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Patterns of Iranian co-authorship networks in social sciences: A comparative study

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ABSTRACT

Collaboration in science is a process in which two or more authors share their ideas, resources and data to create a joint work. This research compares coauthorship networks of Iranian articles in library and information science (LIS), psychology (PSY), management (MNG), and economics (ECO) in the ISI Web of Knowledge database during 2000–2009, and uses network analysis for the visualization of coauthorship networks. Data include all articles with at least one Iranian author and indexed in ISI's Social Science Citation Index (SSCI) for the fields of LIS, PSY, MNG, and ECO. Indicators such as the Collaborative Index (CI), Degree of Collaboration (DC) and Collaboration Coefficient (CC) were calculated for each discipline. Results show that two or three authors were the most common number of authors per paper, and authors of PSY tended to have more multi-authored articles, compared to the other disciplines. LIS had the lowest rank regarding CC. MNG had the densest coauthorship network, and PSY had the sparsest. Iranian authors in the field of PSY mostly collaborated with those in the U.S., while LIS and MNG authors tended to collaborate with U.K. authors, and ECO authors tended to collaborate with Canadians.

1. Introduction

Collaboration is one of the ways of improving the quality of science (Ki-Wan, 2006; Lundberg, Tomson, Lundkvist, Skår, & Brommels, 2006). Coauthorship is an evident form of collaboration and as such, is a target of scientometric and bibliometric studies on collaboration (Inzelt, Schubert, & Schubert, 2009). Collaboration among scientists has been on the rise over recent decades (Wagner & Leydesdorff, 2003) and the wide availability of information technology and network information and facilities has improved national and international scientific collaborations (Wang, Wu, Pan, Ma, & Rousseau, 2005). Collaboration increases the scientific and research potential of a country (Jean Kim, 1999). Although collaboration is not a quality indicator, it is a means to improve the quality of scientific works (Ki-Wan, 2006).

2. Problem statement

Iran has gained one of the highest ranks in terms of the growth rate of articles in international journals in the last 5 years, and if it were to maintain the current level of growth, it could be among the top 10 countries in the world in scientific publications by 2013 (Moosavi, 2004). Past research shows that the quality of Iranian articles has increased in parallel to their quantity (Hayati & Ebrahimy, 2009; Sotudeh, 2010). The Iranian government emphasized scientific collaboration in the Proclamation of the Vision Iran 2025. In this document, which was legislated in November 2004, the government encourages contributing to the world's scientific production (Harirchi, Melin, & Etemad, 2007). However, little is known about collaboration and coauthorship by Iranian scientists in the social sciences. This article is an attempt to fill this gap.

This research aims to analyze the coauthorship networks and calculate the metrics of coauthorship in social sciences in Iran, in order to gain an understanding of the characteristics of national and international collaborations. The results of this study can help science policy makers to take measures for improving collaboration in the social sciences in Iran. Moreover, this research adds to knowledge about collaboration in the social sciences, as it is one of the few studies that investigates the phenomenon in this manner. The different metrics used for the study of coauthorship and collaboration may also offer some useful tools for further work.

3. Research questions

Examination of coauthorship networks in the disciplines of library and information science (LIS), psychology (PSY), management (MNG), and economics (ECO) is driven by the following questions:

- What is the mean number of authors per paper in the disciplines of LIS, PSY, MNG, and ECO?
- What are the values of different collaboration indicators for each discipline?

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- How dense are coauthorship networks of these disciplines?
- Which countries have the most scientific collaboration with Iran in each discipline?

The disciplines of LIS, PSY, MNG, and ECO were chosen because these have the highest number of articles by Iranian authors among the disciplines in the social sciences in the ISI Web of Knowledge database. It should be noted that there are multiple psychology categories in this database. The PSY used here is general PSY; PSYs such as "psychology, biological" were excluded, as they are nearer to the hard sciences and not closely related to the social sciences. This was done to ensure that the data do not include any items which are not from the social sciences.

4. Literature review

The roots of research on coauthorship can be traced back to the works of Price (1963), Clarke (1964), and Price and Beaver (1966), which were mainly concerned with the average number of authors per paper. In his book *Little Science, Big Science*, Price (1963) discussed collaborative trends in multiple authorship, based on a study of *Chemical Abstracts*. He concluded that chemistry papers had a trend toward four or more authors per paper for the period 1910–1960. Hirsch and Singleton (1965, cited in Price & Beaver, 1966, p. 1013), in a study of sociology, showed that multiple authorship partly depended on financial support, and that the average number of authors per paper was higher for works given governmental support, compared to unsupported works. Price and Beaver (1966) studied collaboration in an invisible college and showed a correlation between productivity and collaboration. They were also the first to calculate *fractional productivities*, which were defined as "the score of an author when he is assigned $1/n$ of a point for the occurrence of his name among authors on the by-line of a single paper" (p. 1014).

Coauthorship is often used as an indicator in scientometric and bibliometric research. Ajiferuke, Burell and Tague (1988) modified three indexes called Collaborative Index (CI), Degree of Collaboration (DC), and Collaborative Coefficient (CC), which incorporates some of the merits of both CI and DC (defined in the Procedures section). Acedo, Barroso, Casanueva, and Galán (2006) studied coauthorship networks in the discipline of MNG in SSCI for the years 1980–2002. Their research showed a progressive growth in the number of coauthored papers in management. Osca-Lluch, Velasco, López, and Haba (2009) studied cooperation patterns in Spain between science history researchers by analyzing coauthorship in the scientific publications of the SSCI and the SCI databases. They discovered that papers with two authors accounted for the highest number of jointly-produced works. They also showed that Spanish authors did not have much tendency toward collaboration.

Some research has investigated coauthorship in Iran, but not in the social sciences. Most were studies of coauthorship in science and technology. Osareh and Wilson (2002; Wilson & Osareh, 2003) studied Iranian articles in SCI for the periods of 1995–1999 and 1975–2002. Their studies showed that the country with which Iranian authors collaborated the most was the U.S. Mohammad Hasanzade, Abolghasem Gorji, Shokraneh Nanekaran, and Vali Nejhadi (2008) studied Iranian articles in the ISI database in the medical sciences and found that the number of articles was going up, and that the highest degree of coauthorship belonged to the field of immunology. Velayati (2008), in his examination of Iranian collaboration with neighboring countries, showed that authors from Russia, Turkey, and Pakistan accounted for the highest coauthorship, and that coauthorship was highest in the fields of physics, biology, and chemistry.

Other aspects of collaboration have been investigated. The link between the number of authors and the quality (measured as citations received by) of an article has been studied, with contradictory findings. Some (Glänzel & Schubert, 2001; Hicks & Katz, 1996) suggest that coauthored papers had relatively higher quality, while others (Avkiran, 1997; Lindsey, 1980; Smart & Bayer, 1986) found no link between coauthorship and the quality of papers. The evidence to support a positive correlation between the number of authors and the quality was stronger, however, and more recent evidence supports this (e.g., Figg et al., 2006; Noruzi, 2008). Moreover, Bridgstock (1991) showed that this contradiction in findings of different studies might be because the situation varies in different disciplines, and suggested that perhaps journals and disciplines are inappropriate units of analysis. The literature has also suggested that coauthored articles in the social sciences were more likely to be accepted for publication than single-authored papers (Presser, 1980), and that prestigious journals were more likely to contain multiple-authored articles than less prestigious journals (Beaver & Rosen, 1979).

Another aspect of collaboration is motivation. Hart's (2000) survey of authors of the literature of academic librarianship showed that authors consider "improved quality of the article" as a benefit of coauthorship. Another motivation of authors for collaboration is the pressure they feel from tenure demands to increase their publication output; they see coauthorship as a means to publish more papers. Gelman and Gibelman (1999) maintained that this pressure is one of the main reasons for increase in collaboration in the social sciences.

The review of the literature reveals that although there have been studies of collaboration and scientific production, most of them have either been on science and medicine (e. g., Jonkers, 2009; Velden & Lagoze, 2009; Yoshikane, Nozawa, & Tsuji, 2006) or are out of date (e. g., Ajiferuke et al., 1988; Clarke, 1964; Lawani, 1980). Few collaboration studies have focused on the social sciences, and there is no study about Iranian coauthorship in the social sciences at all.

5. Procedures

Data were gathered from the ISI Web of Knowledge database on April 9, 2010 based on the following query: "CU = Iran AND PY = 2000–2009". Search was limited to SSCI from 1970 to present, and refined for the disciplines of PSY, LIS, MNG, and ECO. In this study, Iranian articles are the articles in which "IRAN" is mentioned as "country" in the address field by at least one of the authors of those articles. Although the dataset is small, it includes all of the Iranian articles published in the four given fields since 1970. Table 1 shows the number of articles per discipline for each year.

CI, DC, and CC were calculated for each year of each discipline. These indexes are:

Collaborative Index (CI)

This index shows the mean number of authors per paper. It was developed by Lawani (1980) and later modified by Ajiferuke, Burell, and Tague (1988).

The formula is:

$$CI = \frac{\sum_{j=1}^{k} j \times fj}{N}$$

where: f_1 = the number of j-authored research papers;
N = total number of research papers published; and
k = the greatest number of authors per paper.

Table 1
Number of articles in each discipline.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	All years
ECO	–	1	1	3	–	4	6	8	9	21	53
LIS	1	–	3	2	4	8	6	16	36	30	106
MNG	2	–	2	2	3	4	3	7	11	22	56
PSY	4	4	19	10	45	13	24	19	22	5	165
Total	7	5	25	17	52	29	39	50	78	78	380

Degree of Collaboration (DC)

DC (Degree of Collaboration) shows the proportion of multiple-authored papers. DC was developed by Subramanyam (1983) and later modified by Ajiferuke et al. (1988).

$$DC = 1 - \frac{f1}{N}$$

where f_1 and N are as before.

Collaborative Coefficient (CC)

Ajiferuke et al. (1988) suggested this index first. It is based on fractional productivity as defined by Price and Beaver (1966).

$$CC = 1 - \left\{ \frac{\sum_{j=1}^{k} \left(\frac{1}{j}\right) f_j}{N} \right\}$$

where f_j, N and k are as before.

CC tends to zero, as single-authored papers dominate and to $1–1/j$ as j-authored papers dominate.

Pajek software (Batagelj & Mrvar, 2009) was used to visualize the coauthorship networks.

The *density* (the ratio of the number of actual edges to all possible edges in a graph with the same number of nodes) of each network was calculated to find which networks are dense and which are sparse. Density is between zero and one.

Density: $\frac{m}{n(n-1)}$

where m is the number of links or lines and n is the number of nodes or vertices in each network.

6. Findings

6.1. The mean number of authors per paper or Collaborative Index (CI)

CI was used to calculate the mean number of authors per paper. The mean number of authors per paper in PSY has been growing, and this field has the highest value of CI (3.22) compared to the other disciplines (Table 2). After PSY, the largest CI belongs to MNG (2.61).

6.2. Degree of Collaboration (DC)

This index gives zero weight to single-authored papers, and always ranks higher a discipline or period with a higher percentage of multiple-authored papers. PSY has the highest DC (0.92) of all disciplines, which is an indication of the tendency of authors toward collaboration (Table 3). After PSY, the highest DC is for ECO (0.89). LIS has the lowest DC (0.70).

6.3. Collaboration Coefficient (CC)

CC was used to measure Collaborative Coefficient of four disciplines (Table 4). The largest CC belongs to PSY (0.59). After PSY, MNG has the largest CC (0.53). LIS has the lowest CC (0.4), which indicates that LIS authors tend to collaborate less than authors in other disciplines.

Table 3
DC in the disciplines of LIS, PSY, MNG, and ECO (2000–2009).

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	All years
ECO	–	1	1	1	–	1	1	0.88	0.89	0.81	0.89
LIS	1	–	0.67	–	0.5	0.5	1.17	0.69	0.75	0.87	0.70
MNG	0.5	–	1	1	0.67	1	0.67	0.86	0.82	0.91	0.86
PSY	1	1	0.95	0.5	0.91	0.85	1	0.95	0.95	–	0.92

6.4. The nature of coauthorship networks

A network is called *sparse* if the number of lines in the corresponding graph is of the same order as the number of vertices. Networks are called *dense* if the number of lines is much higher than the number of vertices (De Nooy, Mrvar & Batagelj, 2005).

Four disciplines in the years of study were compared using standard network centralization indices (degree and clustering coefficient, per Freeman, 1978). 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, Mrvar, & Batagelj, 2005), and the clustering coefficient measures the degree of collaboration of the coauthors of a certain author, and was calculated as an average value for the whole network.

The coauthorship networks of the four disciplines are illustrated in Figs. 1–4. Nodes represent authors, and node sizes the number of papers they have authored. Links represent coauthor links, and thickness of links represents the number of coauthor events. Fig. 1 shows the top 50 authors who had the highest number of coauthored works. As the PSY network was too crowded, this study visualizes the top 50, for a better presentation. The authors who had the greatest number of connections in the PSY network were Rashidpour, Afraz, and Adibi.

Fig. 2 shows the coauthorship network in LIS. It has one large component, in which Jamali and Nicholas have the most coauthorship connections with others.

The MNG coauthorship network (Fig. 3) is full of small components, and in each component three or four authors collaborated. In this network, Abolhasanpour has the most coauthored connections.

In ECO, there are several small components with four, three, or two authors in each (Fig. 4). The most coauthored author in this network is Rashidian.

Table 5 shows the results of the analysis. PSY has the largest number of nodes (310) and the highest number of links (1378). Density in the network of MNG is 0.02 0.MNG is the densest network, while PSY is the sparsest (0.014). ECO has the highest degree of vertices and it shows that each author connects with an average of 8.98 authors in the network. The clustering coefficient of the PSY network is 0.78, which is the highest.

Table 2
CI in the disciplines of LIS, PSY, MNG, and ECO (2000–2009).

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	All years
ECO	–	2	3	2	–	2.25	2.33	2.13	2.56	2.43	2.36
LIS	2	–	1.67	1	2	1.75	1.17	1.75	2.28	2.57	2.42
MNG	1.5	–	2	3	1.67	3.25	2	2.71	2.55	2.81	2.61
PSY	3.25	3.5	3.32	1.6	2.98	4.08	3.08	3.79	2.95	5.4	3.22

Table 4
CC in the disciplines of LIS, PSY, MNG, and ECO (2000–2009).

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	All years
ECO	–	0.5	0.66	0.5	–	0.79	0.54	0.47	0.55	0.49	0.51
LIS	0.5	–	0.78	–	0.31	0.29	0.08	0.35	0.42	0.56	0.4
MNG	0.25	–	0.5	0.67	0.77	0.66	0.39	0.53	0.52	0.57	0.53
PSY	0.59	0.68	0.64	0.27	0.59	0.59	0.63	0.66	0.62	0.78	0.59

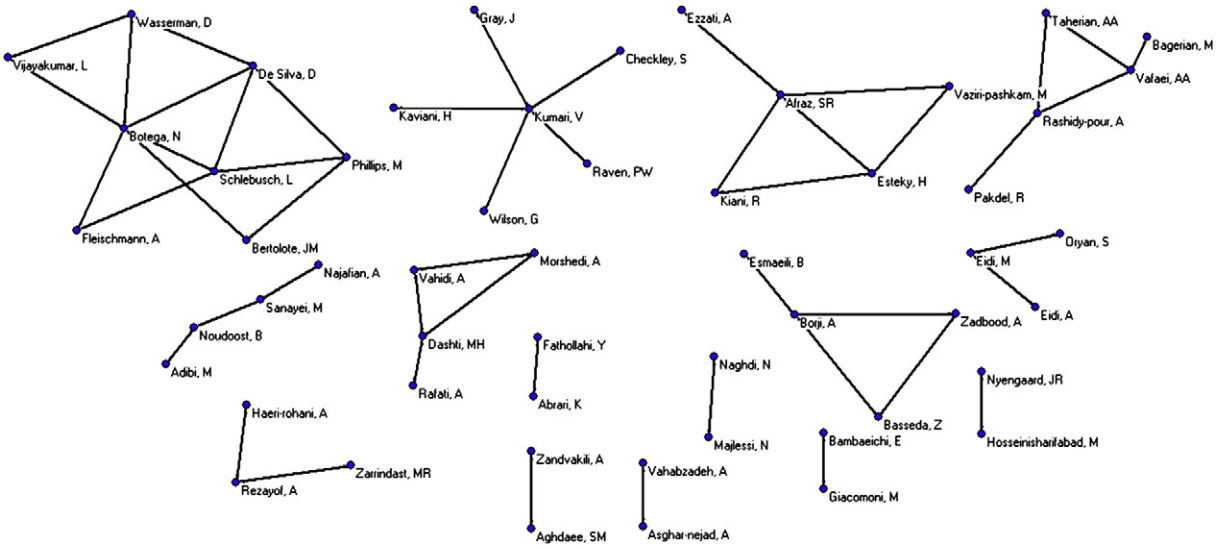

Fig. 1. Coauthorship network in PSY.

6.5. International coauthorship

Fig. 5 shows the percentage of collaboration with different countries in each of the four disciplines. In PSY, the U.S. has the highest number of coauthored papers with Iran; in LIS and MNG, the U.K. accounts for the largest number of coauthored papers with Iran; and in ECO, Canada has the most number of coauthored papers with Iran. "Others" represents those countries with which one coauthored paper has been published for each field. LIS collaborated with nine countries, MNG with 10, ECO with 11, and PSY with 18.

7. Discussion

These findings show that coauthorship in LIS increased during the years of 2000–2009. The study by Ajiferuke et al. (1988), measuring indexes of CI, CC, and DC for this field for the years of 1961–1986, found that CC was 0.08, whereas this index in this study was 0.4, so authors in this discipline have increased in coauthorship in recent years. They also found that DC was 0.15, where in this study it was 0.7. It seems that authors tend to have more multi-authored articles than before. The average number of authors per paper from 1961 to 1986 was 1.20, whereas this amount has increased to 2.40 for the years of 2000–2009. A Kruskal–Wallis test showed that the CC difference was statistically significant ($\chi^2 = 8.711$, $p = 0.033$, and $df = 3$), especially the difference between psychology and the other fields. This might be expected, as psychology is nearer to the hard sciences, compared to the other three disciplines.

Although this dataset is small compared to the study by Acedo et al. (2006) of the whole world, Table 6 compares the two studies for the field of MNG. MNG authors in Iran tend to have more scientific collaboration with others; the number of authors per paper in this study was 2.61, whereas Acedo et al. (2006) found 1.88 authors per paper. Also, the density of this network was much greater, as is neighborhood size. It is apparent in these findings that, as De Nooy et al. (2005) stated, density is often inversely related to network size, in that the larger the social network, the lower the density. This is

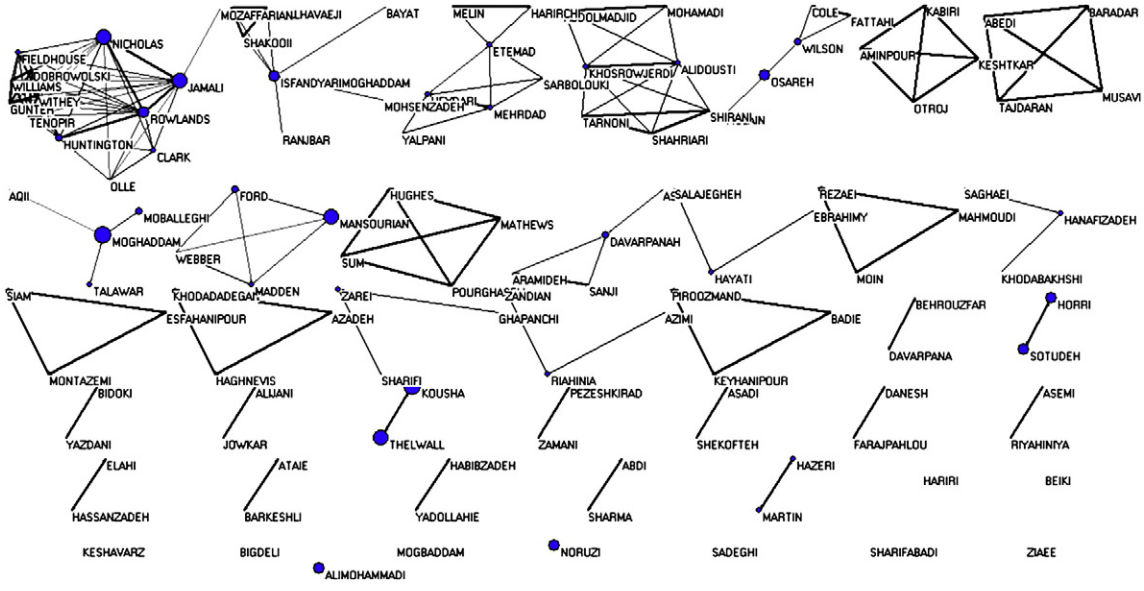

Fig. 2. Coauthorship network in LIS.

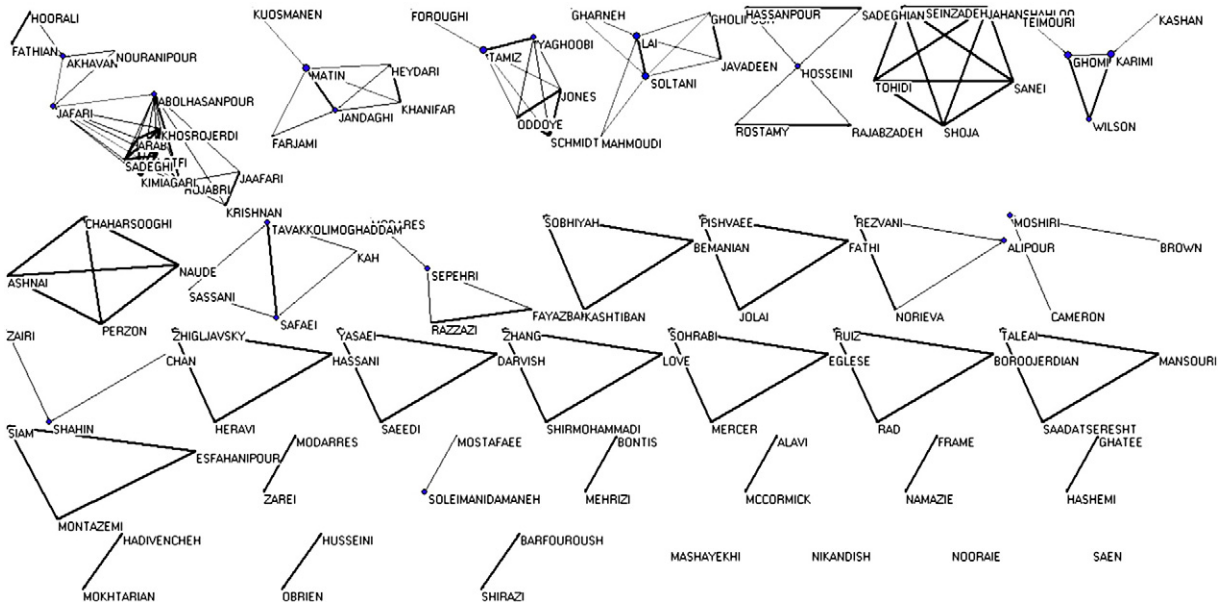

Fig. 3. Coauthorship network in MNG.

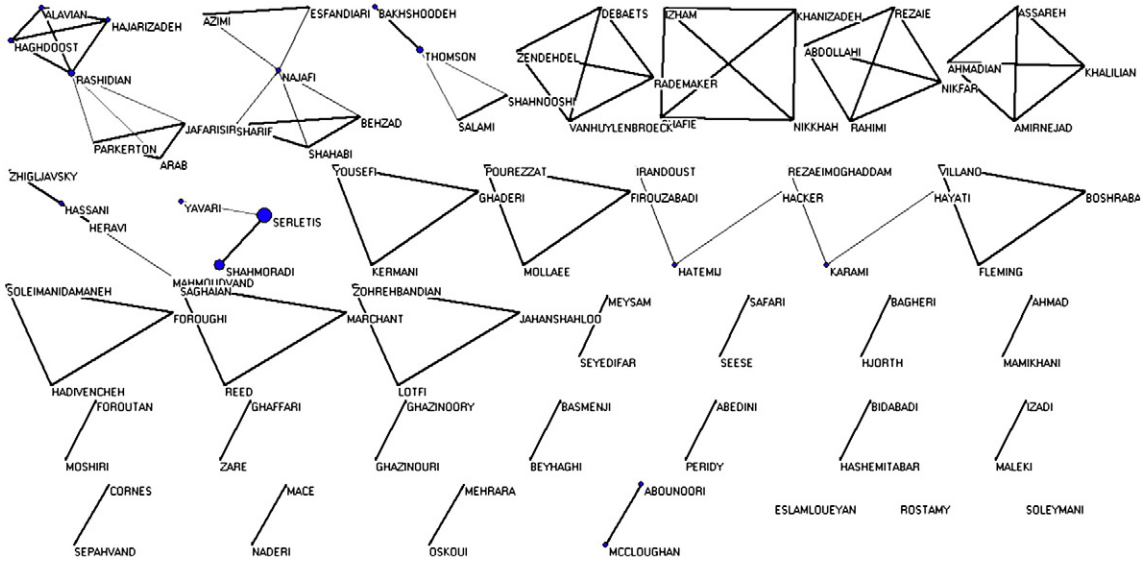

Fig. 4. Coauthorship network in ECO.

because the number of possible lines increases rapidly with the number of vertices, whereas the number of ties that each person can maintain is limited. There is also a similar clustering coefficient (an indicator of the mean relative density of the vertices' neighborhood).

These results also show that the U.S. had the most coauthored papers with Iran in PSY. As Osareh and Wilson (2002) showed, the U.S. had a high rate of collaboration with Iran in the sciences, as well. But for MNG and LIS, the most collaboration in science with Iran is the U.K. That is probably because of Iranian authors who have studied in the U.K. The main driving force of these collaborations between Iran and western countries is Iranian students who study abroad, some of whom are sponsored by the Iranian government. It should be noted that in 2009 the Iranian supreme leader demanded that academic textbooks for humanities and social sciences should be changed to comply with Islamic values. This led to some changes in government policy and action. For example, the government currently prefers not to send students in humanities and social science disciplines abroad, and this might, therefore, lead to a decrease in Iranians' international collaboration in the social sciences.

The average number of authors in LIS and PSY had increased by 2009, but compared to the other three disciplines, LIS authors do not collaborate as much.

Table 5
Co-authorship network analysis in disciplines of LIS, PSY, MNG, and ECO (2000–2009).

	ECO	LIS	MNG	PSY
Number of vertices/nods	100	123	122	310
Number of lines/links	184	320	296	1378
Density	0.018	0.019	0.020	0.014
Degree of vertices	8.98	5.03	4.85	8.89
Clustering coefficient	0.5	0.46	0.63	0.78

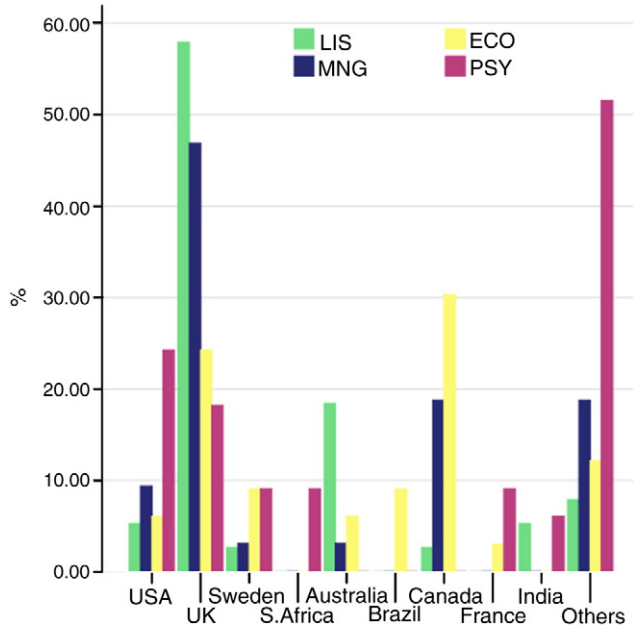

Fig. 5. Percentage of international coauthorship.

Table 6
Comparison of management data with Acedo et al. (2006).

	Our study	Acedo et al. (2006)
Number of papers	56	11022
Authors per paper	2.61	1.88
Nodes	122	10176
Density	0.020	0.0002
Clustering coefficient	0.63	0.68
Neighborhood size[a]	4.85	2.43
Degree centralization[b]	5%	41%

[a] The degree of a vertex is equal to its number of neighbors.
[b] Degree centralization of a network is the variation in the degrees of vertices divided by the maximum degree variation that is possible in a network of the same size.

This study had some limitations which affect generalizability. Data were restricted to ISI data, which covers only a proportion of international journals. Iranian social scientists have publications in non-ISI international journals that were not covered here. Additionally, the dataset was small due to the low number of publications by Iranians in the four given fields.

8. Conclusion

This was the first study of collaboration in the disciplines of library and information science, economics, psychology, and management in Iran using coauthorship indicators and coauthorship networks. Although the sample was small, the results are likely to be valid for the field of social sciences, in the Iranian context. With the exception of economics, the average number of authors per article has increased in all of the disciplines during the period studied. Also, compared to other disciplines, LIS showed less multiauthorship and lower tendency towards collaboration. Comparing these results for the social sciences with the findings of other studies on basic sciences (e. g. Osareh & Wilson, 2002; Osca-Lluch et al., 2009; Wagner, 2005), it appears that authors in these social science disciplines do not tend to collaborate with each other as much as the authors in mathematics, natural science, chemistry, physics, and medicine. One important subject for future research is to study the motivations and barriers for social sciences collaboration.

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