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Scientometric assessment of Saudi publication productivity in computer science in the period of 1978-2012

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Abstract

Purpose – This study aims to analyze Saudi scientific output in the field of computer science in Web of Science database, covering the years 1978 through 2012.

Design/methodology/approach – The study involved analyzing 998 publications in terms of the publication count and its growth, citation, share of international collaboration, research areas and researchers' productivity.

Findings – The results show that the number of papers produced in computer science field has only increased after year 2007; this is because Saudi universities have applied a catch-up strategy to increase its research output. Also, our study reveals that the publication performance of Saudi scientists in computer science was domestic and suffers from low international visibility. Only two universities took the lead in the production of computer science research. Furthermore, computer science research trends in Saudi Arabia focused on engineering, followed by mathematics and telecommunications.

Originality/value – Studies on international academic publication productivity in the Middle East, particularly in Arab countries such as Saudi Arabia, are rarely found. In fact, bibliometric studies on Saudi researchers in the field of computer science are not available. Therefore, the originality of this study resides in being the first study to measure publication productivity of Saudi researchers in the field of computer science.

Keywords Bibliometrics, Web of science, Saudi Arabia, Computer science, Science citation index, Scientific productivity

Paper type Research paper

Introduction

Computer science is a scientific discipline concerned about the theories and techniques of computing and computational systems. As a vital domain for building knowledge-based economy, many academic institutions, research centers and government and private sectors are involved in computer science research. Given the importance of computer science research output in global economy, its growth, rank and publication need to be studied.

Scientometric assessment of academic publications is important to help identify leading institutions and researchers in a given discipline. It relies on many bibliometric metrics and methods such as publication and citation count. Also, research methods used to analyze research publications varied between qualitative, quantitative and computational approaches.

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One early attempt to apply bibliometric techniques to study computer science publications was made in 2001 by Liang *et al.* (2001), where they studied the age structure of Chinese computer scientists. Later on, several bibliometric analyses were conducted in this field and for different countries, such as China, India, Korea, Malaysia and Greek.

Abrizah and Wee (2011) conducted a study to estimate the research productivity of Malaysian computer scientists. They used Web of Science (WoS) to extract 903 papers, and then they applied Lotka's and Bradford's Law to determine researchers' productivity. Bakri and Willett (2011) searched Scopus and WoS databases for the publication of 19 departments of computer science in Malaysian universities. They found statistical significance relationship between departments' publications and citation count.

Similarly, Katsaros *et al.* (2008) examined the scientific performance of academics in 17 Greek Departments of Computer Science using a set of bibliometric metrics. They investigated 552 academics using Publish or Perish software and Google Scholar.

To study the effect of including computer science conference proceedings in Institute for Scientific Information (ISI) WoS database, Bar-Ilan (2010) examined the citation counts of a set of highly cited computer scientists. Her results show an increase in the scientists' publication and citation counts, with $>$ 40 per cent of the citations coming from conference proceedings.

Bibliometric analysis for specific subject areas in computer science was also investigated. Liu *et al.* (2013) analyzed the related literature in the Science Citation Index Expanded (SCIE) database from 1958 to 2011 to study the progress in global parallel computing research using bibliometric approach.

Only recently, new studies focused on computational approaches for bibliometric analysis such as using Bayesian networks (Ibáñez *et al.*, 2011) to discover relationships between bibliometric indices for computer science and artificial intelligence journals. Computer models were also used for identifying instrumental citations in the biomedical literature (Fu *et al.*, 2013). Similarly, a proposed clustering method by Ibáñez *et al.* (2013) was used for measuring the performance of Spanish computer science research activities in terms of quality, prestige, visibility, productivity and international collaboration.

Others developed software programs for bibliometric analysis such as VOSviewer, a computer program for bibliometric mapping (van Eck and Waltman, 2010), and others identified duplicate and fake publications in the computer science literature (Labbé and Labbé, 2013).

In light of the previous literature, we can see that studies on international academic publication productivity of Saudi researchers in the field of computer science are not available. Therefore, the aim of this study is to identify those researchers and institutions publishing in different subject areas of computer science in Saudi Arabia. Such study will help provide a general view of the activity of Saudi scientific community and its contributions to world scientific literature.

Background

In recent years, Saudi living standards have radically improved as a result of comprehensive development programs. Research and development became at the forefront of the Saudi Government's priorities. It is the government's aim to strengthen Saudi Arabia's position by investing in humans and building brains to ensure that its

citizens become more qualified and skilful to match the religious and social needs and economics of the country.

The establishment of King Saud University (KSU) in 1957 marked the starting point of the Kingdom's modern higher education system. Computer science program was offered in the university in 1985 (Al-Salman and Adeniyi, 2000). Graduate studies were then offered at the same university in 1999. Since then, computer science undergraduate programs have been offered in all the country's 25 universities. From the 25 universities, three of them offer graduate studies: KSU, King Fahd University for Petroleum and Minerals (KFUPM) and King Abdulaziz University.

Computer science research is one of the major research priorities in Saudi Arabia. The national plan for science and technology (http://npst.ksu.edu.sa) offers a complete funding program for computer and information technology. The program includes the following tracks: Arabic Language Technologies, Open Source/Software Localization, Advanced Networking and High Performance Computing, IT Security and Islamic Applications of IT.

The first Saudi computer science paper appeared in WoS was in 1978 in the IEEE Transactions on Reliability. To date, no visible attempts are pursued to evaluate the productivity of research in this field. Therefore, the objectives of this study are:

- to examine the distribution of subject categories in Saudi computer science publications;
- to identify active researchers and institutes in Saudi Arabia;
- to identify international collaboration; and
- to detect the research focus and main interest of Saudi computer science publications.

Method

Several bibliometric studies have been published for different disciplines, including computer science and engineering. Searching Scientometrics journal for articles that contain the term "computer" revealed 3,765 results. However, not all results were technically discussing computer science publications' bibliometrics. Thus, we only focused on articles that contain computer science in their title.

By examining previous research methods used in bibliometric studies of computer science publications, we can find two streams:

(1) analyzing individual country bibliometrics; and

(2) conducting cross-country comparison.

In the first stream, different metrics were calculated such as number of publications, citation count and collaboration patterns. As an example, Gu (2002) used a descriptive research approach to explore publication productivity of Malaysian computer science and information technology scientists between 1990 and 1999. A total of 461 publications were collected, and the number of papers per year, authors and their name position in the paper as well as the paper citation were computed.

Comparing research performance against other countries is widely adapted in many bibliometric studies. For instance, Guan and Ma (2004) compared the research performance in computer science for China and India against four countries: USA, UK, Germany and Japan. They used INSPEC database to pull a total of 9,632 papers during

the period 1993-2002 and extracted metrics such as number of published papers and citation counts for performance evaluation. Their findings show that China's computer science publications have improved; however, in terms of publications venues, Indian scientists preferred to publish in Western journals while Chinese preferred to publish in domestic journals.

Wainer *et al.* (2009) studied Brazilian computer science production from 2001 to 2005, and compared it to 12 countries: Russia, India, China, Chile, Australia, Argentina, South Korea, Italy, Portugal, Mexico, Spain and USA. They extracted journal and conference proceedings from ISI and Scopus and applied the following bibliometric measures: total number of publications, publications distribution according to research sub-areas, publications distribution according to journals impact factor and the relation between journal and conference publications.

Gupta *et al.* (2010) compared India's computer science research output against four countries: South Korea, Taiwan, China and Brazil. The papers collected from 1999 to 2008 were analyzed using several bibliometric metrics including number of research output, its rank, growth and international share, citation impact, percentage of international collaboration and major collaborative countries and research communication patterns in most productive journals.

In our study we will follow the first stream approach, given the fact that this is the first time to conduct such scientometric assessment on Saudi computer science publications. Therefore, a thorough investigation of all publications in computer science between 1978 and 2012 conducted by researchers in Saudi Arabia was performed.

Data collection and processing

Documents collected in this study were gathered from SCIE, Thomson Reuters WoS database. The selection started by searching for keywords in the address field that contains "Saudi" in it and setting the citation databases to SCIE and Conference Proceedings Citation Index – Science. A refinement was then made by investigating the keywords and abstracts of each individual paper to include only those in computer science fields. This resulted in 1,022 papers between 1978 and 2012.

The data in each bibliographic record included paper title, year, affiliation, country, document type, research area, journal name, impact factor and number of citations. In addition, supplemental information was coded based on each bibliographic record, which include ACM Category and name of Saudi university.

The 1,022 papers were then divided into nine groups based on their publication type: articles (903), proceedings (60), letters (13), reviews (9), correction (7), correction, addition (2), editorial material (13), meeting abstract (2) and notes (13). Only articles, proceedings, reviews, letters and research notes were considered in this study; however, correction, editorial material and meeting abstracts were excluded because of their low scientific significance. This filtration resulted in 998 publications.

To categorize the 998 publications according to their subjects in Computer Science, the subject classification scheme of the 1998 ACM Computing Classification System (www.acm.org/about/class/ccs98-html) was used. The ACM categories are General Literature, Hardware, Computer Systems Organization, Software, Data, Theory of Computation, Mathematics of Computing, Information Systems, Computing Methodologies, Computer Applications and Computing Milieux. The coding was done manually based on article's keywords, abstract and full text.

Distribution of papers based on their subjects areas is presented in Figure 1. It is clear that most of the papers were published in Computing Methodologies and Computer Systems Organization (20.53 and 20.34 per cent, respectively). This is followed by Information Systems and Hardware (12.8 and 12.6 per cent, respectively), Mathematics of Computing (11.5 per cent) and Software (10.37 per cent). These six subject categories constitute about 88 per cent of the subjects of publications studied in Saudi Arabia.

In view of the differences in affiliation names spelling, many affiliation names were normalized into unified forms, for example, KFUPM came in four different forms, namely, KFUMP, Univ Petr & Minerals, Univ Petro & Minerals, KF Univ Petr & Minerals and King Fahd Univ Petr & Minerals. Also King Abdullah University for Science and Technology (KAUST) came in two different forms: KAUST and King Abdullah Univ Sci & Technol. Similarly, UMM Al Qura University came in three forms: UQU, Oum El Kora Univ and Um Alqura Univ. However, KSU came as KSU in two incidents only and in one incident as Riyadh University (old name of KSU). Al-Imam Mohamed ibn Saud Islamic University came only as Imam Univ and King Abdulaziz University came as KAAU, KAU and King Abdulaziz Univ. We also noticed several private sector involvements in research publications so we assigned Private as a category to them.

Also, number of citation and impact factors was taken from the journal page in the WoS database.

Tools

Publish or Perish bibliographic tool (Version 4.4.7.5058) was used to extract more information about each author (number of papers, citation and *h* index) based on different venues. The data source of the program was set to Google Scholar.

To process the variations in authors' name spelling, we wrote a small program to normalize authors' names. We found that an author might come in different name formats; in some cases the first name might be replaced with initials and the family name might have a hyphen "-". Family names in Saudi Arabia are usually preceded with "Al" and hyphen "-"; we removed the hyphen so that Al-Khalifa becomes AlKhalifa.

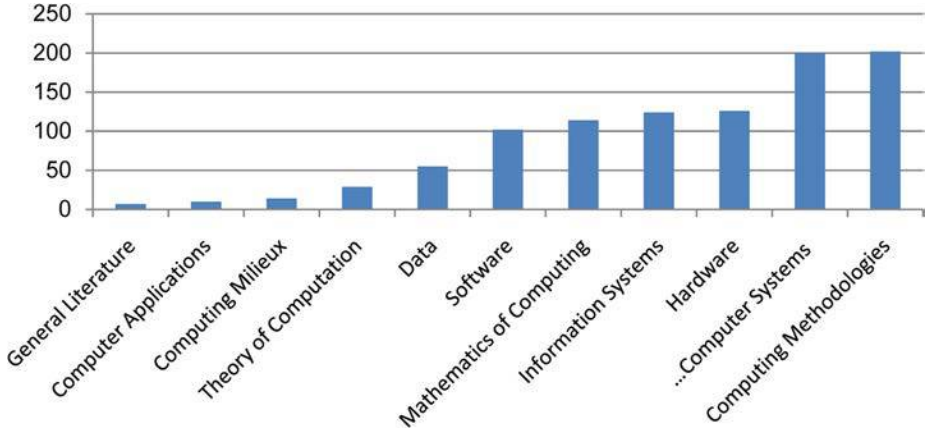

Figure 1.
Distribution of publications' subject areas

This will provide unique name consistently throughout the data set and help in uniquely counting names of authors.

Results

Based on our previous criteria, we have obtained 998 computer science papers that have been published in science citation index (SCI) journals between 1978 and 2012. We have analyzed them based on their publication years, number of citations and collaborating countries. Furthermore, we analyzed the distribution of papers over Saudi institutions and identified active authors. Finally, we detected the research focus and main areas of interest of Saudi computer science publications.

The distribution of annual number of papers and their citations

The number of papers published in conference proceedings and academic journals and their citation counts are considered one of the most commonly used indicators that describe a research output.

To evaluate numerical characteristics of Saudi research performance, Figure 2 shows the 35 years chronological articles growth in WoS during the period 1978–2012. According to the amount of publication contribution for each year, the average Saudi scientists' publication per year is 28.5. The marginal activity period from 1978 to 2007 yielded 537 (52.5 per cent), followed by a rapid growth during 2008–2011 with 311 (30.4 per cent). In year 2012, a slight decrease was observed in publication productivity with 150 (14.6 per cent) papers compared to year 2011.

The most productive year of research publications was 2011, with 166 (16.2 per cent) papers. A spike in year 2000, then a decline in 2001 can be observed; however, no clear explanation can be stated.

It is not surprising that the publication output has increased rapidly in recent years, as the government has invested more heavily in Research and Development (R&D) (Smith and Abouammoh, 2013). Also Saudi Arabia has embraced several major initiatives over the past few years, including the establishment of collaborative arrangements between Saudi universities and leading scholars and departments in

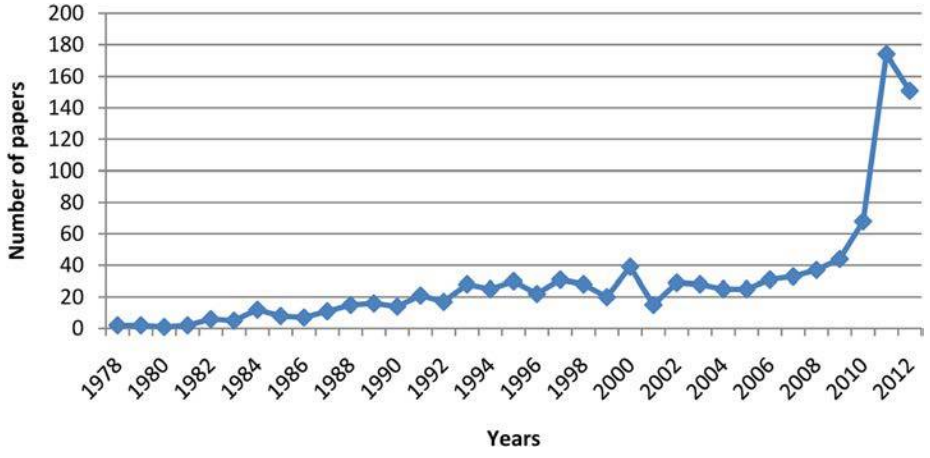

Figure 2.
Publications growth rates

international universities, and supported the establishment of Centers of Research Excellence along with science parks (Smith and Abouammoh, 2013).

The average citation per publication was 6.94 and the average impact factor was 1.27 (the count weighted according to the frequency with which each journal was used). These numbers are low compared to similar bibliographic studies by developing countries such as Brazil (Wainer *et al.*, 2009) and India (Gupta *et al.*, 2010).

The maximum citation was 153 for the journal article "A survey on clustering algorithms for wireless sensor networks" in Computer Communications journal with 1.04 impact factor. The maximum impact factor found was 4.9 (*IEEE Transactions on Pattern Analysis and Machine Intelligence*) and the minimum was 0.105 (*Computer Aided Geometric Design*). Given the fact that the maximum impact factor in computer science journals is 7.474 based on Thomson Reuters Journal Citation Reports 2012[1], the achievement of Saudi computer scientist to publish in a journal with 4.9 impact factor is considered acceptable.

The distribution of papers over Saudi institutions

Figure 3 shows the distribution of publications among Saudi institutes. Notice that KFUPM (founded 1963) is leading with 43 per cent share of all publication since 1978. KSU (founded 1957) is second with 30 per cent. King Abdualaziz University (KAU; founded 1967) comes third with 7.2 per cent. Given that these three universities are considered the oldest in Saudi Arabia and all of them offer graduate programs, yet, KFUPM and KSU took the lead as the most prominent universities in the field of computer science.

On the other hand, KAUST (a research only university), given its recent establishment in 2009, has only produced 4 per cent of the total publications. This indicates a good start for the university in the field of computer science publications.

Interestingly, some private sectors were spotted publishing papers solely or jointly with academic institutes. Among these sectors are Arabian Advanced Systems, Saudi Aramco and Banque Saudi Fransi.

We also noticed that recently established universities and private universities are not that active; their publications count average was 1.6, which is considered very low. Also research institutes such as King Abdulaziz City for Science and Technology were lagging behind in terms of publications.

As a finding, the most active universities in terms of publications are KFUPM and KSU, with 70 per cent of all publications produced from 1978 to 2012.

International collaboration

Based on the publications data, Figure 4 shows the total number of collaborating countries, which consists of 52 countries spanning five continents: America, Europe, Asia, Australia and Africa.

Among the Saudi's major collaborating partners, with the largest share (21.26 per cent) of collaborative papers during 1978-2012, is the USA, followed by Canada (10.28 per cent), United Kingdom (8.59 per cent), China (7.6 per cent), Pakistan (4.3 per cent), Egypt (3.5 per cent), Taiwan, South Korea, Malaysia, Tunisia, Algeria, Australia, UAE and France (with publications share from 2.95 to 2.11 per cent). India, Germany, Italy, Japan, Jordan, Scotland, Poland and Turkey (with publications share from 1.83 to 1.12 per cent) and the rest were below 1 per cent of the publication share.

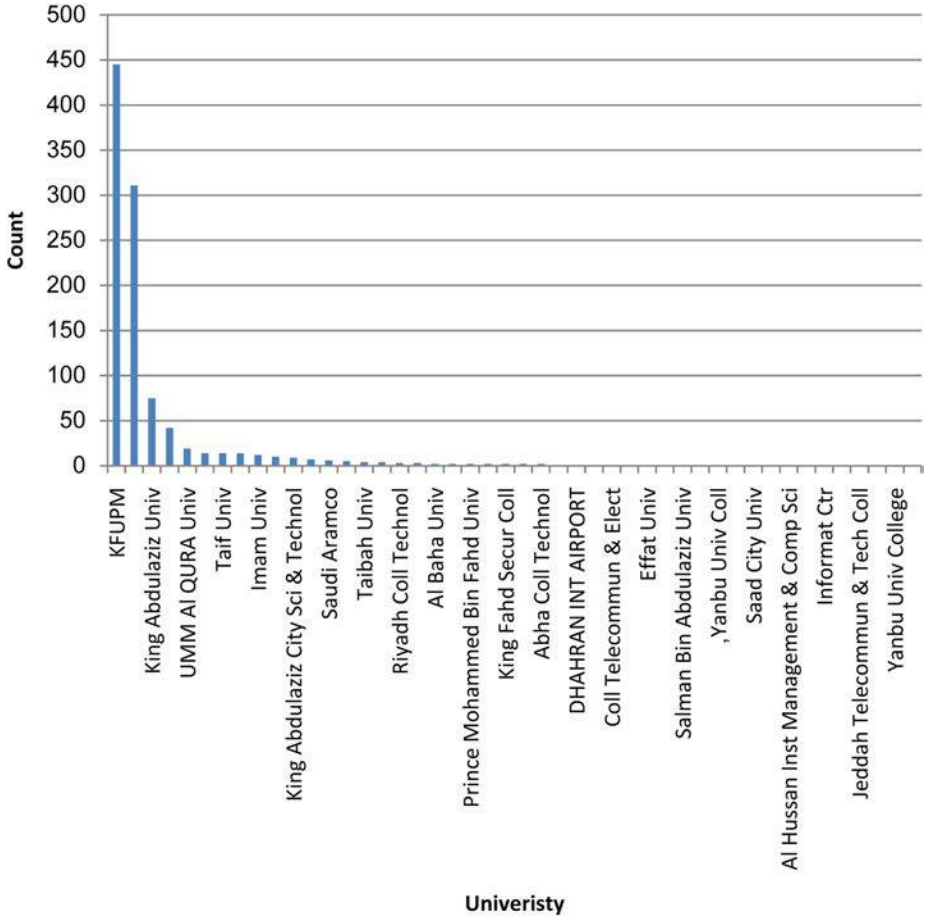

Figure 3.
Publication distribution among Saudi Universities

During the period 1978-2006 (28 years), the share of international collaborative publications was in its minimum, with the USA, Canada and United Kingdom being among the top countries in collaboration. Also, China, Pakistan, Egypt, Taiwan, South Korea and Malaysia were barely contributing. In contrast, the period 2007-2012 (five years) has witnessed an increase in all countries and the emergence of collaboration with new countries such as South Africa, Lebanon, Chile, Switzerland, Morocco, Brazil, Ireland and Greece. This flourishing period was because of the reform done in the Ministry of Higher Education after the scandal of Saudi universities' worldwide ranking[2].

Active authors in Saudi computer science

Taking into considerations the impact and contribution of outstanding authors in computer science research in Saudi Arabia, ten authors are identified as prolific researchers who have published more than ten papers during 1978-2012. Table I shows the top productive authors in our data set; we used Publish or Perish tool to help in

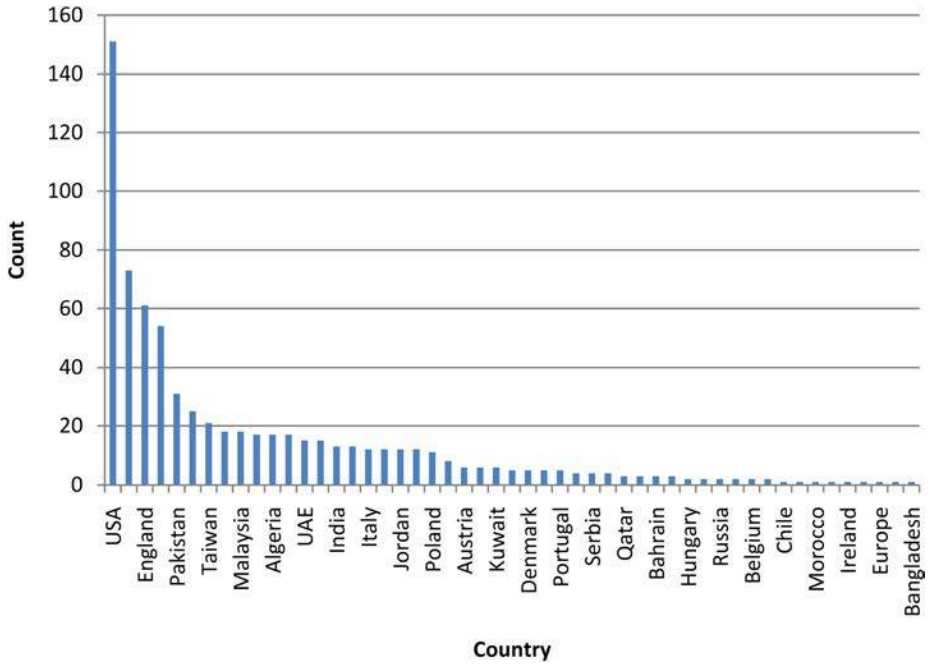

Figure 4.
Distribution of international collaboration

Table I.
Top productive authors with ten papers or more along with their affiliations, TP (total papers in WoS), TPiG (total papers in general from publish or perish), TC (total citations), ACPP (average citation per paper), *h* index and SoIC (share of international collaboration)

Numbers	Author name	Affiliation	TP	TPiG	TC	ACPP	*h* index	SoIC (per cent)
1	Muhammad Khurram Khan	KSU	32	271	1,239	4.57	16	32/32 (100)
2	Sadiq M. Sait	KFUPM	22	236	1,807	7.66	16	4/22 (18.18)
3	Muhammad Sarfraz	KFUPM	21	505	3,466	6.86	31	6/21 (28.57)
4	Khaled H. Salah	KFUPM	20	269	882	3.28	16	9/20 (45)
5	Muhammad Taher Abuelma'atti	KFUPM	20	618	2,480	4.01	26	1/20 (5)
6	Said Salah Eldin Hamed Elnashaie[#]	KSU	11	289	2,796	9.67	26	11/11 (100)
7	Magdi S. Mahmoud	KFUPM	11	447	5,523	12.36	35	8/11 (72.72)
8	Khaled Alghathbar	KSU	10	134	432	3.22	10	8/10 (80)
9	Habib Youssef	KFUPM	10	328	2,965	9.04	25	5/10 (50)
10	Sabri A. Mahmoud	KSU/KFUPM	10	116	930	8.02	13	2/10 (20)

Note: [#] A visiting professor in KSU

fetching more information about each author. Of these authors, six are affiliated with KFUPM, followed by three with KSU and one author who was affiliated with KSU later changed his affiliation to KFUPM. We can observe that the top authors were from two universities: KSU and KFUPM. This is logical because they are the oldest universities in Saudi Arabia. These ten authors together contributed 167 papers (16.8 per cent share) in cumulative publication output of Saudi Arabia.

Furthermore, the *h* index of these top ten authors fluctuates between 10 and 35 with average *h* index per author as 21.4. Five authors have showed higher *h* index than the

average *h* index of all ten authors (21.4). The highest *h* index is registered by Magdi S. Mahmoud (35) from KFUPM, followed by Muhammad Sarfraz (31) also from KFUPM, Muhammad Taher Abuelma'atti (26) from KFUPM, Said Salah Eldin Hamed Elnashaie (26) from KSU and Habib Youssef (25) from KFUPM. Notice that most authors with the highest *h* index are from KFUPM.

The average share of international collaborative papers of these ten authors is 51.94 and it varies from 5 to 100 per cent. Four authors have recorded higher than the average share of international collaborative papers. These are Muhammad Khurram Khan (100 per cent share), Said Salah Eldin Hamed Elnashaie (100 per cent share), Khaled Alghathbar (80 per cent share) and Magdi S. Mahmoud (72.72 per cent share). Notice that Salah Eldin Hamed Elnashaie is actually a visiting professor in KSU, and therefore, when writing his affiliation, he writes his original affiliation and KSU.

Authorship patterns

The number of authors per article ranged from 1 to 9, with an average of 2.45 authors per article. Two authors' articles accounted for the highest percentage (30.5 per cent), followed by single author"s articles (27.53 per cent) and three authors' articles (23.6 per cent). Regarding four, five, six, seven, eight and nine authors it was 11.75, 3.41, 1.4, 0.8, 0.7 and 0.2 per cent, respectively.

Figure 5 shows that single-author articles as well as two-author articles are increasing over years in steady pace. This might be attributed to the fact that rules of academic promotion in Saudi Arabia lean toward having publication by single authors in order to get the points for promotion. However, three-and four-author articles have witnessed steady increase until year 2011, but afterward it showed a decline. As for five-author articles it only started in 1984 and showed an increase in years 2010, 2011 and 2012. On the other hand, six-, seven-, eight-and nine-author articles were not that common before year 2007.

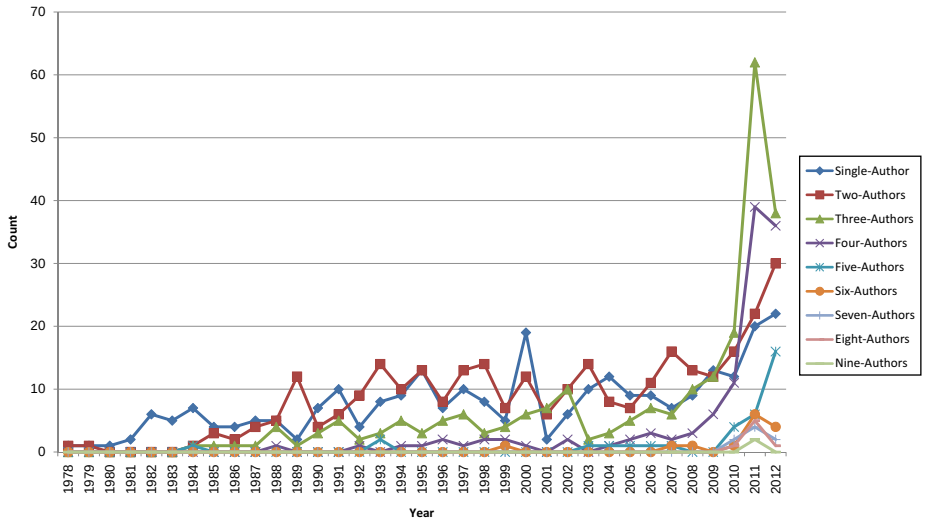

Figure 5.
Count of articles authored by different number of authors through the years

Trends of publications

Inspecting the research areas' field displayed in WoS for each article, we found that the maximum research priority (329 publications, 33 per cent share) is assigned to engineering, followed by mathematics (112 publications, 11.22 per cent share), telecommunications (102 publications, 10.2 per cent share), automation and control systems (88 publications, 8.81 per cent share each), operation research and management science (74 publications, 7.41 per cent share), *Information Science and Library Science* (36 publications, 3.6 per cent share), *Optics and Business and Economics* (13 publications each, 1.31 per cent share), *Medical Informatics* (11 publications, 1.10 per cent share), *Physics* (6 publications, 0.6 per cent share), *Imaging Science and Photographic Technology* (5 publications, 0.5 per cent share), *Health Care Sciences and Services* (4 publications, 0.4 per cent share), *Robotics, Physical Geography and Neurosciences and Neurology* (3 publications each, 0.3 per cent share), *Mathematical and Computational Biology and Mechanics* (2 publications each, 0.2 per cent share) and, finally, *Chemistry, Instruments and Instrumentation, Radiology, Nuclear Medicine and Medical Imaging* (1 publication each, 0.1 per cent share).

Of 17 research areas reported above, only engineering, mathematics and telecommunication research areas witnessed increase in their activities from 1978 to 2011 as reflected in Figure 6, while in the remaining research areas there is stability in publication activity.

In terms of publishing journals, Table II shows the top 25 journals that have publication count ten or more. Among the 249 journals Saudi computer scientists published in, only 25 journals (10 per cent) have 10 articles or more, and these 25 journals represent 47.98 per cent of the total publications. The rest 119 journals (47.7 per cent) published between 9 and 2 articles.

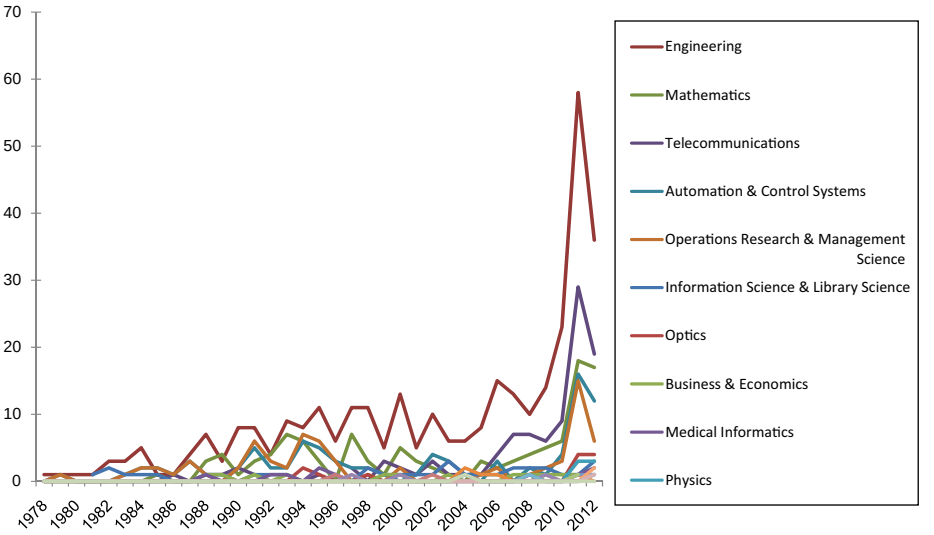

Figure 6.
Growth of research areas in the period 1978–2012

Journal	Number of articles	Impact factor
Mathematical and Computer Modelling	61	1.346
International Journal of Systems Science	37	0.991
Computer Communications	30	1.044
Computers and Electrical Engineering	30	0.837
Expert Systems with Applications	29	2.203
Information Sciences	29	2.833
Analog Integrated Circuits and Signal Processing	27	0.592
international Journal of Innovative Computing Information and Control	25	0
IEEE Transactions on Reliability	20	1.285
Pattern Recognition	19	2.292
Journal of Systems and Software	16	0.836
Computers and Graphics	15	1
Engineering Applications of Artificial Intelligence	13	1.665
Canadian Journal of Electrical and Computer Engineering-Revue Canadienne de Genie Electrique et Informatique	11	0.241
Computer Systems Science and Engineering	11	0.371
Fuzzy Sets and Systems	11	1.759
IEEE Transactions on Information Theory	11	3.009
Microprocessing and Microprogramming (Journal of Systems Architecture)	11	0.724
Wireless Communications and Mobile Computing	11	0.884
Advances in Engineering Software	10	1.092
Information and Management	10	2.214
International Arab Journal of Information Technology	10	0.127
Journal of Network and Computer Applications	10	1.065
Neurocomputing	10	1.58
Pattern Recognition Letters	10	1.034

Table II.
Top publishing journals with their impact factor

Discussion and conclusion

In this paper we have investigated the scientometric assessment of Saudi research performance in the field of computer science, during the period of 1978–2012.

Bibliometric methods have been used to conduct this study; also data from ISI WoS have been used. Thirty-five years of publication window gave us a good understanding of the research areas Saudi computer scientists work on, their international collaboration and their scientific impact.

The research outputs from computer scientists in Saudi Arabia have remained at relatively low level until 2007. Afterward, the publication productivity has increased remarkably using a catch-up strategy. This strategy was critiqued in an article by Bhattacharjee (2011) published in Science. In fact, we noticed affiliated researchers that publish in high impact factor journals were not actually from Saudi universities. Consulting the list of highly cited computer science researches in the ISI Highly Cited database (http://highlycited.com), we found that 18 were affiliated to King Abdulaziz University, 2 for KSU, 1 for KAUST and 1 for KFUPM. However, having such highly citied researchers associated with Saudi universities did not change significantly the scientific output of Saudi computer scientists. Hence, many publications do not have a

significant impact on the international scientific output due to their low citation count. The results of the scientometric assessment showed that KFUPM has shown good quality of research as well as having prolific researchers. This might be attributed to the work environment that the university provides.

Examining the distribution of research areas in Saudi computer science publications, we found that most publications that focused on engineering, mathematics and telecommunications areas are influenced by KFUPM's prominent presence in WoS. On the other hand, active researchers in Saudi Arabia showed that they rely on international collaboration to publish in high impact journals. Most Saudi researchers were highly visible in WoS after 2007, and international collaboration has increased accordingly with this movement.

Given all the efforts invested by Saudi Higher Education institutes to increase the visibility and impact of Saudi research output in WoS; yet, the scientific impact of computer science publications suffer from low international visibility and low volume. This might be attributed to three factors:

(1) researchers prefer to publish their research results in domestic journals or fast-track non-indexed journals;

(2) most of Saudi Arabia universities have only a teaching function, which hinders scientists from conducting research; and

(3) also, language barriers might be another reason of the low productivity of computer science publications, even though most of the PhD holders in this field have graduated from Western universities in USA, UK, Canada and Australia.

We also noticed that most published articles were in low impact factor journals, and because of that the research output by Saudi scientists is still way behind the major occidental countries as well as some Asian countries such as Malaysia and India. Furthermore, there was shortage in female computer scientists in the data set; we only spotted few Saudi female names publishing in WoS.

The research tradition in Saudi Arabia higher education is, perhaps, less well established thus far and is still under active development. Most examined publications do not have an impact on the computer science field. Therefore, we can conclude, the research output in the field of computer science in Saudi Arabia is relatively low, and there is also a shortage of qualified researchers in this field; most names appeared in the prominent authors list were actually non-Saudi residents. The number of Saudi PhD holders that are publishing in WoS is low. As a result, the government must undertake actions to urge Saudi computer scientists to conduct more robust and rigor research and publish in prestigious venues. This can be achieved by promoting "research culture" among juniors through mentorship, the establishment of designated research groups staffed by Saudi PhD holders and the development of PhD programs that are linked to strong international universities.

Also the Ministry of Communications and Information Technology should play a role in improving Saudi computer science research output by setting up centers of excellence at leading research and academic institutions staffed with various faculty members and involving multiple specialties.

Notes

1. http://thomsonreuters.com/journal-citation-reports/
2. The July 2006 announcements of the Webometrics rankings caused an embarrassment to Saudi universities because KFUPM (the only Saudi University in the list) ranked 2,998 of 3,000 worldwide (Smith and Abouammoh, 2013).

References

Abrizah, A. and Wee, M.-C. (2011), "Malaysia's computer science research productivity based on publications in the web of science, 2000-2010", *Malaysian Journal of Library and Information Science*, Vol. 16 No. 1, pp. 109-124.

Al-Salman, A.S. and Adeniyi, J. (2000), "Computer science education in a Saudi Arabian university: a comparative study of its B.Sc. program", *SIGCSE Bulletin*, Vol. 32 No. 4, pp. 34-39.

Bakri, A. and Willett, P. (2011), "Computer science research in Malaysia: a bibliometric analysis", *Aslib Proceedings*, Vol. 63 Nos 2/3, pp. 321-335.

Bar-Ilan, J. (2010), "Web of science with the conference proceedings citation indexes: the case of computer science", *Scientometrics*, Vol. 83 No. 3, pp. 809-824.

Bhattacharjee, Y. (2011), "Saudi universities offer cash in exchange for academic prestige", *Science*, Vol. 334 No. 6061, pp. 1344-1345.

Van Eck, N.J . and Waltman, L. (2010), "Software survey: VOSviewer, a computer program for bibliometric mapping", *Scientometrics*, Vol. 84 No. 2, pp. 523-538.

Fu, L.D., Aphinyanaphongs, Y. and Aliferis, C.F. (2013), "Computer models for identifying instrumental citations in the biomedical literature", *Scientometrics*, Vol. 97 No. 3, pp. 871-882.

Gu, Y. (2002), "An exploratory study of Malaysian publication productivity in computer science and information technology", *Journal of the American Society for Information Science and Technology*, Vol. 53 No. 12, pp. 974-986.

Guan, J. and Ma, N. (2004), "A comparative study of research performance in computer science", *Scientometrics*, Vol. 61 No. 3, pp. 339-359.

Gupta, B.M., Kshitij, A. and Verma, C. (2010), "Mapping of Indian computer science research output, 1999–2008", *Scientometrics*, Vol. 86 No. 2, pp. 261-283.

Ibáñez, A., Larrañaga, P. and Bielza, C. (2011), "Using Bayesian networks to discover relationships between bibliometric indices. A case study of computer science and artificial intelligence journals", *Scientometrics*, Vol. 89 No. 2, pp. 523-551.

Ibáñez, A., Larrañaga, P. and Bielza, C. (2013), "Cluster methods for assessing research performance: exploring Spanish computer science", *Scientometrics*, Vol. 97 No. 3, pp. 571-600.

Katsaros, D., Matsoukas, V. and Manolopoulos, Y. (2008), "Evaluating Greek departments of computer science/engineering using bibliometric indices", *Proceedings Panhellenic Conference in Informatics*, available at: http://delab.csd.auth.gr/papers/PCI08kmm.pdf (accessed 3 August 2013).

Labbé, C. and Labbé, D. (2013), "Duplicate and fake publications in the scientific literature: how many SCIgen papers in computer science?", *Scientometrics*, Vol. 94 No. 1, pp. 379-396.

Liang, L. Kretschmer, H., Guo, Y. and Beaver, D de B. (2001), "Age structures of scientific collaboration in Chinese computer science", *Scientometrics*, Vol. 52 No. 3, pp. 471-486.

Liu, Z., Liu, Y., Guo, Y. and Wang, H. (2013), "Progress in global parallel computing research: a bibliometric approach", *Scientometrics*, Vol. 95 No. 3, pp. 967-983.

Smith, L. and Abouammoh, A. (2013), *Higher Education in Saudi Arabia: Achievements, Challenges and Opportunities*, Springer Verlag, Berlin.

Wainer, J., Xavier, E.C. and Bezerra, F. (2009), "Scientific production in computer science: a comparative study of Brazil and other countries", *Scientometrics*, Vol. 81 No. 2, pp. 535-547.

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