. Hence,

the importance of studying these publications and analyzing them through bibliometric studies.

Bibliometric analysis is essential for evaluating the volume of scientific production (number of scientific articles in indexed journals), its impact (citation rate of articles), and on national and international collaborations (co-authorship). It requires knowledge of statistics and data analysis to process information related to these aspects. In addition, this analysis relies on data related to the discipline (the journal, the content of the publication) and the geographical location (the addresses of the authors' laboratories).

In Morocco, the Special Commission on Education and Training (COSEF-1999/2004) recommended that "scientific research should be the subject of internal evaluation, within each institution, intended for the self-evaluation of researchers and programs, and external evaluation by independent organizations and experts" [2] .

Hence, Moroccan researchers need to obtain visibility on their ranking and on their position in relation to the scientific community in their specialty fields nationally, regionally and internationally.

In the current context characterized by a continuous quest for scientific excellence and better positioning on the global scale, universities became interested in the Bibliometric indicators to measure their research activities. Indeed, three reasons motivated this study: on the one hand the absence of literature on the measurement and analysis of the scientific production of Moroccan researchers "computer science" field, on the other hand, the absence of a census of the scientific publications of Moroccan authors, in addition to the unsatisfactory place occupied by Moroccan universities in the world ranking [3]. This study will try to give a look at the last 10 years of research in this area (from 2007 to 2016).

In this article, we first try to give an overview on the state of scientific research in Morocco in general, as well as a bibliometric review of this production in the field of "Computer Science" while making a comparison with the neighbouring countries (Tunisia and Algeria). The analysis of this situation will propose ways to improve the visibility of the Moroccan scientific production and Moroccan researchers and to stimulate their interest in scientific publication.

It remains to be noted that the choice of the "Computer Science" field is motivated by its importance on a worldwide scale. It is the discipline that has democratized the access to scientific and technical information through the development of IT infrastructures in areas such as the acquisition and analysis of data, computing platforms, data storage architectures, networks and communication. As well as its use in various scientific and technological fields. The success of existing and future scientific and experimental programs depends among other factors on an efficient exploitation of the recent and future advances in computing technology [4].

2 Literature review

2.1 Scientometrics analysis

Interest in the ranking results of universities and higher education institutions is growing more and more and becoming an expected event every year. This ranking, which is based on the scientific and educational quality of these universities, reflects the level of scientific development of countries.

Although the global rankings are based on different criteria (such size of the institution, prices & medals) to assess the quality of educational institutions, statistics on scientific publications remain as the common criteria. In this sense, bibliometrics remains an essential tool for measuring the scientific performance of universities, especially those whose aim is competing and achieving a considerable international visibility in the scientific community.

Hence, the importance of Bibliometrics (called Scientometrics) turns the main tool of science, quantitative analysis, on itself. There are various definitions used for "bibliometrics." essentially, bibliometrics is the application of quantitative analysis and statistics to publications such as journal articles and their accompanying citation counts. Quantitative evaluation of publication and citation data is now used in almost all nations around the globe with a sizeable science enterprise [5].

2.2 Research field : Computer Science

Among the most active areas of science in terms of research, we find "computer science" (CS). It is a global competitiveness cluster, although it is a recent activity, its ancient roots are related to the work of mathematicians and electronics engineers.

Although "computer science" is an active field of research, there is no research that addressed the bibliometric analysis Moroccan scientific production in this field, with the exception of a study by the Moroccan Institute Scientific and Technical Information which covers the Moroccan scientific research and the problem of affiliations [6] [7].

2.3 International studies

Internationally, Arif et al. [8] were interested in their research in analyzing the collaboration scenario in CS in India. Their study aims to build and visualize the scientific social network graphs of co-publication. Moreover, comparing the network metrics of institutions(Indian Institutes of Technology), they deduce that their networks are no more than a representation of a "small world" of real social networks and that the co-author's social networks are just an image of the researchers' social relationships.

Murray's study [9] focuses on measuring the scientific productivity of the university with the aim of tracing the characteristics of teachers' scientific output .Also, evaluating the variation in the number of scientific publications of KwaZulu-

Natal University in South Africa. This study applied statistical methods and equations on a sample of 249 faculty members. The result is the imperative relationship between increasing scientific production and obtaining PhD degree.

In the absence of a similar research in his country, Pornsalnuwat [10], conducted a study that focuses on the state of scientific research in the university from 2003 to 2013 based on an analysis of the scientific productivity of teachers at Assumption University in Thailand. The review of 852 productions (articles, books, book chapters, conferences) led the author to propose a long-term program based on motivation, resources, personal skills and education- cultural policy.

Similarly, Gerard's study [11] tried to position a part of the Hong Kong University's scientific publications in the global scientific production. In order to improve the university's position in the world universities ranking, this study was based on four axes: the measurement of the scientific production during one hundred years (1911-2012), the research of the influencing factors, the impact of university administrations, the comparison with other universities of other countries such as Japan, Malaysia and South Korea.

Moreover, Okafor [12] focused on the scientific production of engineering faculties of public universities in Nigeria. The study of the quality of this production was crowned by the recommendation to improve the research environment in Nigerian faculties as well as the implementation of a database of scientific researches made by its researchers, so that they are more visible and accessible.

In addition, Akakandelwa [13] relied on the Web of Science (WOS) database to analyze 220 publications made by researchers at the Zambian University during the period from 2002 to 2007. The purpose of this research was to define the different types of publications and the impact of co-authorship on the scientific output of the university. This study showed that there is a strong correlation between the co-publishing and scientific publication rates especially in the exact sciences.

Also, Gorraiz [14] established a comparative study of the scientific production of three European universities: Oslo, Vienna and Zurich during the period from 2000 to 2006, based on the WOS database. The author's aim was to analyze the impact of the co-publication on the scientific productivity of the institutions, as well as the proposal for of improving the positions of these universities in the world rankings, notably through scientific cooperation between them.

Two other studies that have addressed, among other things, the Moroccan corpus. Hammouti [15] made a comparative bibliometric study of scientific production of the three Maghreb countries: Morocco, Algeria and Tunisia between 1996 and 2009 . Similarly, the author analyzed the positioning of the authors of these three countries using their index Hiresch (h-index).

In addition, Landini et al. [16] examined the structure and evolution of scientific collaboration networks in the countries of North Africa: Morocco, Algeria, Tunisia and Egypt. Using publications and patents, the team concluded that even if the scientific collaboration networks have been expanding internationally, they remain very limited regionally (North Africa).

To conclude, based on the analysis of previous work, the common goal is to identify the scientific production made in co-productions with teachers and

researchers in several universities and research centers. Several goals derive from this research, which are defining the hubs/leaders and connections of a scientific collaboration network, studying the impact of this co-produced production on the positioning of universities globally. Or evaluating and comparing the volume of scientific publication produced in collaboration between research centers and universities at the national level of a country or with other countries.

Our study presents a new contribution to its previous ones for various reasons:

Firstly, it is characterized by the focus on a particular area of science, namely the field of computer science. Then, the examined corpus study expanded to cover approximately all types of publications: Conference paper, Article, Book, Book chapter and Editorial. Finally, for this study, we combined the bibliometric analysis of publications in co-authorship and cartography of scientific co-publication collaborations in the field of computer science. This is at the national level concerning Moroccan researchers and at the Maghreb level for Moroccan, Tunisian and Algerian universities.

This cartographic representation illuminates the state of the Moroccan researchers' corpus in computer science in order to participate in exploration, evaluation and decision-making.

3 Methodology

Thus, to describe the Moroccan scientific production in the field of "computer science" during the period from 2007 to 2016, we used the database "Scopus". The latter, in addition to its user-centric design, covers over 21,500 journal titles from peer-reviewed sources. It is a base that supports the dimension of geographical localization of scientific production, which is considered, by many specialists, as one of the baselines for bibliometrics.

In order to achieve our goals we propose:

a.) A bibliometric review based on the search strategy in the following "Scopus" database:

- Country identification: Maroc / Morocco in the field "Country Affiliation"
- The specification of scientific publications in the field of "computer science"
- A limit on the scope of years: between 2007 and 2016.

b.) An analysis of the collected data following a comparative approach with other neighboring countries (Tunisia and Algeria) on the basis of quantitative criteria (Production Indicator & visibility indicator) [5], and those for the search of explanatory factors of the bibliometric review results.

The process and homogenization of bibliometric data are made using Open Refine. In addition, the data analysis is done with the SCI2 tool (spacialization) to identify nodes and edges of the network. Finally, the cartographic representation of the networks is generated with Ghephi.

4 Results and discussion

4.1 Morocco's situation in terms of scientific research

In general, and according to SCImago Journal & Country Rank [17], between 2007 and 2016, scientific production in Morocco experienced a positive evolution continuously until 2014 and decreased slightly in 2015 to increase the year after.

Overall, this production increased from 1646 to 5694 items per year (see Table 1), an increase of 345, 9%.

Table 1. Evolution of scientific production in Morocco from 2007 to 2015

Year	Documents	Citable documents	Citations	Self-citations	Citations per document
2007	1646	1572	19763	3163	12.01
2008	1882	1787	21621	3430	11.49
2009	2240	2101	18450	3291	8.24
2010	2510	2351	20163	4589	8.03
2011	2998	2822	20115	4185	6.71
2012	3559	3315	26317	5299	7.39
2013	3913	3554	18121	4081	4.63
2014	4728	4226	15226	3657	3.22
2015	4611	4234	11105	2544	2.41
2016	5694	5374	3739	1352	0.66

Source: SCImago Journal & Country Rank- Country Indicators

Moroccan scientific production ranks fifth among African countries, with 40,737 publications from 1996 to 2015 (behind South Africa, Algeria, Tunisia and Nigeria)

Table 2. Ranking of African Countries by Number of Scientific Publications from 1996 to 2016

	Country	↓ Documents	Citable documents	Citations	Self-Citations	Citations per Document	H index
1	South Africa	213998	196132	2689207	569883	12.57	361
2	Tunisia	67698	64445	459550	100266	6.79	144
3	Nigeria	67008	63719	432647	89702	6.46	153
4	Algeria	49697	48608	294124	61266	5.92	125
5	Morocco	47329	44578	358395	66849	7.57	151

Source: SCImago Journal & Country Rank- Country Indicators. Moreover, in 2000, Morocco ranked second after South Africa

4.2 Publications of Moroccan researchers in "computer science" in comparison with Tunisia and Algeria

For the purposes of this article, the comparison in terms of scientific production is made with two countries: Algeria and Tunisia. This is justified by several reasons, including:

- Considering Morocco, these are the three core countries of the small Maghreb [18];
- Reconciliation of the three countries in terms of geographic, economic, historic situation.
- The 3 countries are among the top 5 African countries in terms of scientific publications;
- The presence of conventions and memorandum of understanding in the field of higher education and scientific cooperation between these countries.

The analysis of the scientific participation of Moroccan researchers in the field of CS at the international scale is made based on several criteria. These are related to publication numbers, collaboration statistics, linguistic peculiarities, authors' rankings and forms of publication.

Publication statistics: Compared to neighboring countries, Moroccan scientific production in "computer science" follows almost the same progression as Tunisia and Algeria (see graph 1).

According to the "Scopus" database, Tunisia comes in first place with 11892 publications in "computer science", followed by Algeria with 8911 publications and Morocco with 5698 publications.

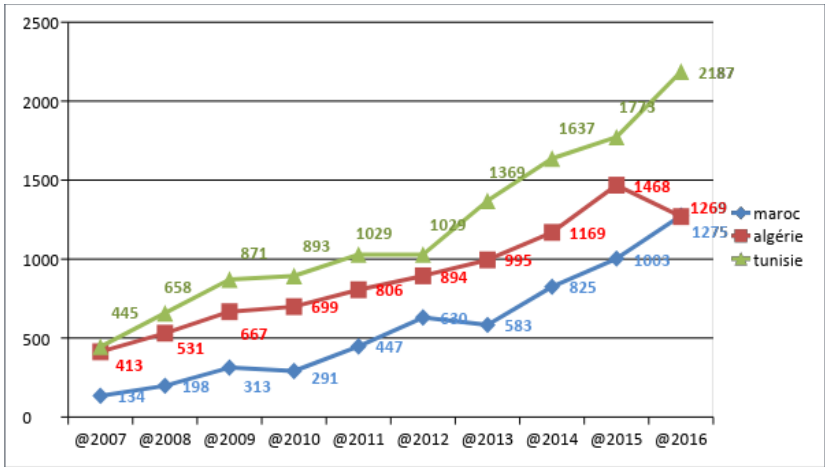

Fig. 1. Growth of Moroccan production in "Computer Science" from 2007 to 2016: in comparison with Tunisia and Algeria

The publication of the first articles in "computer science" by the authors of the three countries, in journals indexed by Scopus, goes back to the same period: Tunisia in 1971, Algeria in 1972 and Morocco in 1974.

Collaboration statistics: On a national level. The analysis of research results on collaboration in terms of co-publication between Moroccan universities in the field of CS, showed a reluctance of researchers when it comes to working cooperatively outside their research laboratory.

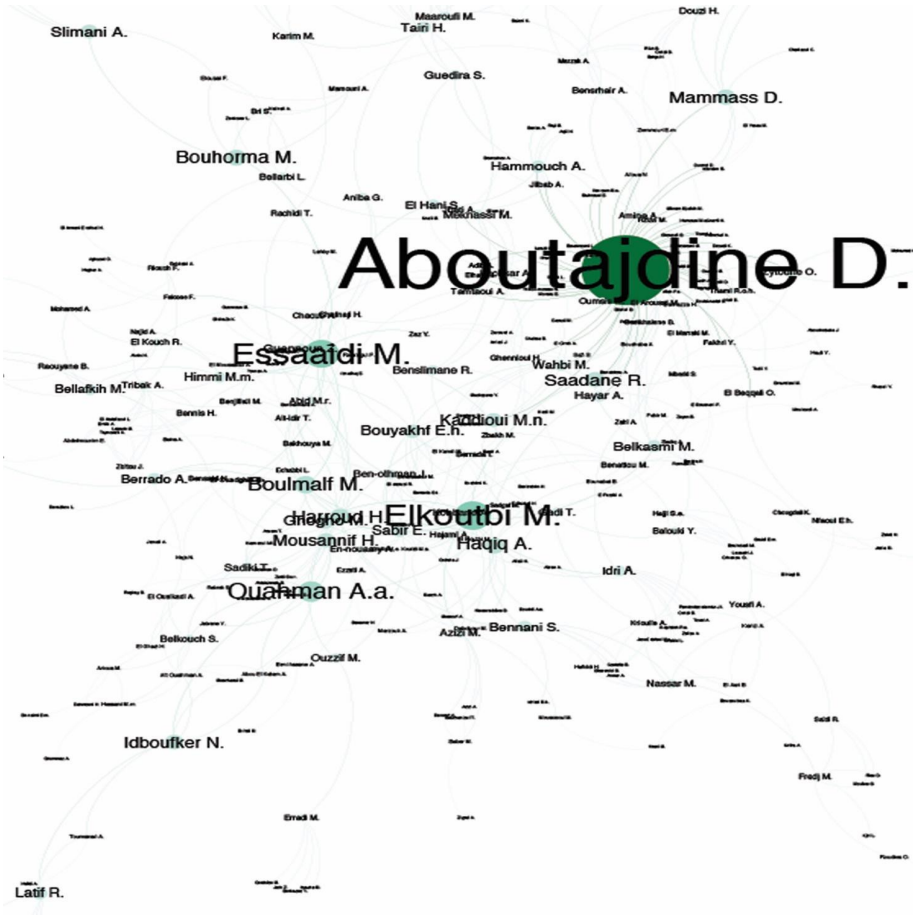

Fig. 2. Mapping of scientific collaboration between Moroccan authors in "computer Science" from 2007 to 2016

On the Maghreb level: According to the Knowledge Assessment Methodology (KAM) of the World Bank [19], in 2012, Morocco ranks first in terms of collaboration, in the list of countries in the MENA1 region with a rate of 70 scientific

1 Middle East and North Africa : Algeria, Bahrain, Djibouti, Egypt, Iran, Jordan, Kuwit, Lebanon, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, United Arabt Emirates, Yemen.

and engineering articles written in collaboration with foreign authors per million inhabitants.

More specifically, the three countries in our analysis, have many co-publications with France (1072 Morocco, 3512 Tunisia, 2607 Algeria), as their main scientific partner. This high rate of partnership is largely linked to European cooperation programs (research fellowship & cotutelle).

On the other hand, according to the research done on Scopus, a low rate of co-publication between these three countries (from 2007 to 2016):

- Morocco-Algeria: first collaboration in 2006 with a total of 51 co-publications
- Morocco-Tunisia: first collaboration dates back to 2003 with a total of 45 co-publications
- Morocco-Tunisia-Algeria: first collaboration in 2016 with a total of 3 publications in co-publication

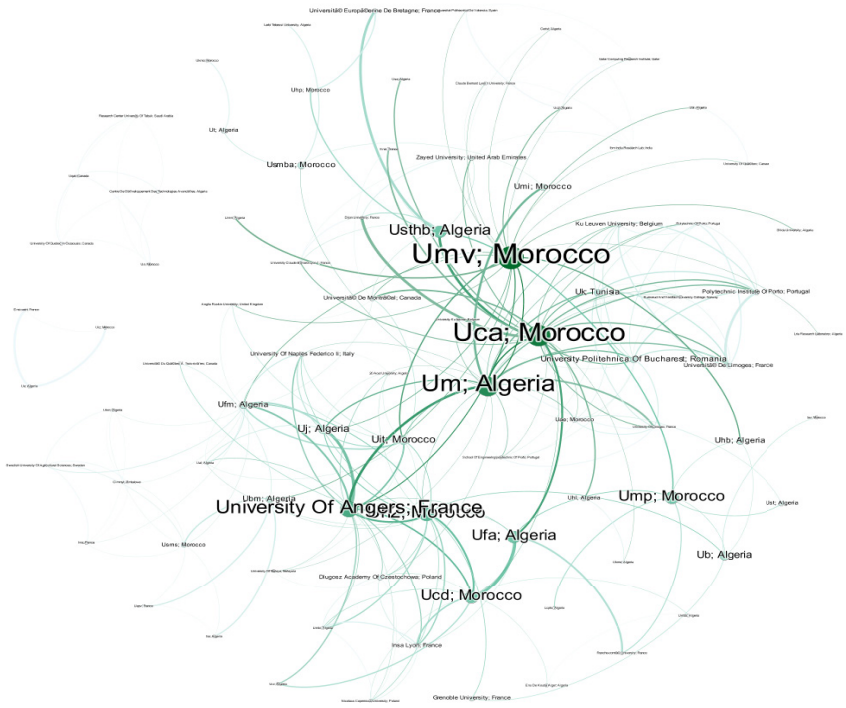

Fig. 3. Mapping of scientific collaboration between the affiliates of Morocco and Algeria in "computer Science" from 2007 to 2016

Between Morocco and Algeria, the universities that work more frequently together are Mohamed V University (Rabat) and Cadi Ayyad University (Marrakech) on the Moroccan side and Mostaganem University on the Algerian side.

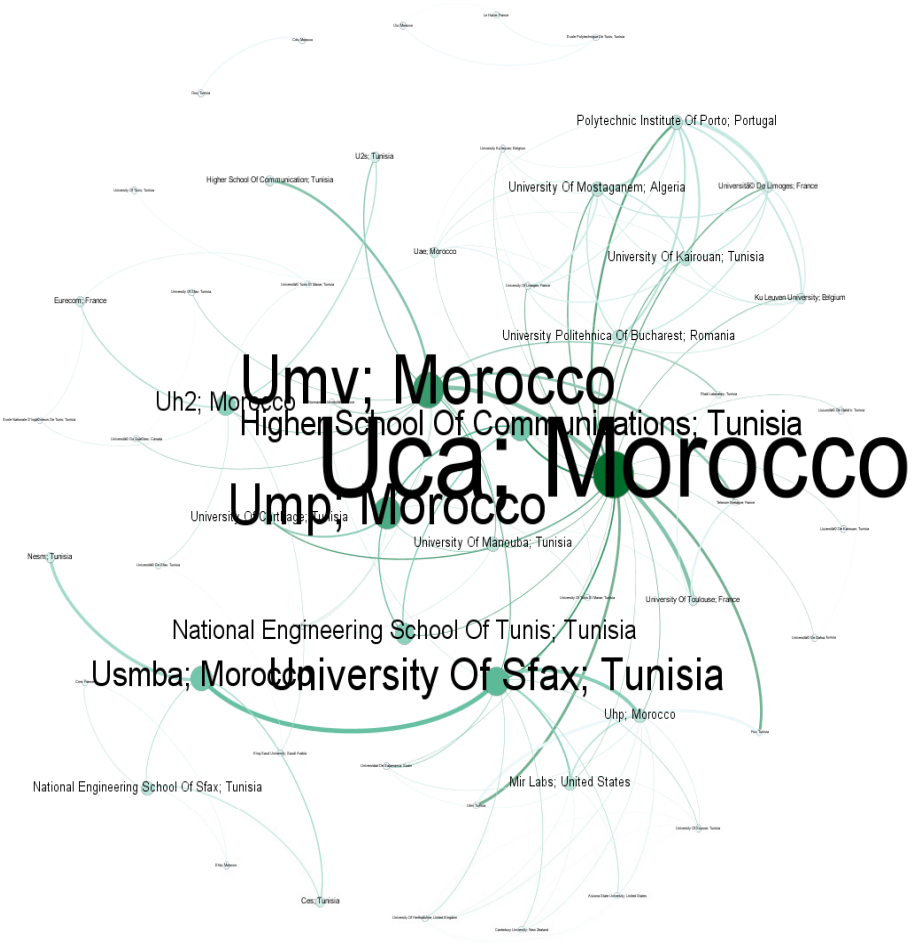

Fig. 4. Mapping of scientific collaboration between the affiliates of Morocco and Tunisia in "computer Science" from 2007 to 2016

For the collaboration between Morocco and Tunisia, the universities that work more frequently together are Mohamed V University (Rabat) and Cadi Ayyad University (Marrakech) on the Moroccan side and Sfax University on the Tunisian side.

Overall, scientific collaboration and more precisely scientific publication between the three countries remain modest and limited.

Language statistics: The English language ranked first as the language of publications in the three countries (98.9% Morocco, 98.6% Tunisia, 96.7% Algeria), followed by French, Spanish and Arabic.

Author and Affiliation: The ranking of authors reflects the position of the universities to which they belong.

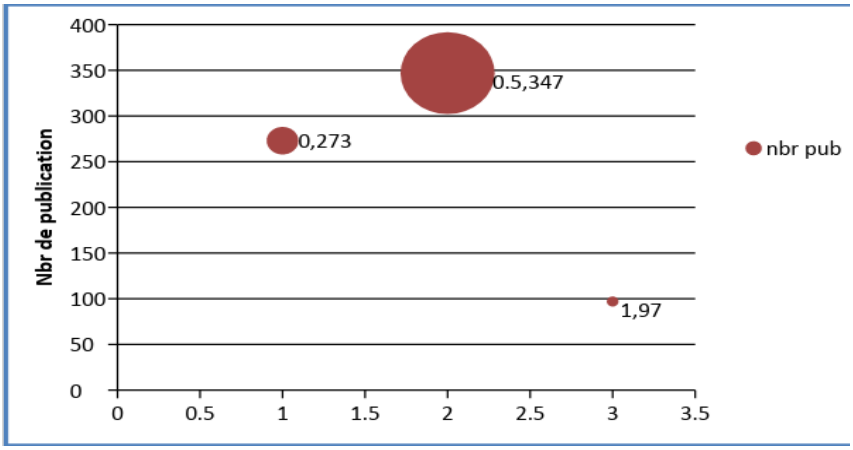

Fig. 5. The number of publications of the top-ranked affiliations by country

Among the three North African countries, the Tunisian university of Sfax comes first with 347 publications of Alimi Adel who has an H-index of 24. Followed by the Moroccan Mohammed V University with 273 publications of Aboutajdine Driss who has a H-index of 15. Finally, the Algerian Center for Research on Scientific and Technical Information (CERIST) with 97 publications by Badache Nadjib who has an H-index of 14.

Note: Top authors of Tunisia and Morocco belong to the top universities of each country.

Review: The specialized journal in which Moroccan authors publish the most is "Journal Of Theoretical And Applied Information Technology" which published the most articles (368).In Tunisia and Algeria, authors publish the most in the same journal "Reading Notes In Computer Science Including Subseries Reading Notes In Artificial Intelligence And Reading Notes In Bioinformatics" (876 articles for Tunisia, 425 articles for Algeria).

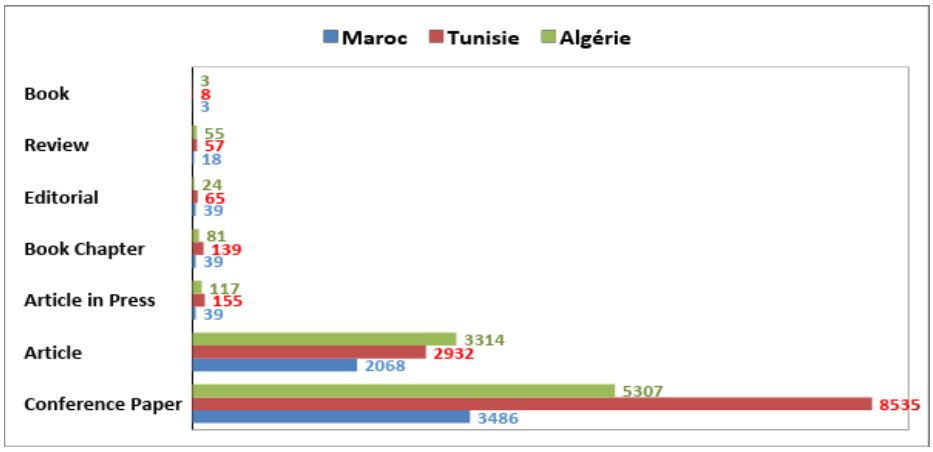

Fig. 6. Comparison between Morocco, Tunisia and Algeria by type of publication

In addition, the data extracted from SCOPUS database showed that Conference Paper are the most popular types of publications in the three countries (55.2% Morocco, 71.77% Tunisia, 59.25% Algeria), followed by scientific articles, article in press and book series.

There is a lack of communication and coordination between universities in neighboring countries or sometimes between the universities of the same country. This problem that causes loss opportunities, outreach and visibility every day because of lack of collaboration.

Nationally, in 2003, the National Coordinating Commission for Higher Education [20] was created in the Ministry of Higher Education, Scientific Research and Management Training. Among the roles of this structure is to boost solidarity and financial assistance between the different structures of the Research & Development system in Morocco. However, few collaborative actions are palpable on the ground.

With Tunisia, modest projects were completed as part of the Moroccan-Tunisian Standing Joint Committee for Scientific Research and Technology (CMPMT), which is organizing an integrated action program. Less for Algeria, a memorandum of understanding was signed in 2012 between the two countries to boost cooperation in the field of higher education and scientific research.

Nevertheless, there are some limitations to this study. The search for scientific collaboration between the entire Moroccan academic corpuses is confronted with problems related to affiliation provided by the authors, it is mainly:

- Mix between different levels: university, faculty, higher education school, team, laboratory
- Loss of "institutional" links between affiliations;
- A single entity may be present under different names;
- Different transcription of authors' names.

5 Conclusion & Recommendation

The quality and quantity of publications are among the major factors concerning the ranking and reputation of universities. It is in this perspective that this article examines the state of scientific research in the field of Computer Science in Morocco during the last decade.

Using bibliometric data analysis, this study evaluates the scientific productivity in terms of publication in the field of "Computer Science", comparing Morocco with two North African Maghrebian countries: Tunisia and Algeria.

In general, the results of this study showed that Morocco has fallen two places during the last ten years. Furthermore, in the field of Computer Science, the scientific production is evolving while occupying the second behind Tunisia, at the Maghreb level.

Certainly, this article pointed out that the comparison between the three countries has very similar characteristics: language of publication, type of publication, ranking of the most cited authors, etc. However, the collaboration between Morocco and its neighbors remains very limited in terms of scientific and technical research.

Similarly, to other fields, in the field of research, cooperation and collaboration between countries is necessary for the achievement of progress and strategic objectives.

In addition, it is internationally recognized that scientific research requires significant infrastructure and resources, which is costly for a developing country such as Morocco. As a result, several countries have come together to conduct collaborative research.

The important thing is to make attempts at cooperation for scientific and technical purposes. Firstly, to create a pool of qualified specialists and secondly place the establishment of a cooperation mechanism (Social networks) between Maghreb researchers. As a result, several stakeholders must commit to the success of setting up a structure dedicated to promoting research and scientific cooperation. Among these stakeholders, the major actors in this sector, namely the Ministry of ENRSFC2 and CNRST3.

Due to the low percentage of GDP (0.71% in 2010)[21] devoted to scientific research, Morocco must encourage other sources of funding based on international partnerships and cooperation by implementing partnership policies at local, national and international level; as well as continuing and intensifying programs already initiated (VOLUBILIS, PMARS, TEMPUS). Likewise, setting up of joint research programs, exchanges (teachers - students), joint programs, training courses, joint organization of scientific events. Finally, encouraging the mobility of researchers between partner countries by exempting/reducing certain costs (transport, accommodation, registration for scientific events, etc.)

[2] ENRSFC : Enseignement National, Recherche Scientifique et Formation des Cadres

[3] CNRST : Centre National pour la Recherche Scientifique et Technique

In addition, the improvement of the visibility and ranking of the Moroccan university and the Moroccan researcher within its global scientific community depends first and foremost on the quality of the referencing. To achieve this end, our study proposes:

First, the adoption of the unique identifier (ORCID)4 and the standardization of the affiliation name, to avoid problems related to the identification of publications. Second, the establishment of a national system for the identification of skills by field. Third, the facilitation of scientific exchanges and the strengthening of existing scientific networks in order to amplify solidarity efforts in international cooperation. Fourth, the creation of specialists' networks to promote the culture of "Team research" and develop productive collaborations between researchers in the same field in order to strengthen teamwork. Last, the provision of prizes and awards to encourage the publication of team research in journals of high scientific value.

Finally, we hope that others researchers will dig deeper into this data and benefit from the results collected by this case study in order to not only characterize and develop the national scientific profile of computer science researcher. But to identify trending and priority CS specialties of research in the Moroccan researchers' network, analyze scientific collaborations of the same corpus through academic social networks and predict new collaboration of potential success (prediction model).

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4 ORCID : Open Researcher and Contributed ID, it is a nonproprietary alphanumeric code to uniquely identify scientific and other academic authors and contributors

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