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Original Research

Scientific Outputs and Co-authorship Patterns in the Fields of Electronic, Civil and Mechanical Engineering of Azarbaijan Shahid Madani University (2000-2019): A Scientometric Analysis

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Abstract

The purpose of this study was to investigate the scientific outputs and co-authorship patterns of Azarbaijan Shahid Madani University in the fields of electrical, civil, and mechanical engineering, based on Web of Science (2000-2019). The paper relied on both quantitative and scientometric methods. 1870 and 291 records were retrieved respectively for "Azarbaijan Shahid Madani University" and "the fields of electrical, civil, and mechanical engineering". The questions and assumptions were answered through descriptive and inferential statistics. VOSviewer and SPSS were used respectively for mapping and testing assumptions. The findings showed that the total scientific outputs of electrical engineering in the world, indexed by the Web of Science (2000-2019) were 2,973,902, of which 44,768 records (1.6%) belonged to Iran (rank 16). During the same period, the total civil engineering records was 395,649, of which 11,876 records (3%) belong to Iran (rank 10). In addition, the total scientific outputs of mechanical engineering were 941,586, of which 25,263 records (2.7%) belonged to Iran (rank 12). The findings showed that in Iran Azarbaijan Shahid Madani University in electrical engineering is ranked 36th (2000-2019). The findings showed that Ajami with 43 (17%), Hoveidae with 5 (23%), Gharraei and Mohammadpourfard, each with 10 records (17%), were the top authors in the fields of electrical, civil, and mechanical engineering (2000-2019), respectively. Also, Ajami with 43 (1000 citations), Najafi with 42 (564 citations), Banaei with 41 records (473 citations), and Oskuee with 16 records (305 citations) have high co-authorship densities (37, 31, 22, and 29, respectively). Moreover, there was no meaningful difference between men and women in electrical, civil, and mechanical engineering in scientific outputs (Sig=0.0927). Furthermore, there was a significant difference in scientific outputs among electrical, civil, and mechanical engineering researchers in departments and university ranks.

Keywords: Scientometrics, Web of Science, Co-authorship Network, Co-authorship Density, Azarbaijan Shahid Madani University, Iran.

Introduction

In today's world, research and scientific production are associated with national progress, and quality and quantity of scientific production are considered critical elements of the development index (Osareh, Soheili, Farajpahlo & Moarefzadeh, 2012). The status of scientific production is one of the major criteria for the sustainable growth of countries (Noroozi Chakoli & Madadi, 2015). A set of reliable methods is used to measure the quality and quantity of scientific production. Scientometrics is one the most common methods in this context (Soheili & Osareh, 2007; Repanovici, 2010; Osareh et al., 2012). Today, scientometrics studies in different subject matters (such as science mapping and visualizing scientific publications) are carried out internationally (Heydari & Safavi, 2012). The measure of the scientific production indexed in reliable databases like Web of Science (WoS) is one of the most important criteria of scientific evaluation and ranking (countries, researchers, educational centers, and universities) globally. The quantity of university participation and contribution, the degree of co-authorship, scientific production growth, citations, etc., are determined by scientometrics methods (Yousefi, Gilvari, Shahmirzadi, Hemmat & Keshavarz, 2012).

Researchers consider scientific collaboration to effectively utilize resources, share knowledge, and prevent mistakes from duplication and repetition (Hudson, 1996). A co-authored paper is an indication of collaboration between researchers. Collaboration results in author networks among researchers (Soheili & Mansoori, 2014). Different authors (As nodes) and links would be identifiable in such networks. Creating nodes by connecting researchers to each other via scientific collaboration and co-authorship (*By links between them*) would result in a type of social network, showing researchers' circles and scientific borrowings (Newman, 2004). Furthermore, visualizing co-authorship networks and scientific maps would contribute to future planning and balanced development in different fields of study while increasing awareness about the status of research (Shekofteh & Hariri, 2013).

Many studies have been carried out for analyzing scientific production (Mehrad & Naseri, 2009; Osareh, Norouzi Chakoli & Keshvari, 2010; Erfanmanesh, 2011; Asadi, Joulaei, Saqafi & Bazrafshan 2014; Riahiasl & Sharafi, 2016; Noorafrooz, Vaezi & Ghodrat 2016; Tavkolizadehravary, Hazeri, Nagafi & Soheili, 2016; Ebadollah Amouqhin & Ziaei, 2017; Abbasiniasar & Ghaffari, 2017; Fazelivarzaneh, Bahmani & Ghaderiazad, 2018; Mostafavi & Pounaki, 2020) and mapping co-authorship networks (Nikzad, Jamali & Hariri, 2011; Osareh et al., 2012; Ahmadi, Osareh & Soheili, 2013; Roshani, Ghazinoori & Tabatabaiyan 2013; Soheili et al., 2013; Osareh, Serati Shirazi & Khademi, 2014; Yaminfirooz, Gilvari, Shahmirzadi, Hemmat & Keshavarz, 2016; Tahmasbi, 2017; Mousavi Chalak & Riahi, 2018; Zandian, Moradian & Hassanzadeh, 2018; Shahbazi, 2019; Haidari, Zavaraqi & Mokhtarpour, 2020) in Iran and abroad (Lee, 2003; King, 2004; Bartol, Budimir, Dekleva-Smrekar, Pusnik & Juznic, 2014). For example, Tahmasebi (2017) in his research about scientific production and co-authorship networks among the researchers of Tehran Research Institute of Tuberculosis and Lung Diseases, has shown that authors have little desire for scientific collaboration. In another research dedicated to studying scientific production and co-authorship networks of researchers of the Azarbaijan University of Shahid Madani in basic sciences, Shahbazi (2019) showed that researchers with higher scientific collaboration play a major role in structuring co-authorship networks. Also, Zandian et al. (2018) found that the co-authorship network of medical science researchers in Iran has a modest cohesion. Mousavi

Chalak and Riahi (2018) found that Iran has a relative growth of scientific production in diabetes on regional and international levels. In another study, Osareh et al. (2014) found that scientific collaboration among Iranian researchers in pharmacology has been reasonable.

Literature review indicates that no research has been done about the scientific production of researchers of Azarbaijan Shahid Madani University (ASMU) in the fields of electrical, civil, and mechanical engineering. These fields are important because they are related to subfields such as construction, electronic systems, machinery, industrial parts, and thermal, fluid, and agricultural systems. It is imperative to identify the position of different countries, universities, and related people in the world ranking and analyze the scientific production and collaboration among the researchers of the aforementioned fields. As a response to the lack of necessary and sufficient information about the status of scientific production and collaboration among the researchers of the Faculty of Engineering (the fields of electrical, mechanical, and civil engineering) of Azarbaijan Shahid Modani University, the present study is an effort to study, compare and analyze scientific trends of these researchers in the Web of Science (WoS). The findings of this research would contribute to setting future direction and planning for a balanced development of different fields of study.

Research Questions

1. What are the trends of scientific production in electrical, civil, and mechanical engineering (2000-2019) in Azarbaijan Shahid Madani University (ASMU), and what is Iran's standing in the world ranking in these fields?
2. Who are the most productive electrical, civil, and mechanical engineering researchers at ASMU?
3. What is the status of co-authorship among the researchers of ASMU in the fields of electrical engineering, civil, and mechanical engineering?
4. What is the status of international scientific collaboration among researchers of ASMU in the fields of electrical, civil, and mechanical engineering?
5. What is the density of co-authorship among the researchers of ASMU in the fields of electrical, civil, and mechanical engineering?

Research Hypotheses

1. The averages of scientific outputs of electrical, civil, and mechanical engineering faculty members vary according to gender.
2. There are no significant differences between the averages of the scientific outputs of electrical, civil, and mechanical engineering departments.
3. Averages of scientific outputs of faculty members of electrical, civil, and mechanical engineering departments vary according to the researchers' academic ranks.

Materials and Methods

The present study applied a quantitative approach by using scientometrics methodology. Scientometrics has previously been used in many studies (Zandian et al., 2018; Fazelivarzaneh et al., 2018; Shahbazi, 2019; Bahari & Moody, 2020; Zakiani, Ghaffari & Imandoost, 2020). Scientific outputs of researchers of Azarbaijan Shahid Madani University and Engineering Faculty (the fields of electrical, civil, and mechanical engineering) and Iran's scientific production in these fields indexed in WoS from 2000 to 2019 make up the statistical

population of this research. Also, the data from the Azarbaijan Shahid Madani University scientometrics system has been used to test the research hypotheses.

***CU**=IRAN Refined by: organizations-enhanced: (Azarbaijan Shahid Madani univ) **Timespan**: 2000-2019. **Indexes**: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, I.C. **Results**: 1,870*

We Used the above search formulae, and 215, 17, and 59 documents (records) were found in the fields of electrical, civil, and mechanical engineering, respectively. Also, 1870 documents from Azarbaijan Shahid Madani University in WOS were identified and analyzed. SPSS was used to analyze the data, and VOSviewer was used to map the scientific production. Finally, an independent t-test and analysis of variance were utilized to answer the research hypotheses.

Findings

Based on the findings, the total number of scientific productions of Azarbaijan Shahid Madani University researchers indexed in WoS is 1870 documents (2000-2019). There are 215, 17, and 59 indexed electrical, civil, and mechanical engineering documents, respectively (Total 291). Findings indicate the steady growth of scientific production in electrical engineering, with the only exception of 2017, in which there was a minor decrease. The scientific production in the field of electrical engineering doubled in 2019 in comparison to the previous year. On a similar note, the scientific production in civil engineering quadrupled in 2019 compared to the previous year. Finally, scientific production in mechanical engineering enjoyed a similar growth during the previous years (Table 1).

Table 1

The trend of scientific production of researchers in the fields of electrical, civil, and mechanical engineering of Azarbaijan Shahid Madani University based on the data from Web of Science

Row	Field of Study / Year	Engineering, Civil		Engineering, Mechanical		Engineering Electrical Electronic	
		Frequency	%	Frequency	%	Frequency	%
1	2019	9	52.00	10	17.00	50	23.00
2	2018	2	12.00	9	15.00	27	12.50
3	2017	1	6.00	6	10.00	21	9.50
4	2016	3	18.00	١٠	17.00	27	12.50
5	2015	2	12.00	11	19.00	33	15.50
6	2014	-	-	8	13.50	28	13.50
7	2013	-	-	3	5.00	21	9.50
8	2000-2012	-	-	2	3.50	8	4.00
Total		17	100%	59	100%	215	100%
AZARBAIJAN SHAHID MADANI UNIV (ASMU)= 1870							

Table 2 indicates that the total number (2000-2019) of electrical and electronic engineering documents indexed by WoS is 2,973,902, of which 44,768 documents (1.6%) belong to Iran (rank 16). China, the USA, and Japan respectively are in the first to third ranks. In the same period, the total number of civil engineering documents indexed by WoS was 395,649, of which 11,876 documents (3%) belong to Iran (rank 10). Here, China, the USA,

and England lead the ranking. Finally, in the same period, the total number of mechanical engineering documents indexed by WoS is 941,586, of which 25,263 documents (2.7%) belong to Iran (rank 12). China, the USA, and Japan are in first to third place respectively.

According to the researchers of the present article, Azarbaijan Shahid Madani University is ranked 36th among Iranian universities in electrical and electronic engineering in the period 2000-2019. The Sharif University of Technology, Tehran University, and the Amirkabir University of Technology are first to third ranks. Azarbaijan Shahid Madani University ranks 51st among Iranian universities in mechanical engineering, and the Sharif University of Technology, Amirkabir University of Technology, and Tehran University respectively lead the ranking. Finally, in civil engineering, Azarbaijan Shahid Madani University stands at 57 among Iranian universities, and Tehran University, Iran University of Science and Technology, and Amirkabir University of Technology respectively lead the ranking.

Table 2
Countries with the highest levels of scientific outputs in the fields of electrical, mechanical, and civil engineering (Timespan 2000-2019)

Rank	Engineering Electrical Electronic	%	Engineering, Mechanical	%	Engineering, Civil	%
1	China (586,405)	21%	China (222,059)	23.6%	China (92,016)	23%
2	USA (563,222)	20%	USA (173,047)	18.3	USA (81,037)	20.4%
3	Japan (191,035)	7%	Japan (48,157)	5.1	England (18,214)	4.6%
4	India (149,729)	5%	Germany (46,398)	4.9%	Italy (16,678)	4.2%
5	Germany (131,412)	4.7%	England (45,724)	4.8%	Canada (16,663)	4.2%
6	S. Korea (118,530)	4.2%	France (44,534)	4.7%	Germany (15,109)	3.8%
10	Italy (95,981)	3.4%	Russia (30,389)	3.2%	*Iran* (11,876)	*3%*
12	-	-	*Iran* (25,263)	*2.7%*	-	-
16	*Iran* (44,768)	1.6%	-	-	-	-
World	*2,793,902* Documents	100%	941,586 Documents	100%	395,649 Documents	100%

According to the findings, Ali Ajami, with 43 documents (17%), has the highest ranking in producing electrical and electronic engineering documents, Nader Hoveidae with 5 documents (23%) has the highest ranking in the field of civil engineering, and Reza Gharraei and Mousa Mohammadpourfard each with 10 documents (17%) have the highest ranking in the field of mechanical engineering in the period 200-2019 (Table 3). Furthermore, Mohammadreza Banaie (42) and Sajad Najafi (41) in electrical and electronic engineering, Hosein Soltani-Jigheh (3) and Akbar Heidarzadeh (3) in civil engineering, and AmirHosein Mosaffa (6) and Naier Razmara (5) in mechanical engineering, are ranked second and third, respectively.

Table 3
Top authors with the highest levels of scientific output in the fields of electrical, civil, and mechanical engineering at Azarbaijan Shahid Madani University based on the data from WoS

	Engineering, Electrical, and Electronic n=215			Engineering, Mechanical n=59			Engineering, Civil n=17		
Row	% of 215	Frequency	Researcher's Name	% of 59	Frequency	Researcher's Name	% of 17	Frequency	Researcher's Name
1	17.0%	43	Ajami Ali	17%	10	Mohammadpour Fard Mousa	13.6%	5	Hoveidae Nader
2	16.0%	42	Banaei M. Reza	17%	10	Gharraei Reza	12.0%	4	Soltani-Jigheh Hosein
3	11.0%	41	Najafi Sajad	10%	6	Mosaffa AmirHosein	6.3%	3	Heidarzadeh Akbar
4	7.6%	16	Oskuee MRJ (PhD Student)	8.5%	5	Razmara Naier	-	2	Dini Mehdi
5	5.6%	12	Behjat Vahid	-	3	Saviz MR	-	2	Rezaei AH
6	4.2%	9	Safari Amin	-	3	Hashemi MH	-	-	-
7	3.8%	8	Salehi Javad	-	-	-	-	-	-
8	-	5	Hosseinzadeh S	-	-	-	-	-	-
9	-	4	Monfaredi Khalil	-	-	-	-	-	-
10	-	3	Yousefi M	-	-	-	-	-	-

Based on the findings (Table 4), from 215 published documents by Azarbaijan Shahid Madani University's researchers in the field of electrical engineering, 10 documents (5%) have a single author, 69 documents (32%) have two authors, and 136 documents (63.00%) have three or more authors. From 17 documents published in the field of civil engineering, 5 documents (29%) have a single author, 2 documents (29%) have two authors, and 10 documents (58.80%) have three or more authors. From 59 documents published in the field of mechanical engineering, 9 documents (15.25%) have a single author, 5 documents (8.74%) have two authors, and 45 documents (56.26%) have three or more authors.

Table 4
The status of co-authorship among the researchers of electrical, civil, and mechanical engineering in Azarbaijan Shahid Madani University

Row	Field of study Authors	Electrical and electronic engineering		Civil engineering		Mechanical engineering	
		Number	%	Number	%	Number	%
1	Single author	10	5.00	5	29.00	9	15.25
2	Two authors	69	32.00	2	11.76	5	8.47
3	Three or more authors	136	63.00	10	58.80	45	56.26

Total	215	100	17	100	59	100
Co-authorship coefficient	*0.63*		*0.52*		*0.58*	

Based on the findings, international scientific collaboration among electrical engineering researchers at the Azarbaijan Shahid Madani University has been more than civil engineering and mechanical engineering. In the field of electrical engineering, China (4%), Belgium (3%), and Germany (3%) respectively occupied the three top ranks regarding scientific collaboration. In the field of civil engineering, Iraq (4%), Vietnam (2%), and Equator (2%) respectively stood at the three top ranks regarding scientific collaboration in this university. Finally, in mechanical engineering, Canada, Netherlands, and United States had the greatest number of scientific collaborations with Azarbaijan Shahid Madani University (Figures 1 to 3).

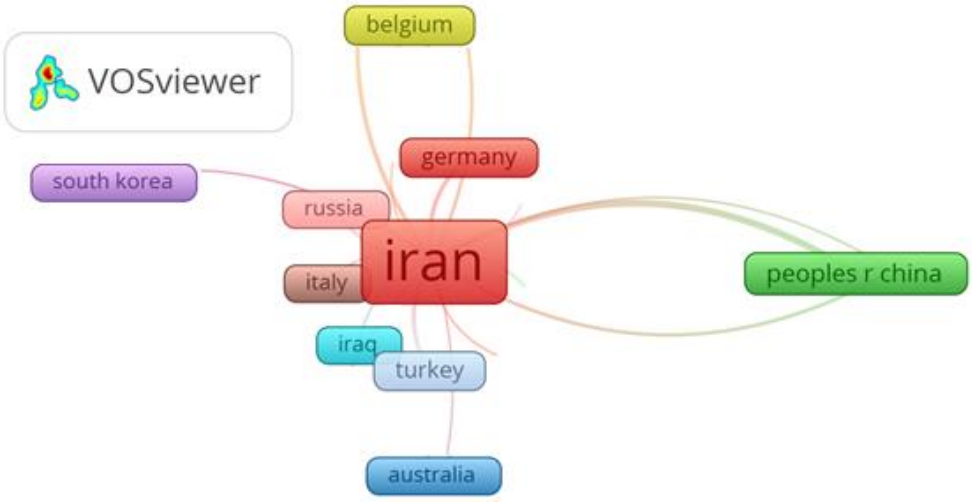

Figure 1. The map of international scientific collaboration among the researchers of Azarbaijan Shahid Madani University in the field of electrical and electronic engineering

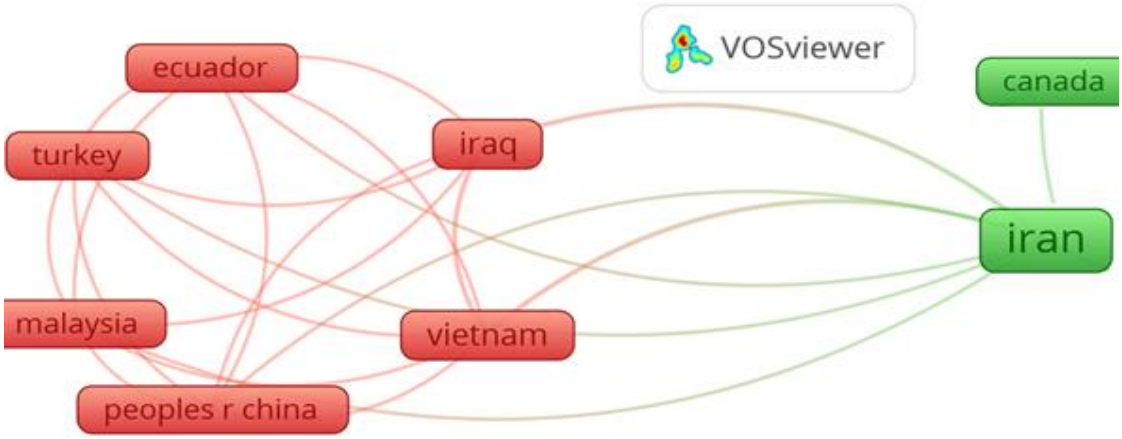

Figure 2. The map of international scientific collaboration among the researchers of Azarbaijan Shahid Madani University in the field of civil engineering

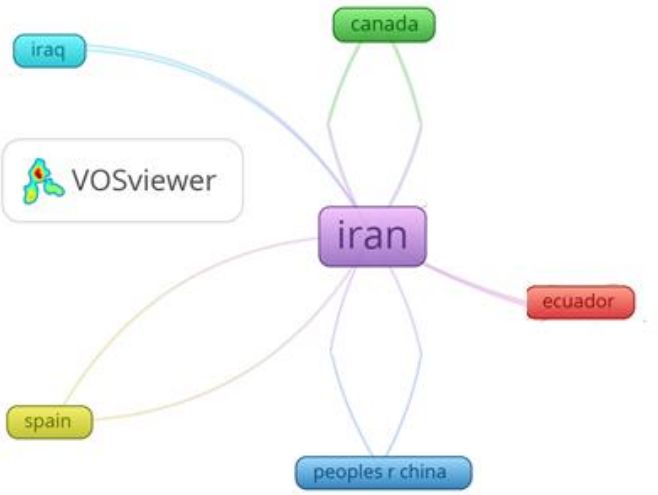

Figure 3. The map of international scientific collaboration among the researchers of Azarbaijan Shahid Madani University in the field of mechanical engineering

The analysis of co-authored network produced 14 clusters of authors (34 authors or nodes) that have 3 or more documents in electrical engineering (figure 4). The findings indicate that Ali Ajami with 43 documents (1000 citations), Sajad Najafi with 42 documents (564 citations), Mohamadreza Banaei with 41 documents (473 citations), and MRJ Oskuee with 16 documents (305 citations) have more co-authorship densities (37, 31, 22, and 29, respectively) than their peers (figure 4).

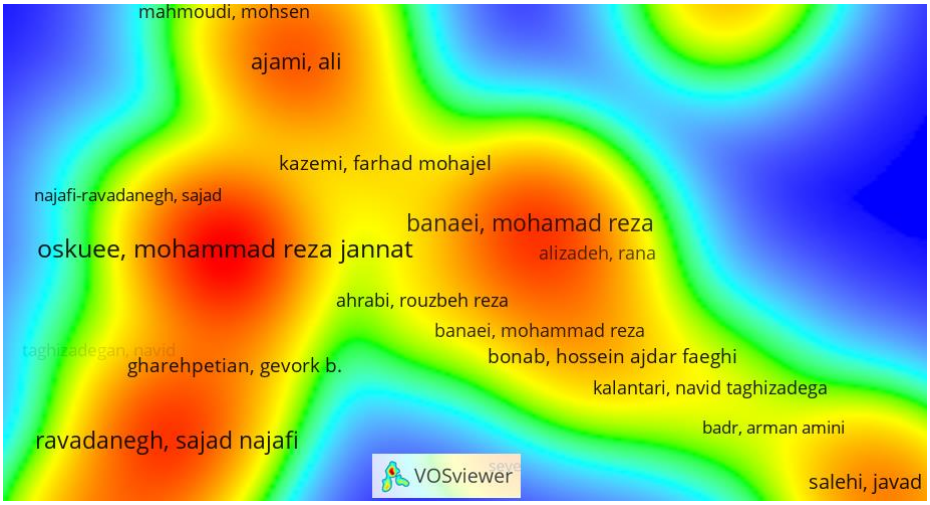

Figure 4. The map of co-authorship density among the researchers of Azarbaijan Shahid Madani University in the field of electrical and electronic engineering

Figure 5 shows the results of the cluster analysis of the co-authorship network, in which there are 12 authorship clusters (37 authors) with at least 1 document in civil engineering. Based on these findings, Hosein Soltani-Jigheh with 4 documents (12 citations), Nader Hoveidae with 4 documents (10 citations), and Akbar Heidarzadeh with 3 documents (78 citations) have more co-authorship densities (4, 1, and 4, respectively) than their peers.

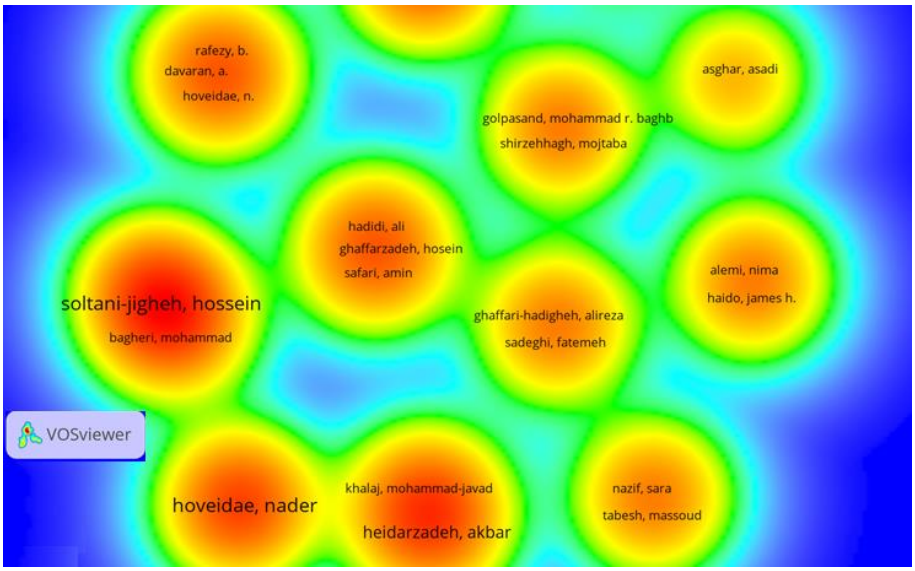

Figure 5. The map of co-authorship density among the researchers of Azarbaijan Shahid Madani University in the field of civil engineering

The co-authorship network analysis in mechanical engineering resulted in 24 authorship clusters (116 authors) with at least 1 document (Figure 6). Based on the findings, AmirHosein Mosaffa with 7 documents (169 citations), Reza Gharraei with 10 documents (49 citations), and Naier Razmara with 5 documents (49 citations) have more co-authorship densities (15, 9, and 7, respectively) than their peers.

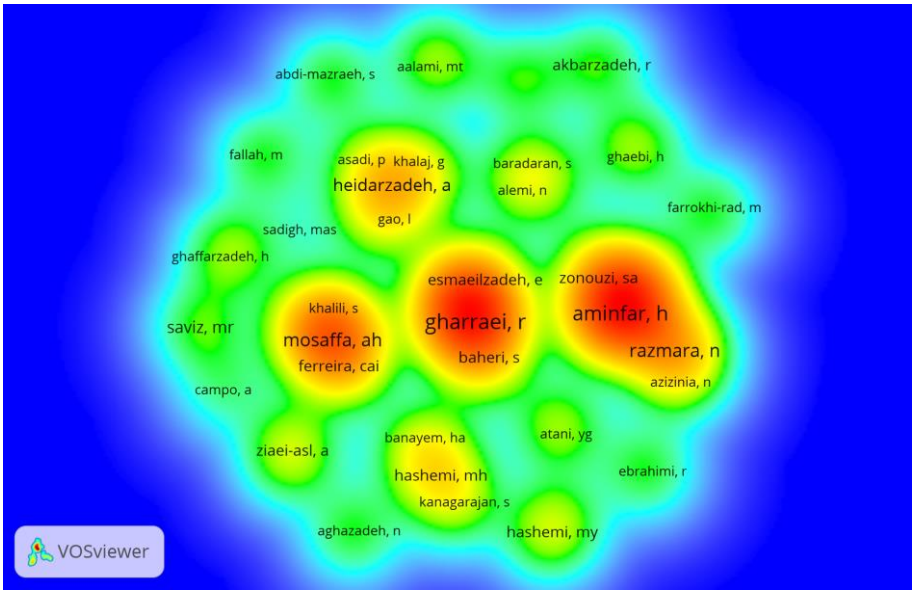

Figure 6. The map of co-authorship density among the researchers of Azarbaijan Shahid Madani University in the field of mechanical engineering

Results of the t-test indicate no meaningful difference between males and females about scientific output in electrical, civil, and mechanical engineering (Sig=0.0927). In other words, in these fields of study, the average scientific production of male faculty members is not higher than that of female faculty members (table 3).

Table 5
Results of the t-test about the difference of scientific output between males and females

Mean		t	df	Sig
Female	Male			
5.51	8.42	.092	38	.0927

The analysis of variance showed a meaningful difference regarding scientific production among researchers of electrical, civil, and mechanical engineering departments (Sig=0.019). As such, electrical engineering faculty members have published 10 more documents than their peers in mechanical engineering and 14 more documents than their peers in civil engineering (Tables 6 and 7).

Table 6
Results of the analysis of variance about the difference of scientific production among the researchers of electrical, civil, and mechanical engineering departments

F	Mean Square	df	Sum of Squares	Sig.
4.410	703.830	2	1407.661	.019

Table 7
LSD Post Hoc Tests for comparison of the average scientific outputs based on departments

Department	Department	Mean Difference (I-J)	Sig.
Department of Civil Engineering	Department of Mechanical Engineering	-4.077	.416
	Department of Electrical Engineering	-13.989*	.007
Department of Mechanical Engineering	Department of Civil Engineering	4.077	.416
	Department of Electrical Engineering	-9.912*	.049
Department of Electrical Engineering	*Department of Civil Engineering*	13.989*	.007
	Department of Mechanical Engineering	9.912*	.049
*. The mean difference is significant at the 0.05 level. LSD: Post Hoc Tests			

The analysis of variance in means of scientific productions based on academic rank shows a meaningful difference (Sig=0.002) (tables 8 and 9). As a result, higher academic rank correlates with higher levels of scientific production among faculty members. Based on table 9, professors have produced 36, 47, and 50 documents more than associate professors, assistant professors, and instructors, respectively.

Table 8

The analysis of variance about the difference in means of scientific productions based on academic rank

Sum of Squares	df	Mean Square	F	Sig.
4747.690	3	1582.563	22.205	.000

Table 9

LSD Post Hoc Test for comparison of the average scientific outputs based on academic rank

(I) Academic Rank	(J) Academic Rank	Mean Difference (I-J)	Sig.
Professor	Associate Professor	36.111*	.000
	Assistant Professor	47.370*	.000
	Lecturer	50.500*	.000
Associate Professor	Professor	-36.111*	.000
	Assistant Professor	11.259*	.001
	Lecturer	14.389*	.036
Assistant Professor	Professor	-47.370*	.000
	Associate Professor	-11.259*	.001
	Lecturer	3.130	.616
Lecturer	Professor	-50.500*	.000
	Associate Professor	-14.389*	.036
	Assistant Professor	-3.130	.616
*. The mean difference is significant at the 0.05 level. Post Hoc Tests: LSD			

Discussion

In this study, the scientific outputs of Faculty Engineering (Fields of electrical, civil, and mechanical engineering) researchers of Azarbaijan Shahid Madani University (ASMU) were analyzed from 2000 to 2019. The findings showed that researchers of ASMU have published 1853 documents during this period. Of these documents, researchers in mechanical engineering have produced 215, 17, and 59 documents (Total 291), respectively. In 2019, the scientific outputs in electrical engineering were doubled, and civil engineering was quadrupled compared to the previous year. The financial incentive for published papers in credible journals might have been one of the reasons for the increase of the scientific output. Another reason might have been the increase of electrical engineering and civil engineering students' acceptance at the graduate level. Supervisors usually guide graduate students to publish their articles in credible journals. In line with the findings for the first research question, Zakiani, Ghaffari & Mohseni (2019) have found that the scientific production in different engineering fields has soared, and the average growth rate of scientific output is satisfactory. Also, Asadi et al. (2014) have indicated that scientific outputs in the Sharif University of Technology in civil, electrical, and electronic engineering are rising. In the Shahid Chamran University of Ahvaz, the highest scientific outputs from 2000 to 2016 belonged to electrical and mechanical engineering (Khademizadeh & Kamaei, 2019). Furthermore, the scientific outputs in different engineering and basic sciences had the highest

growth rate in Kashan University (Abbasi niasar & Ghaffari, 2017) and Mazandaran University (Narimani & Razavi, 2018).

Findings for Azarbaijan Shahid Madani University showed that around 16% of scientific outputs had been done by electrical, civil, and mechanical engineering researchers. Shahbazi (2019) found that 57% of the scientific outputs of Azarbaijan Shahid Madani University were published by physics, chemistry, and mathematics researchers. Around two-thirds (73%) of scientific documents indexed by WoS belonged to researchers of six fields of study during the previous years. Based on the analysis done by the present author (2000-2019)[1], electrical engineering in Azarbaijan Shahid Madani University ranks at 36 among Iranian universities. Sharif University of Technology, Tehran University, and the Amirkabir University of Technology respectively lead the ranking. In mechanical engineering (2000-2019), Azarbaijan Shahid Madani University stands at 51, while the Sharif University of Technology, Amirkabir University of Technology, and Tehran University respectively lead the ranking. Also, in civil engineering, Azarbaijan Shahid Madani University ranks 57th, and Tehran University, Science and Technology University, and the Amirkabir University of Technology respectively occupy the first three positions. In many previous studies, Tehran University is the most prolific producer of science in different fields of study among Iranian universities (Ebrahimi & Hayati, 2008; Erfanmanesh, 2011; Zakiani et al., 2020).

Findings of the present study showed that from 2000 to 2019, Iran has produced 1.6% (44,768) of total scientific outputs of the world in the field of electrical engineering and ranks 16th. At the same time, China (21%), the United States (20%), and Japan (7%) respectively lead the ranking. In the field of civil engineering, Iran, with 3% (11,876) of total scientific production, ranks 10th, while China (23%), the United States (20.4%), and England (4.6%) rank from 1st to 3rd, respectively. In the field of mechanical engineering, Iran accounts for 2.7% (25,263) of total scientific production and ranks 12th, while China (23.6%), United States (18.3%), and Japan (5.1%) respectively occupy the first three ranks. Based on a report by World Bank[2], China, the United States, and Japan were among the strongest economies of the word in 2019. A review of the Scimago[3] indicates that from 1996 to 2019, Unites States was the biggest producer of science in the world (12,839,607 documents), followed by China, the United Kingdom, Germany, Japan, and France, respectively.

Findings showed that Ali Ajami with 43 documents (17%) in electrical engineering, Nader Hoveidae with 5 documents (23%) in mechanical engineering, and Mousa Mohammadpourfard and Reza Gharraei, each with 10 documents (17%) in civil engineering, led the ranking in their fields of study. A separate analysis of WoS by the present researcher showed that Ali Ajami and MohaadReza Banaei, both from electrical engineering, are among the top ten authors in Azarbaijan Shahid Madani University[4]. These two researchers have written 50 fewer papers than the top researcher of the university, who has produced 94 documents. In another part of the analysis of WoS, it became clear that in the field of electrical engineering, Gevork Gharehpetian (Amirkabir University of Technology) with 391 papers, Ebrahim Babei (University of Tabriz) with 260 papers, and SeyedHossein Hosseini (University of Tabriz) with 254 papers, respectively lead the ranking in Iran[5]. Azarbaijan Shahid Madani University's number one author in electronic engineering has 350 fewer papers than the number one author in Iran. In other words, the top researcher of electrical engineer in Iran from 2000 to 2019 has written 350 papers more than his peer in Azarbaijan Shahid Madani University. In the field of mechanical engineering[6], Reza Ansari (University

of Gilan) with 197 papers, Davood Ganji (Babol Noshirvani University of Technology) with 191 papers, and Momamad Reza (Amirkabir University of Technology) with 188 respectively stand at the positions of 1 to 3 in Iran.

In comparison, the top researcher of Azarbaijan Shahid Madani University has written 187 papers less than the most prolific author in mechanical engineering in Iran. In the field of civil engineering[7], Alie Kaveh (Iran University of Science and Technology) with 197 papers, Omid Haddad (University of Tehran) with 172 papers, and Alireza Vatankhah (University of Tehran) with 99 papers respectively, lead the ranking in Iran. The comparison shows that the top author of Iran in civil engineering has published 192 more documents than his peer in Azarbaijan Shahid Madani University. Some of the reasons for this discrepancy might include "expert knowledge", professional experience, lab facilities, scientific connections, and "scientific level of students".

Higher levels of scientific collaboration among researchers result in a higher level of scientific development (Rahimi & Fattahi, 2007; Shahrabi Farahani, Eskrootchi, Mohaghegh & Hosseini, 2014; Zakiani et al., 2020). Due to the unique nature of each field of study and their differences, scientific collaboration and participation vary greatly in different contexts. In some fields of study, the necessity of using lab facilities, raw materials, and human resources to develop research projects drives researchers to travel to foreign countries or collaborate with their peers (Mardani, Najafi & Sharif-Moghadam, 2013). The findings showed that in Azarbaijan Shahid Madani University, the level of scientific collaboration among electrical engineering researchers is higher than that of their peers in the fields of mechanical engineering and civil engineering. Researchers of electrical engineering in this university (with 215 documents) have scientifically collaborated with researchers from 18 different countries (including China and Germany). Researchers of civil engineering in Iran (with 17 documents) have scientifically collaborated with 7 different countries (including Iraq). In the field of mechanical engineering, Iranian researchers (with 59 papers) have collaborated with researchers from 10 countries (including Canada and United States). Jafari (2015) has found similar results, in which Iranian researchers have had the most scientific collaboration with their peers in Canada, China, Britain, and United States. Furthermore, in the fields of energy and fuel, Iranians have had the most international scientific collaborations with the United States, Canada, and China (Fazelivarzaneh et al., 2018).

Findings showed that 5% of published documents had had a single author in electrical engineering, and 95% of them have had two or more authors. In civil engineering, 29% of the documents have had a single author, and 71% of them have had "two or more authors". Also, in mechanical engineering, 15% of documents belong to a single author, and 85% of them belong to "two or more authors". Therefore, co-authorship in electrical engineering is higher than that of mechanical engineering and civil engineering. Asadi and Saghafi (2012) have found in their research that "two or more authors" do 92% of scientific production in technical and engineering fields of study (1990-2010), and a single author does only 8% of them. Also, Makizadeh, Hazeri, Razmjoo & Soheili (2017) found that two-author or more has been the most common authorship model in Nanotechnology in Iran.

In the map of co-authorship density, researchers with less scientific collaboration with each other are placed in distant positions. The density of each researcher is determined based on the number of his or her scientific productions and the importance of adjacent nodes (Yaminfirooz et al., 2016). It should be mentioned that the color spectrum from red to blue

indicates the weight of the density (Yaminfirooz, Tahmasbi & Amiri, 2018). The red, yellow, green, and blue colors indicate high to low densities. Researchers in the greenhouse have less co-authorship than researchers in the yellow area, and researchers in the red area have had the highest level of co-authorship with their peers (Fallah, Fahimifar & Chamani, 2016). The findings showed that in the field of electrical engineering, Ali Ajami with 43 documents (1000 citations), Sajad Najafi with 42 documents (564 citations), MohamadReza Banaei with 41 documents (473 citations), and M, RJ Oskuee with 16 documents (305 citations) have had the highest levels of density and co-authorship (37, 31, 22, and 20, respectively) with other researchers. These researchers have had the highest levels of participation and are more important to their peers. In other words, the researchers, as mentioned above, have had an important role in communicating information and having scientific collaboration with their peers. The reason for the high level of co-authorship density among some researchers in the field of electrical engineering might be related to “common background for collaboration”, “professional position", "Administrative responsibility”, “ownership of lab facilities”, and “communication skills”.

In the field of civil engineering, findings showed that Hosein Soltani-Jigheh with 4 documents (12 citations), Nader Hoveidae with 4 documents (10 citations), and Akbar Heidarzadeh with 3 documents (78 citations) have had higher co-authorship density (4, 1, and 4, respectively) than their peers. In other words, these researchers, as the connection points among their peers, have played a key role in the co-authorship network. However, the entanglement and the scientific connection between different clusters were low in civil engineering since the clusters had tried to do research in separate groups. The low level of scientific collaboration in civil engineering might be due to the nature of the field of study, less common ground for collaboration, and “low level of published documents”. In the field of mechanical engineering, AmirHosein Mosaffa with 7 documents (169 citations), Reza Gharraei with 10 documents (49 citations), and Naier Razmara with 5 documents (49 citations) have had more co-authorship (15, 9, and 7, respectively) than the rest of their peers.

The analysis of clusters in the co-authorship network for the fields of electrical, civil, and mechanical engineering indicates that male researchers have had more collaborations than their female counterparts. As such, Bahari and Moody (2020) found that male researchers have had more collaboration with each other in producing scientific journals. Abbasiniasar and Ghaffari (2017), in their research about scientific productions at the University of Kashan from 2012 to 2016, found that co-authorship is more common among male researchers. Hayati and Didgah (2010) have reported that factors such as gender, common motivations, language, and physical location might affect co-authorship networks.

Also, findings showed no meaningful difference between male and female faculty members in terms of scientific outputs. In other words, the average scientific production of male faculty members is not higher than that of their female peers. Studies of Gudarzi (2010), Hejazi and Behravan (2009), Fahimnia, Noroozi and Bamir (2016), Ghaffari and Salahshour (2014), and Bland, Burce, Deborah, Kelly & Justin (2005) have not found any indication of a meaningful difference between males and females in terms of scientific production. Analysis of variance about differences in the average of scientific production among electrical, civil, and mechanical engineering fields showed a significant difference (Sig=0.019). In line with these results, Godazgar and Alizade Aghdam (2006) found a meaningful difference (0.001) in averages of scientific production among different faculties. Researchers in different fields of

basic sciences and "technical engineering" have had more scientific production than their peers in various fields of human science.

Findings showed that the average scientific outputs vary based on academic rank. In other words, professors have been scientifically more productive than associate professors, assistant professors, and instructors. The significant effect of academic rank on scientific production has been confirmed by other researchers such as Shahbazi (2019), Abbasiniasar and Ghaffari (2017), Bigdeli, Khosravipour & Zanganeh (2019), Ghaffari and Salahshour (2014), and Riahinia and Emami (2012).

Conclusion

The present research has some limitations worthy of mentioning. Some of the scientific outputs of Azarbaijan Shahid Madani University, especially those in electrical, civil, and mechanical engineering, are published in journals unindexed by WoS. So, there is a high chance that the scientific outputs of researchers in this university's technical and engineering fields have produced much more documents than the ones mentioned in this research. Also, maybe in some papers, the Azarbaijan Shahid Madani University title is misspelled, so they have not been retrieved and analyzed in the present research.

The present study is an effort to promote the analysis of scientific outputs in electrical, civil, and mechanical engineering at Azarbaijan Shahid Madani University. The following suggestions are made based on the findings of this research:

1. It is suggested that the productive researchers of Azarbaijan Shahid Madani University in different fields, including electrical, civil, and mechanical engineering, receive commendation during various ceremonies to become more motivated.

2. Regarding results of this research and the low level of scientific production in engineering fields of study in Azarbaijan Shahid Madani University compared to other universities of Iran, the reasons for this low performance are investigated, and the existing problems are solved.

3. It is suggested that scientific documents of the Technical and Engineering Faculty of Azarbaijan Shahid Madani University indexed by WoS be compared and contrasted with those indexed by *Scopus*.

4. It is suggested that more incentive points be allocated to effective people in co-authored networks. Doing so will increase competition among individuals for scientific collaborations.

Overall, Azarbaijan Shahid Madani University officials can consolidate scientific collaborations and expand research infrastructure to promote the quality and quantity of scientific outputs and increase the publication of engineering papers in credible international journals. Undoubtedly, improving research infrastructures (such as budget, lab facilities, access to scientific sources, etc.) and increasing material and intellectual incentives can play an important role in fostering scientific productions. In return, the growth of scientific production would enhance the national and international position of Azarbaijan Shahid Madani University.

Endnotes

1. **Engineering, Mechanical**: Sharif University of Technology (1,896), Amirkabir University of Technology (1,669), University of Tehran (1,561) ;**Engineering Electrical Electronic**: Sharif University of Technology (5,098), University of Tehran (5,038), Amirkabir University of Technology (4,684);

Engineering, Civil: University of Tehran (1,615), Iran University Science Technology (1,267), Amirkabir University of Technology (1,208)

2. https://datacatalog.worldbank.org/dataset/gdp-ranking
3. https://www.scimagojr.com
4. Sheikholeslami Sm (94), Darabi F (66), Sardroodi Jj (66), Rezapour S (61), Akbari-Moghanjoughi M (60), Abbasi A (56), Agbolaghi S (49), Habibi B (44), Ajami A (42), Banaei Mr (43)
5. Gharehpetian Gb (391), Babaei E (260), Hosseini Sh (254)
6. Ansari R (237), Ganji Dd (191), Eslami Mr (188)
7. Kaveh A (197), Bozorg-Haddad O (172), Vatankhah AR (99)

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