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## Scientometric Analysis of Scientific Products with Co-authorship Networks: The Case of Sharif University of Technology

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# Scientometric Analysis of Scientific Products with Co-authorship Networks: The Case of Sharif University of Technology

By Maryam Asadi, Somayeh Joolaei, Saman Saqhafi, and Azam Bazrafshan

## Introduction

Evaluation and measurement of science emerged in the world, because it has always been assumed that science could help the health and welfare of the inhabitants of the earth. Identifying the most important individuals, institutions, universities and academic activities related to scientific production promotes collaboration and the exchange of information in various fields of science. The scientific community consists of producers, consumers, and scientific sources. Scientific cooperation plays an important role in promoting quality and quantity of scientific productions. The new results of research will be an accumulation of previous research and outcomes of the new research; the new research is then put into the body of scholarly knowledge.

Researchers use formal and informal scholarly communication. Formal communication includes or consists of published materials that have been reviewed by peers such as scholarly journals. Informal scholarly communication can be meetings, calls between researchers, and pre- and post-prints. Garvey (1979) states, "communication is the essence of science." Abelson as cited in Lacy and Busch believes that, "without communication there would be no science" (1983, p.193).

Besides the publication of scholarly articles, collaboration is very important in the scientific community, and one of the forms of collaborations is co-authorship in which two or more authors collaborate to create scientific work. In recent years, factors such as specialization and the growth of interdisciplinary research have prompted researchers to cooperate with each other. Because of the nature of fields and the differences among them, scientific collaboration and cooperation in various fields of science are different. In some fields, the need to have access to laboratory facilities, materials, and manpower in a research project is so great that some people travel to other countries or

regions to use their facilities and work with other scientists. In these cases, co-authorship is a natural result of collaboration.

Some research studies visualize the co-authorship network by using software. Co-authorship creates a link between two or more authors, and these links form networks. These networks contain very important information about authors, and the authors' collaborative patterns, as well as the authors' status in the structure of networks.

There are four kinds of networks: social networks, information networks, technology networks, and biological networks (Newman, 2003). Co-authorship networks are a type of social network. Scientometric studies analyze the ranking of the people in a social network, looking for the importance of the people or the centrality of them (Chakrabarti & Faloutsos, 2006; Getoor & Diehl, 2005).

There are studies that have examined co-authorship in various methods, for instance, investigating writing patterns and producing qualitative papers (Durden & Perry, 1995; Vimala & Reddy, 1996; Maske et al., 2003; Englebrecht et al., 2008; Cho et al, 2010), surveying the relationship between co- authorship and international collaboration (Frenken et al., 2005; Kim, 2006), and visualizing co- authorship networks by using scientometric software (Braun et al., 2001; Acedo et al, 2006; Chakrabarti & Faloutsos, 2006; La Rowe et al, 2007; Qi et al, 2008; Gossart & Özman, 2009; Lu & Feng, 2009; Velden et al., 2010). These authorship networks include important information about the authors and can indicate patterns of collaboration and the situation or placement of authors in the structure of the network. The main objective in the analysis of social networks is the ranking of people in the social network.

Studies of co-authorship in Iran have been published. For example, Hassanzadeh et al., (2009) and Hayati and Didgah (2010) studies focused on clarifying scientific collaboration in all fields of science and explored the relationship of collaboration to citation. Additional studies focused on the relationship of collaboration with the geographical location (Velayati, 2008; Didgah & Erfanmanesh, 2009). Rahimi and Fattahi (2008) used a questionnaire to examine co-authorship among faculties of a university. Osareh & Wilson (2002) studied Iranian articles in SCI for periods of 1995-1999 and 1975-2002. Their study indicated that Iranian authors collaborated most frequently with authors in the United States.

Some studies have explored the reasons and motivation behind collaborating in scientific fields. For example, Harirchi et al. (2007), in an exploratory study, investigated the patterns of collaboration among Iranian researchers in Biology, Chemistry, and Physics. The main collaborative motives behind co-authorship were identified and described. Among those mentioned were sharing laboratory devices, accessing knowledge, and increased efficiency of the study at hand. It is clear that emigrated Iranian scientists play an important role as collaborators and probably also as links to the international scientific communities as a whole. Cultural factors mix scientific and work-related ones. Other results showed that international collaborations are very low among Iranian researchers.

In analysis of co-authorship networks of the Iranian researches, Hassanzadeh and his colleagues looked at 625 documents from Iran Medical University in the Web of Science database up to 2007. Their results indicated that in five different fields, just three authors wrote their papers individually, which reflects the high willingness of authors to collaborate with others (Hassanzadeh et al., 2009). Pashootanizadeh and Osareh (2009) analyzed citations from 2000 to 2008 and visualized scientific maps of agricultural. They tried to determine core institutes and authors, contributions, core journals, growth rate of scientific

productions, the format, and language of the documents.

Hariri and Nikzad (2011) surveyed co-authorship networks of Iranian articles about or regarding library and information science, psychology, management, and economics in ISI in 2000-2009. The results indicated that most contributions had two or three authors. Also researchers in psychology have the highest coefficient of collaboration, and library and information science had the lowest. Management had the greatest degree of consistent collaboration, and psychology had the least degree of consistent collaboration in the co-authorship network.

The purpose of this research was to conduct scientometric analysis of scientific products, as well as to visualize and analyze co-authorship networks in scientific works of the Sharif University of Technology (SUT) in 2005-2010. The results of this study provide enlightenment on collaboration, provides a tool for strategic planning of research in this particular university, and provides insight into tools to develop in the future.

In particular, the research focused on:

- R1. What is the number of scientific publications per year from 2005 to 2010 in SUT and what is the trend of growth of the scientific products during that time?
- R2. What types of documents and in what language are the scientific products from SUT?
- R3. What countries most frequently collaborated with SUT?
- R4. What are the core journals in which SUT's products have been published?
- R5. What universities and institutes have collaborated with SUT?
- R6. Who are the most productive and effective researchers in SUT?

R7. What is the distribution of citations per papers?

R8. What is the level of productivity of published papers by one author, two authors, or three or more authors at SUT?

R9. What is the proportion of single and co-authored publications of researchers of SUT?

R10. What is the nature and the structure of co-authorship networks of SUT's scientific products?

Sharif University of Technology (SUT) is a university of higher education in technology, engineering, and physical sciences in Tehran (Iran) that was established in 1966. It is one of the most prestigious universities in Iran, and is considered Iran's MIT. Currently, Sharif University has 12 science and engineering departments—Materials Science and Engineering, Chemical Engineering, Petroleum Engineering, Chemistry, Civil Engineering, Computer Engineering, Electrical Engineering, Industrial Engineering, Mathematical Science, Mechanical Engineering, Physics, and Aerospace Engineering. There are only two non-engineering departments, which are the Philosophy of Science department and Management and Economics department, which offer exclusively PhD and M.Sc. graduate degrees.

## Methodology

This study is a descriptive approach with scientometric method. The population of this research comprises documents produced by SUT authors and indexed in Web of Science (WOS) during 2005- 2010. Data were gathered from ISI Web of Science (WOS) database on July 17, 2011 based on the following query: "AD=Sharif Univ Technol AND PY=2005-2010." There were 4378 items (including articles, papers from proceedings, abstracts, etc.) retrieved. Each of the items was categorized according to Web of Science (WOS) subject categories. Following the work of Batagelj & Mrvar (2009), HistCite and Pajek software were used to identify the most cited and affective work and to visualize the co-authorship networks. Two indexes,

Local Citation Score (LCS) and Global Citation Score (GCS), were calculated. LCS index consists of citations in the collection to the author, and GCS index is citations in Web of Science to papers by author in the collection.

The proportion of co-authored publications to the single-authored publications was calculated using the following formula:

$$\text{Co-authorship ratio} = \frac{\text{No. of Coauthored Publications}}{\text{No. of Single-authored publications} + \text{No. of Coauthored Publications}}$$

According to Sutter & Kocher (2004), a ratio greater than 0.5 indicates more co-authored than single- authored publications, and a ratio of less than 0.5 indicates more single-authored than co-authored publications. The density (the ratio of the number of actual edges to all possible edges in graph with the same number of nodes) of each network was calculated to find which networks are dense and which are sparse.

$$\text{Density is between } \frac{m}{n(n-1)}$$

where m is the number of links or lines and n is the number of nodes or vertices in each network (Hariri and Nikzad, 2011).

## Results

*R1. What is the number of scientific publications per year from 2005 to 2010 in SUT and what is the trend of growth of the scientific products during that time?*

The total number of papers in the Web of Science (WOS) database by researchers of Sharif University of Technology (SUT) was 4378. As indicated in Figure 1A, there was growth in the number of scientific publications from 403 works in 2005 to 1048 works in 2010.

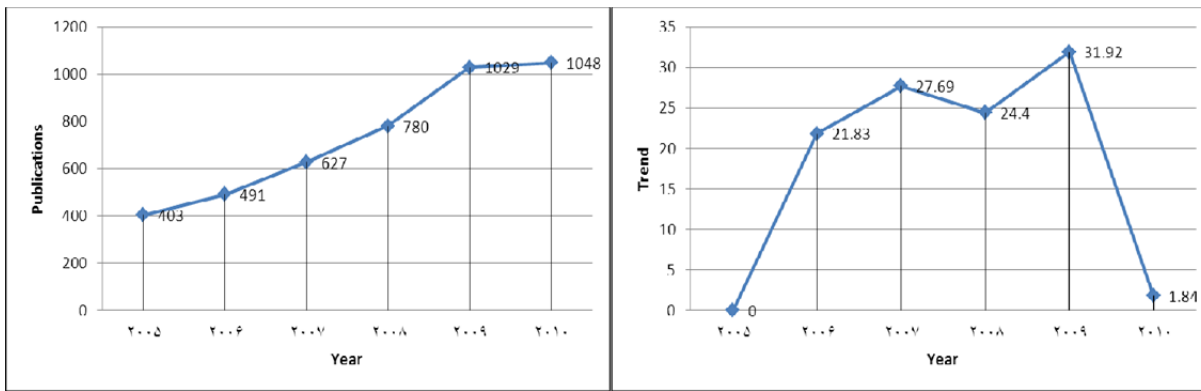


Figure 1A. The number of scientific publications in SUT; Figure 1B. The pattern of growth of scientific products in SUT.

In order to calculate trend of growth of the scientific products in SUT, the following formula was used:

$$PR = \frac{(V_{Present} - V_{Past})}{V_{Past}} \times 100$$

Where PR = percent rate,  $V_{Present}$  = present or future value and  $V_{Past}$  = past value.

Fig.1B shows the pattern of growth of the scientific publications in SUT including a considerable surge that occurred in 2005-2007, whereas growth slumped in 2008 and peaked in 2009. There is then a drastic plunge in publication from SUT in 2010 with a dramatic fall from 31.92 to 1.84.

The geometric mean is used to calculate the average annual growth rate of works in this period. Results showed that this rate was 32 percent; as previously mentioned, there are breaks in the growth of publications in some years.

**R2. What types of documents and in what language are the scientific products from SUT?**

The results of the analysis of the type of documents showed that the documents were in seven different formats. As expected, articles were the most frequent type of format with 4085 titles; proceeding papers were the next highest in frequency with 183

titles, and also had the most citations according to LCS and GCS indices (Table 1).

Document Type	Recs	LCS	GCS
Article	4085	46	16487
Article; Proceedings Paper	183	3	519
Meeting Abstract	27	0	0
Editorial Material	25	0	29
Correction	18	0	0
Review	17	0	213
Letter	9	0	14

Table 1. Document Type of Scientific Publications in 2005-2010 (N.4378)

As shown in table 2, the documents were published in three languages. English accounted for 4361 documents and was the highest rank in terms of numbers and GCS and LCS indices. It shows that English is the dominant language in science and in the ISI databases. Only three documents were not written in English.

Language	Recs	LCS	GCS
English	4361	49	17260
French	2	0	1
Italian	1	0	1

Table 2. Language of Scientific Publications in 2005-2010 (N.4378)

R3. What countries most frequently collaborated with SUT?

The analysis of documents indexed in ISI showed that SUT's researchers collaborated with 59 countries. Table 3 shows the five most frequent countries participating in the scientific production with SUT.

Country	Recs	LCS	GCS
USA	244	2	957
Canada	198	4	919
UK	153	1	780
Germany	96	0	410
France	90	0	594

Table 3. The top countries participating in the production of Scientific Publications with SUT in 2005-2010 (N.4378)

R4. What are the core journals in which SUT's products have been published?

One of the most important channels of exchange of scientific information is scientific journals. Table 4 shows the core journals publishing SUT's scientific publications from 2005 to 2010 based on the number of papers and LCS and GCS indices. *Materials Science and Engineering* contained 77 titles, *Materials and Design* had 70 titles, *Scientia Iranica* holds 68 titles, *Journal of Materials Processing Technology* included 49 titles, and *Journal of Alloys and Compounds* had 46 titles. These journals were the most frequent publishers of scientific articles from SUT faculty and are found in Table 4A. Table 4B and 4C detail the five core journals that had the highest rank based on LCS and GCS respectively.

Journals (A)	Recs	LCS	GCS
<i>MATERIALS SCIENCE AND ENGINEERING A-STRUCTURAL MATERIALS PROPERTIES MICROSTRUCTURE AND PROCESSING</i>	77	0	475
<i>MATERIALS &amp; DESIGN</i>	70	3	301
<i>SCIENTIA IRANICA</i>	68	0	29
<i>JOURNAL OF MATERIALS PROCESSING TECHNOLOGY</i>	49	0	236
<i>JOURNAL OF ALLOYS AND COMPOUNDS</i>	46	0	238
Journals (B)	Recs	LCS	GCS
<i>PROCEEDINGS OF THE INSTITUTION OF MECHANICAL ENGINEERS PART I-JOURNAL OF SYSTEMS AND CONTROL ENGINEERING</i>	7	5	11
<i>MATERIALS &amp; DESIGN</i>	70	3	301
<i>CHAOS SOLITONS &amp; FRACTALS</i>	25	2	262

PHYSICA E-LOW-DIMENSIONAL SYSTEMS & NANOSTRUCTURES	15	2	78
NONLINEAR DYNAMICS	12	2	32
Journals (C)	Recs	LCS	GCS
MATERIALS SCIENCE AND ENGINEERING A-STRUCTURAL MATERIALS PROPERTIES MICROSTRUCTURE AND PROCESSING	77	0	475
APPLIED MATHEMATICS AND COMPUTATION	41	0	347
MATERIALS & DESIGN	70	3	301
PHYSICAL REVIEW B	40	0	281
ORGANIC LETTERS	3	0	267

Table 4. Core journals in which SUT's products have been published in 2005-2010 (top 5).

Notes: (A) Core Journals publishing SUT's scientific products based on a number of papers; (B) Core Journals publishing SUT's scientific products based on a LCS index; (C) Core Journals publishing SUT's scientific products based on GCS index.

R5. What universities and institutes have collaborated with SUT?

The data indicated that 1017 institutes and universities were contributors to the items retrieved. The five most active contributors after analysis based on LCS and GCS are found in Table 5. Islamic Azad University is the highest ranked.

R6. Who are the most productive and effective researchers in SUT?

Results suggested that from 2005 to 2010, 5562 works from researchers in Sharif University were indexed in Web of Science. The five researchers ranking the highest in records and according to the two indices found in Table 6. Haeri (69 titles), Simchi (69 titles), Pourjavadi (65 titles), Zad (56 titles), and Akhavan (53 titles) were the most productive authors. The most effective authors according to LCS index were Haeri, Tavazoei, Jafari, Alasty, and Ahmadian and GCS index were Saidi, Azizi, Simchi, Akhavan, and Shahokhian, respectively.

Institution (A)	Recs	LCS	GCS
Sharif Univ Technol	4352	49	17218
Islamic Azad Univ	200	2	468
Univ Tehran	187	2	667
Amir Kabir Univ Technol	96	1	379
Iran Univ Sci & Technol	89	2	388
Institution (B)	Recs	LCS	GCS
Sharif Univ Technol	4352	49	17218
Islamic Azad Univ	200	2	468
Univ Tehran	187	2	667
Iran Univ Sci & Technol	89	2	388
Amir Kabir Univ Technol	96	1	379
Institution (C)	Recs	LCS	GCS
Sharif Univ Technol	4352	49	17218
Univ Tehran	187	2	667
Islamic Azad Univ	200	2	468
Inst Stud Theoret Phys & Math	85	0	428
Iran Univ Sci & Technol	89	2	388

Table 5. The top five Institutions participating in the production of Scientific Publications in 2005-2010.

Notes: (A) The top institution participating in the production of scientific publications based on a number of papers; (B) The top institution participating in the production of scientific publications based on a LCS index; (C) The top institution participating in the production of scientific publications based on GCS index.

*R7. What is the distribution of citations per paper?*

An analysis of the citations used by the researchers allows us to determine the dissemination of their scientific ideas and influence on other researchers that used them as a source of knowledge and new ideas (Osca-Lluch et al, 2009). The number of citations of a publication shows the impact of the work in the field of science. The citation analysis section in Web of Science (WOS) database was used to analyze distribution of citations per paper. Results suggested that there are 13488 citations to 4378 works produced by SUT. The average citation per 4378 papers produced by SUT's researchers has been 3.07 citations (Figure 2).

*R8. What is the publication pattern from 2005 to 2010 of single authors, two authors, or three or more authors at SUT?*

For the purpose of determination of writing patterns, author field in Web of Science (WOS) database was searched and data were classified into three groups—one author, two authors, and three or more authors. Figure 3 shows writing patterns among SUT's authors during 2005-2010. Results indicated that the level of productivity for single-author or one author products is stagnating and the number of publications with two and three or more authors is increasing sharply. It showed authorship by three or more is the dominant type of authorship; this could indicate that cooperation (co-authorship) is of an acceptable level among SUT's researchers.

Author (A)	Recs	LCS	GCS
Haeri M	69	6	438
Simchi A	69	1	592
Pourjavadi A	65	0	456
Zad Al	56	0	337
Akhavan O	53	1	518
Author (B)	Recs	LCS	GCS
Haeri M	69	6	438
Tavazoei MS	38	6	323
Jafari S	5	5	17
Alasty A	40	4	210
Ahmadian MT	34	4	182
Author (C)	Recs	LCS	GCS
Saidi MR	42	0	685
Azizi N	29	0	643
Simchi A	69	1	592
Akhavan O	53	1	518
Shahrokhian S	37	1	501

*Table 6. The most productive and effective authors in SUT (top 5).*

Notes: (A) Core Journals publishing SUT's scientific products based on a number of papers; (B) Core Journals publishing SUT's scientific products based on a LCS index; (C) Core Journals publishing SUT's scientific products based on GCS index.



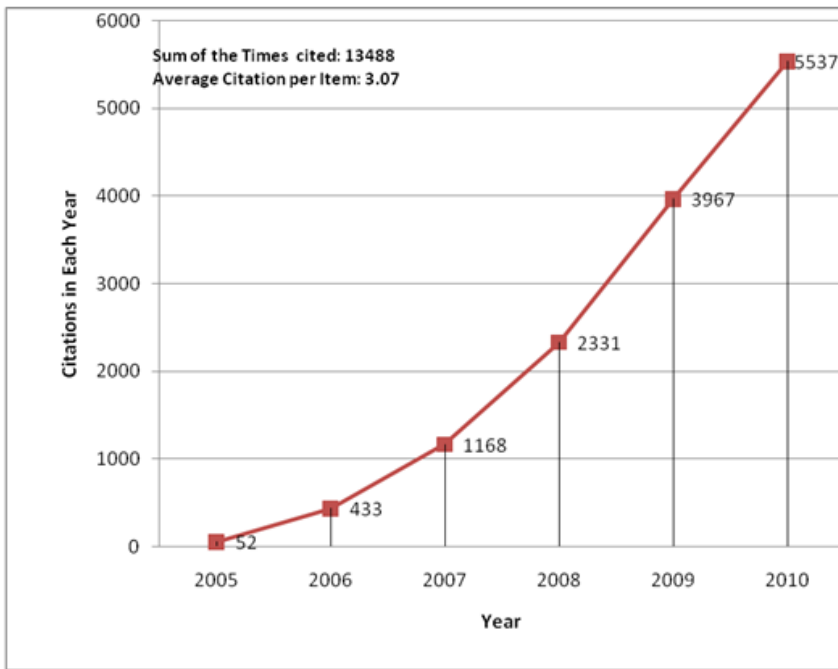


Figure 2. Average Citation per paper in 2005-2010

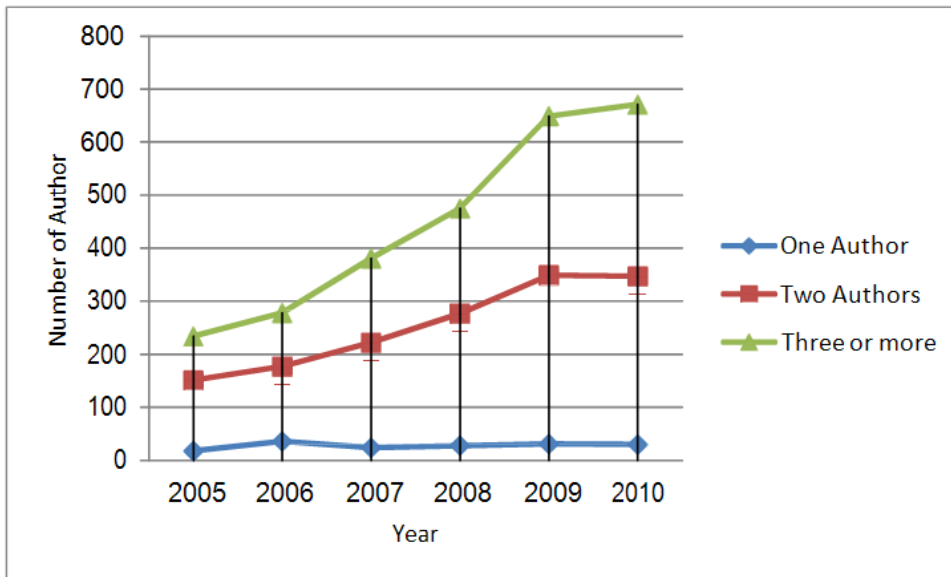


Figure 3. Publication pattern of SUT's authors in 2005-2010

*R9. What is the proportion of single and co-authored publications of researchers of SUT?*

Papers with at least two authors or more are considered as collaborative. Results showed 96.2 percent of productions were co-authored and only 3.8 percent of them were single authored publications (Figure 4). Using the co-authorship ratio formula, the proportion of coauthored productions to single authored publications was determined to be 0.96 percent, which indicates that the number of co-authored productions is more than single authored productions in these periods in SUT.

*R10. What is the nature and the structure of co-authorship networks of SUT's scientific products?*

A network is called "sparse" if the number of lines in the corresponding graph is of the same order as number of vertices. Networks are called "dense" if the number of lines is much higher than the number of vertices (De Nooy et al., 2005). It should be noted that drawing the network for subjects including chemistry, physics, mathematics, electrical engineering, and computer engineering were not provided, because of the high number of data and software limitation in data analysis. Therefore, these subjects were divided into sub-categories. In total, according to the subject categories of Web of Science (WOS), 25 subjects were determined, and each of them was illustrated co-authorship networks.

Co-authorship networks of 25 subjects were visualized but only the five networks with high density are shown. The co-authorship networks of five disciplines are illustrated in Figures 5-9. In these networks, vertices (nodes) represent authors, the size of vertices (nodes) are the number of productions they have authored. Lines or links showed the links of the author, and the thickness of links represents the number of coauthor events. Figure 5 shows one large authorship component and five smaller but still significant authorship components, in which Jalali, Parastar, Shahrokhiyan, and Gholikhani have the most co-authorship connections with others. In Figure 6, there is one large component and Soltanie and Pourjavadi have the most co-authorship connections with others. Figure 7 has one larger component and three rather large components, in which Saidi, Azizi, Moghadam, Taheri, MirJafari, and Hashemi have the most co-authorship connections with others.

There are two large components in Figure 8 in addition to six other rather large components, in which Tabar, Sadeghi, Ejtehadi, Darbandi, Jafari, and Zobdeh have the most co-authorship connections with others. Figure 9 shows has one large component and three additional large components and Akbari, Ghorbani, and Hatami have the most co-authorship connections with others.

Figures 4-9 are found on the following pages.

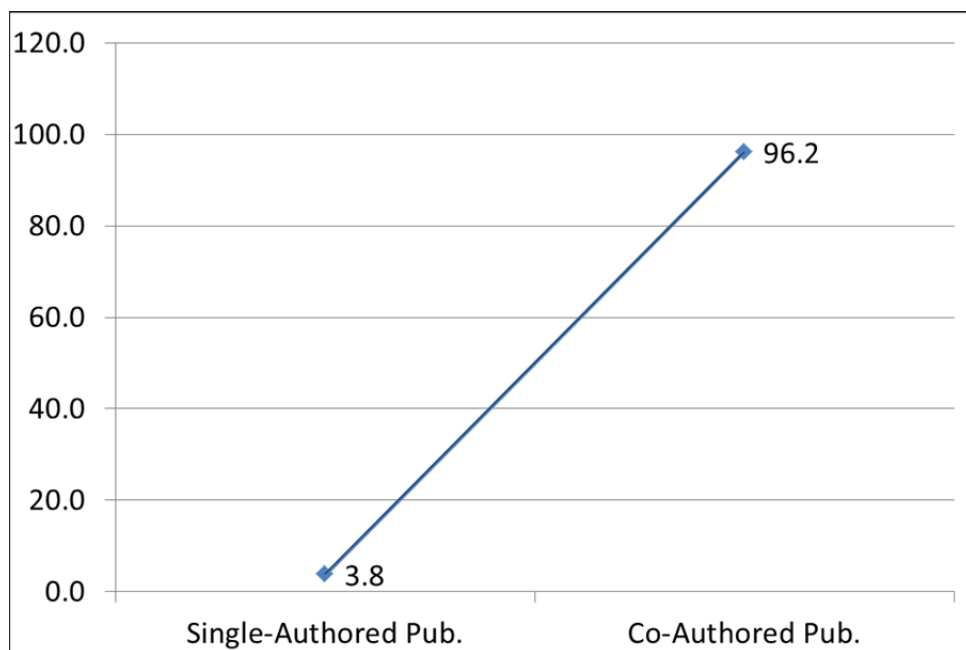


Figure 4. Proportion of single and coauthored publications

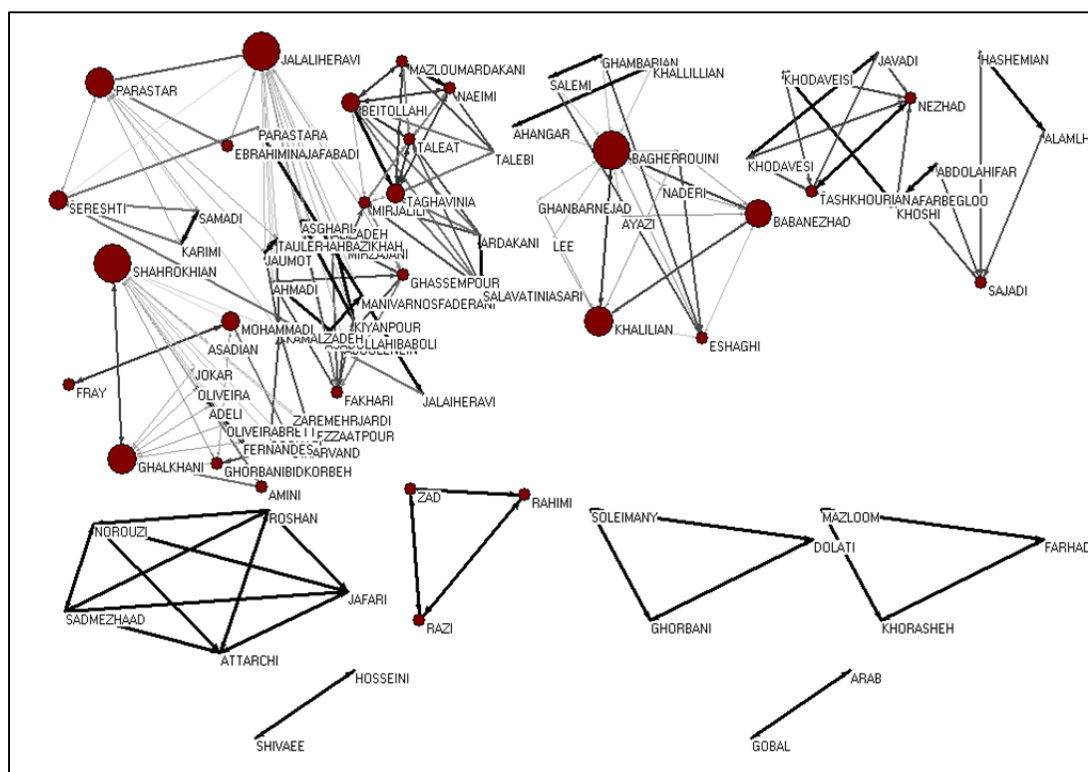


Figure 5. Co-authorship network in Chemistry Analytical



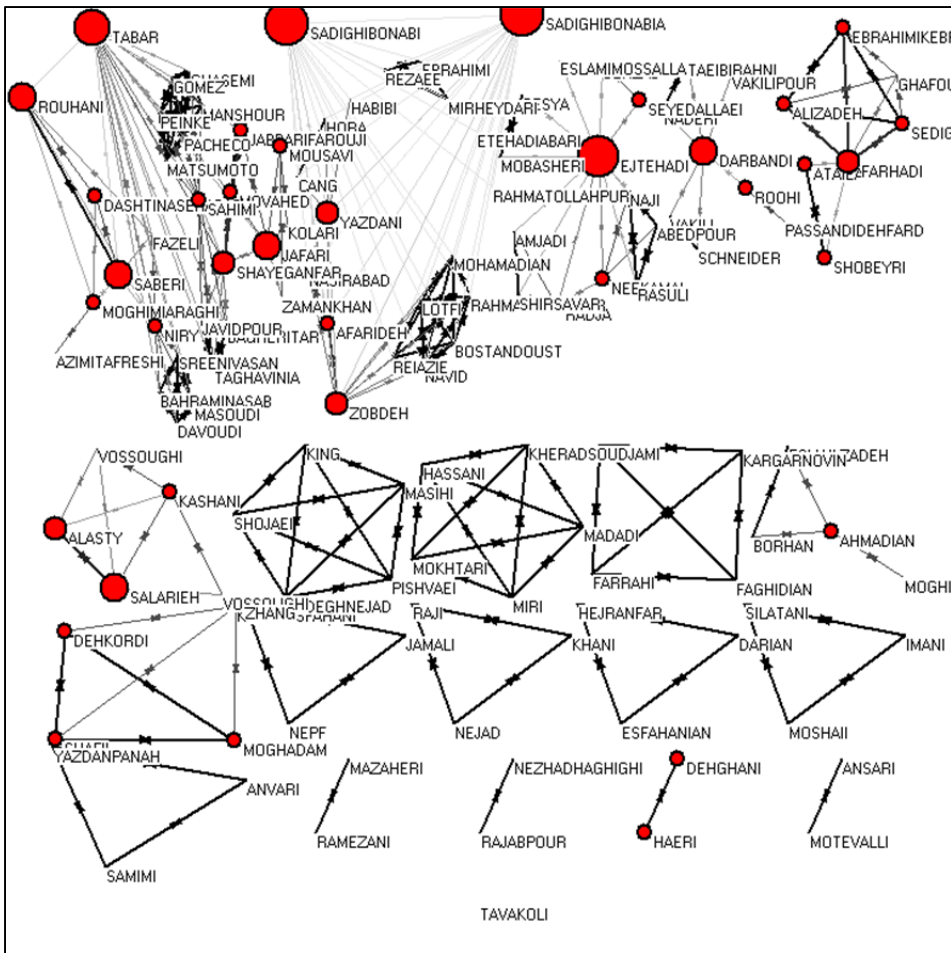


Figure 8. Co-authorship network in Physics Fluids Plasmas

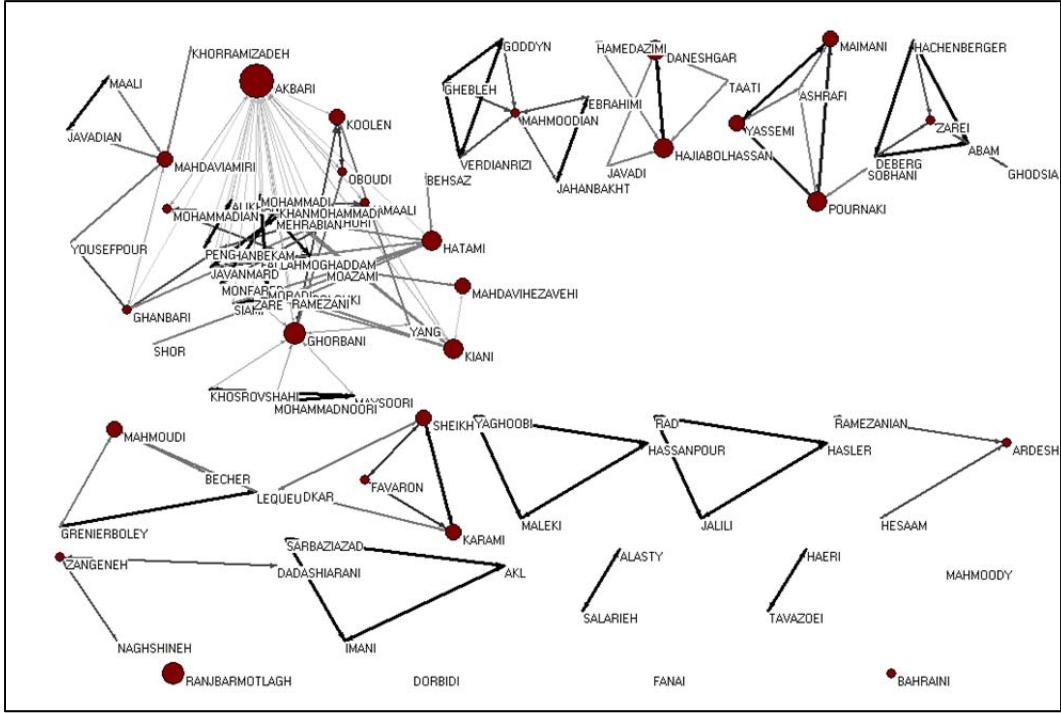


Figure 9. Co-authorship network in Mathematics

Table 7 shows the results of the analysis (number of vertices, lines, density, and degree of vertex) in 25 subjects. It should be noted that the degree of a vertex is the number of lines incident with it. Vertices with high degree are more likely to be found in dense sections of a network (De Nooy et al., 2005). As shown in Table 7, civil engineering has the largest number of nodes (237) and physics applied has the highest number of links (870) to other subjects. Analytical chemistry (0.08890), polymer science (0.07510), and organic chemistry

(0.07050) have the highest density, and manufacturing engineering (0.01440), material science (0.1590), and industrial engineering (0.01670) are the most discrete among authors. The results also suggested that the average number of links connected to a vertex (degree of vertex) in networks of organic chemistry (8.8819), physical chemistry (8.3799), and physics fluids plasma (8.3125) were the maximum, which indicated that, for example, each author in organic chemistry connected with 8 authors.

**Table7. Co-authorship network analysis based on ISI subject categories**

Subjects	Number of Vertices (Notes)	Number of Lines	Density	Degree of Vertex
CHEMISTRY ANALYTICAL	89	348	0.08890	7.8202
POLYMER SCIENCE	37	100	0.07510	5.4054
CHEMISTRY ORGANIC	127	564	0.07050	8.8819
PHYSICS FLUIDS PLASMAS	128	532	0.06490	8.3125
MATHEMATICS	91	252	0.06150	5.5385
ENGINEERING PETRULUM	64	234	0.05710	7.3125
NANOSCIENCE NANOTECHNOLOGY	70	274	0.05670	7.8286
OPTICS	134	428	0.04800	6.3881
CHEMISTRY PHYSICAL	179	750	0.04710	8.3799
MECHANICS	115	288	0.04390	5.0087
ENGINEERING AEROSPACE	63	168	0.04300	5.3333
ENGINEERING ENVIRONMENTAL	86	314	0.04300	7.3023
ENGINEERING BIOMEDICAL	93	358	0.04180	7.6989
ENGINEERING ELECTRICAL ELECTRONIC	127	326	0.04070	5.1339
TELECOMMUNICATIONS	127	326	0.04070	5.1339
ENGINEERING CHEMICAL	125	754	0.03790	7.54
COMPUTER SCIENCE INFORMATION SYSTEMS	61	138	0.03770	4.5246
PHYSICS APPLIED	216	870	0.03750	8.0556
COMPUTER SCIENCE ARTIFICIAL INTELLIGENCE	63	146	0.03740	4.6349
COMPUTER SCIENCE HARDWARE ARCHITECTURE	96	280	0.03070	5.8333
COMPUTER SCIENCE INTERDISCIPLINARY APPLICATIONS	110	264	0.02200	4.8
ENGINEERING INDUSTRIAL	158	414	0.01670	5.2405
MATERIALS SCIENCE	206	672	0.01590	6.5243
ENGINEERING CIVIL	237	676	0.01208	5.7046

## Discussion and Conclusion:

The results of the present study indicate that there was growth in the number of scientific productions of Sharif University in 2005-2010, but there were fluctuations in the rate of growth. Overall the rate of growth of the scientific products in SUT was 32 percent in this period. Price (1963), in his book *Little Science, Big Science*, noted that the number of scientific articles doubles every 15 years. Such growth cannot be attributed to only one factor and it can be concluded that this growth is part of the nature of science (Price, 1963).

The results indicated that there are more articles and documents in English and that they have the highest citations according to the LCS and GCS. This coincides with Pashootani and Osareh's research (2009). Of the 59 countries collaborating with Sharif University, the USA, Canada, UK, Germany, and France are top collaborators in producing scientific works.

Of the 1017 universities and institutes that collaborated with Sharif University, there were five that were most active. Azad Islamic University ranks the highest. It is speculated that the following types of collaborative activities between the faculties of Sharif University and Islamic Azad University are reasons for their ranking: teaching, guiding theses, and research projects. In addition, one could infer that the collaboration among faculty of one institute (the writers of articles are in one institute, organization, or university) and multi-institutional collaboration (at least one of the writers are from another organization, institute or university) have a higher rank and international collaboration has the lower rank. It seems that using the experiments and guidance of international institutes and making contracts can develop and promote international researches in Sharif University.

Harirchi et al.'s research (2007) confirmed that Iranian researchers had the lowest international collaboration in all fields of science. Benefits of scientific international collaboration have always been discussed by scientists and policy makers, and it also has been an important research topic in the field of scientometric and quantitative researches of

science and technology. Policy makers should pay more attention to collaboration and should provide further areas of cooperation. Haeri, Simchi, Pour Javadi, Zad, Akhavan wrote most articles, and Haeri, Tavazoee, Jafari, Alasti, Ahmadian according to LCS index and Saeedi, Azizi, Sim Chi, Akhavan, Shahrokhian according to GCS are the most effective ones in production of Sharif University. There are 13488 citations to 4378 works of Sharif University from 2005- 2010 and in average; every work is cited 3.07 times which is deemed an acceptable level of collaboration. The results indicated that publications by single authors are declining and that co-authorship is rising steadily. The results showed that collaboration is at an acceptable level in Sharif University with coefficient 0.96. Durden and Perri (1995), Vimala and Reddy (1996), Englebrecht et al (2008), Maske et al., (2004), and Durden and Gaynor (2003) confirmed that co-authorship has led to increased production of articles and cooperation is growing dramatically. The following are factors that the literature reports as leading to co-authorship: reducing the costs of technology and communication, using the knowledge and facilities of others, increasing productivity, increasing the probability of acceptance of articles in journals, and increasing visibility.

Civil engineering had the largest number of nodes and applied physics had the highest number of links among the 25 subjects. The results indicated that analytical chemistry, polymer science, and organic chemistry had the highest density. Organic chemistry, physical chemistry, and physics fluids plasma had the highest average number of links connected to a vertex (degree of vertex) of links according to vertex index.

It is expected that this paper will provide the financial authorities at Sharif University with reason to give research committees appropriate facilities and budget for more faculty projects. It is proposed that the university provide possibilities for the exchange of knowledge between universities, both inside and outside of the country. Additionally, faculty would benefit from training practices that focus on writing scientific papers, increasing



familiarity with databases, and increasing their familiarity with foreign languages; this should be done in order to increase the production of scientific projects.

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