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Oranus Tajedini Dr.
*Shahid Bahonar University of Kerman, Kerman, Iran.*, tajedini.o@gmail.com

Narges Shirazi
*Iran Public Libraries Foundation, Kerman, Iran.*, n.shirazi@pl.ir

Enayatollah Sharifpour
*Department of Persian Language and Literature, Shahid Bahonar University of Kerman, Kerman, Iran.*, sharifpura@uk.ac.ir

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# Investigating the Relationship between Centrality Measures and Productivity of Persian Language and Literature Researchers

**Oranus Tajedini**

Assistant Prof., Department of Knowledge and Information Science, Shahid Bahonar University of Kerman, Kerman, Iran.
tajedini@uk.ac.ir

**Narges Shirazi**

M.A. in knowledge and information science, Iran Public Libraries Foundation, Kerman, Iran.
n.shirazi@pl.ir

**Enayatollah Sharifpour**

Associate Professor, Department of Persian Language and Literature, Shahid Bahonar University of Kerman, Kerman, Iran.
sharifpur.a@uk.ac.ir

**Abstract**

**Objectives:** The present study was to identify the structure of co-authorship networks in the field of Persian language and literature, and to investigate how these structures assist researchers in successfully publishing their research works. More specifically, this study investigated the relationship between centrality and productivity of researchers in the field of Persian language and literature.

**Methodology**: This descriptive study was conducted through scientometric approach using social network analysis. The population of the study included all documents which were published by Persian language and literature researchers and have been indexed in ISC since 2012.

**Findings and conclusion**: The results showed that the topological macrostructure of the researchers' co-authored scientific outputs enjoyed low cohesion and density; there was low willingness to co-authorship. Most of the outputs were written by a single author or two authors. The number of scientific outputs increased in 2009 and 2010, and the production in this area is increasing.

**Keywords:** Persian language and literature, Centrality measures, Productivity, Research collaboration, Scientific collaboration, Social network analysis.

**Introduction**

Over the past decades, the cooperation among individuals, research organizations and various countries to produce knowledge has been increasing. Scientific collaboration as an important activity facilitated the provision and dissemination of knowledge, and as a result, it attracted the researchers' attention (Ye, Li, & Law, 2011). In research context, co-authorship is the most observable and accessible indicator of scientific cooperation. A co-authorship social network represents the multidimensional relationships among researchers (e.g. colleagues) sharing their knowledge indirectly through publishing articles. This interconnected chain of relationships forms a kind of social network in which valuable resources are shared in the form of information, knowledge and awareness through social interactions. This network can provide its members with a joint capital, known as social capital. It has been proven that this capital has a positive effect on knowledge production and knowledge transfer. Members of co-authorship networks can benefit from the social capital through social interactions, broaden their horizons of awareness and seek better results (Jiang, 2008).

Analysis of social networks provides techniques for analyzing the structure of a network as a whole, as well as techniques for analyzing individual nodes and their locations in the network. The use of social network analysis as well as information visualization techniques enables researchers to identify the structural characteristics of co-authorship population, and the effective members of the population, to estimate the constraint and the efficiency of the network, and to determine the type of network. Therefore, by presenting the structure and studying a field of science cross-sectionally, the requirements of the field's development will be provided.

The analysis of social networks is based on the assumption that the relationship between social factors can be determined by drawing the corresponding graphs. The graph nodes represent social factors while the edges connect the pairs of nodes. Therefore, the graphs represent the social interactions between the nodes. These types of graphs provide researchers with the opportunity to use Mapping Theory to analyze issues, including the network of interconnected social relations of authors. Obviously, if this theory is not used, it is difficult to understand these relationships and interactions (Liu, et al., 2005).

The estimation of co-authorship in scientific publications is theoretically simple, and is significantly related to the degree of scientific cooperation. Collaboration can be useful for many reasons. It provides a great deal of ideas, methods and resources. It also facilitates sharing costs and saving time as a result of the division of labor (Lu & Feng, 2009). According to Cheong and Courbit (2009), numerous studies have highlighted the positive relation between scientific collaboration and co-authorship. Thus, co-authorship can be considered as one of the most convincing forms of research collaboration.

Given the positive effects of collaborative scientific activities, understanding these activities is very important because analyzing collaborative research activities from different perspectives and paying attention to their impact on scientific cooperation networks lead to a scientific understanding of the structure of research communities. For instance, National Institution for Academic Degrees and University Evaluation of Japan has accepted

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collaborative and scientific participation as an important point in the evaluation of research activities (Marin & Wellman, 2011). Research activities should be evaluated from a variety of perspectives, including the roles in scientific cooperation networks. Different perspectives may yield different results in research evaluation.

As mentioned, in analyzing co-authorship networks, ranking individuals in the social network, (i.e., analyzing prominent or central individuals) is an important and fundamental task (Chakrabarti & Faloutsos, 2006). The results of the studies show that the use of centrality metrics in assessing the scientific productions of researchers, especially in identifying co-authorship, has been noted in recent years. The networks which are created based on collaborations are analyzed based of various metrics; one of the most useful and commonly used metrics of these networks is centrality metric (Tajedini, et al., 2018). Centrality metrics are used to identify the position of specific nodes within a network (Nooy, Mrvar & Batagelj, 2011) because individuals who are at the center of the network are more powerful than other individuals, have more impact on other network members and access most sources within the network. The most important centrality metrics include betweeness, degree, and closeness.

Language and literature of each nation are the symbols of the identity of that nation; they are similar to a mirror which shows the general culture and the history of the nation. History, rich culture and civilization, divine religion and native national language are the most prominent signs of Iran's history; the great variety of works of famous poets, lecturers and authors point to the ancient history of Iran's culture and civilization (Alavi & Alliakbarpoor, 2011). Persian language and literature is considered as the common property and heritage of all Persian speakers of the whole world in general; it also organizes the cultural identity of Iranians in particular. Iranian culture in Iran's broader civilization is in debt of Persian language and literature (Mousavi, 2015).

The most important element of Iranians' cultural identity is Persian language and literature, which is the spiritual heritage of all the Iranian tribes with its 1,000 year history. At the political and international level, it is Persian literature which consistently maintains Iranians' identity at a high level (Salahimoghaddam, 2015).

Despite the wide range of studies in the field of scientific collaboration and co-authorship, the structural analysis of the social network of researchers in the field of Persian language and literature has been neglected; no study analyzing the structure of the social network of researchers in the field of Persian language and literature was found in the literature. On the other hand, it seems that there is an end to the era of single authorship; co- authorship networks are growing; researchers and authors tend to collaborate more than they did in the past. Therefore, researchers need to know more about the structure of co-authorship social networks, their impact on the number and the productivity of scientific productions. Therefore, this research study seeks to investigate the relationship between the centrality and productivity metrics of Persian language and literature.

## Literature review

In his research study, Bordons (2015) investigated the relationship between the scientists' research performances and their status in the co-authorship social network in three fields of nano, pharmacology and statistics. He found that there was a positive relationship between the number of co-authors (i.e., centrality degree) and the strength of the links and the G index in each of the three mentioned areas.

Wang (2014) investigated the research collaboration social network in the field of educational technology management. He found that the researchers' social network in this area was extremely fragile and might reduce research progress. In addition, there was a significant relationship between network formation and geographic location of researchers, distribution of journals and organizational affiliation.

Studying a 64-year period (i.e., 1948 to 2012) which included 5417 articles, Abrizah, et al. (2014) investigated successful researchers in the field of information sciences. They analyzed the prolific researchers (i.e., researchers with the highest betweeness, cooperation and co-authorship) in terms of productivity, citation impact and co-authorship. The results of their research showed that the most prolific researchers in the field of information sciences did not have a normal distribution of co-authorship; the most prolific researchers were not necessarily the ones with more co-authorship. In addition, the total citations of each researcher compared to their total publication were a better indicator of the researchers' scientific impact.

Yu, Shao and Zhiguang (2013) investigated scientific collaboration in the field of cardiovascular diseases in China. The research population included the articles published in five journals on cardiovascular diseases from 2000 to 2010. They used homograph, co-authorshipt, and centrality metrics to analyze the data. The results of the study showed that although the percentage of co-authorship papers and the average number of authors in each article in cardiovascular area were generally increasing, the geographical distribution of co-authorship was not satisfactory. Therefore, the Chinese government should play an important role in supporting or encouraging authors to collaborate scientifically across different regions.

Badar, Hite and Badir (2012) explored the relationship between the centrality of co-authorship network (degree, closeness and betweeness) and the efficiency of researchers in the field of chemistry in Pakistan. They found that there was a significant relationship between the centrality of degree, closeness and efficiency of the researchers.

Abbasi, Altmann and Liaquat (2011) presented a theoretical framework based on social network theories and analytical methods to explore collaborative networks of researchers. In this project, social network analysis scales, such as the centrality of degree, closeness and betweeness, were used to examine the impact of social networks on the performance of researchers in a given order. The findings showed that researchers' performances were directly related to the SNA scales, except centrality of closeness and betweeness. Therefore, researchers who cooperated with many other researchers had a better performance than did others. In addition, researchers with high power relationships had a better research performance than those with low power relationships. Furthermore, researchers who maintained a strong

collaborative relationship with a specific group of researchers performed better than those who had multiple relationships with the same group.


**Research hypotheses**

1. There is a significant relationship between the degree centrality and the productivity of researchers in the structure of co-authorship social network of Persian language and literature.
2. There is a significant relationship between the closeness centrality and the productivity of researchers in the structure of co-authorship social network of Persian language and literature.
3. There is a significant relationship between the betweeness centrality and the productivity of researchers in the structure of co-authorship social network of Persian language and literature.


**Methodology**

The method of the present study is network analysis, which examines and analyzes the effectiveness of social structures of individual, group or organizational relationships on the believes. It also bases the analysis of social networks on the importance of interrelationships between institutions (Haythornthwaite, 2005). In fact, the analysis of the social network is conducted to understand (i.e., identifying authors with the centrality role) the nodes (i.e., co-authors) and their relationships (i.e., interactions) in the network, as well as to identify co-authorship patterns in the field of Persian language and literature.

The population of the study included all documents (i.e., 5283 articles) which were published by Persian language and literature researchers and have been indexed in ISC since 2012. The data of each document included the names of the author(s), title and date. Data collection was carried out in two steps. First, to retrieve the data from ISC database, articles in the field of Persian language and literature were searched, retrieved and saved. In fact, there were some inconsistencies in the authors' names; the names of some authors were written in different ways. For instance, the middle name or two-part last names were written differently in different articles (e.g. Vasheghani Farahani Ebrahim may be written as Vasheghani-Farahani Ebrahim). This made the process of data processing difficult. In order to solve this problem, the full names of these individuals were searched, and the most frequent names were selected. The preprocessing process was performed; repeated and incorrect forms, as well as identical forms with different spellings, were identified and corrected. As mentioned, the data in each article included the names of the author(s), title and date. The names of authors were standardized because some authors had their names written differently in different articles. In order to prepare the authors' matrix, the file was converted into Primp software's format, and the data were entered. Subsequently, the resulting matrix was uploaded using the Ucinet software, and the centrality metrics (i.e., degree, closeness and betweeness) were obtained. Then, using the complementary version of Ucinet, Net Draw, the co-authorship network was drawn.

In the second step, a scheme for viewing relationship matrices was developed so that it could be used as input for Ucinet. Each relationship matrix cell represented the number of

collaborations between two specific nodes (researcher/ country/ organization). The authors' file standardized in the previous step was converted to Primp format; the data were in separate rows; each row started with "<Author>" and ended with the "#" sign. An example of the data is provided below.

<AUTHOR>#   Aghagolzadeh, Ferdous

قوام، ابوالقاسم#قبول، احسان<AUTHOR>>

After changing the file, it was saved in the text format and was retrieved through Primp software. Then, the co-authorship matrix was created. In fact, co-authorship matrix is a square with equal number of rows and columns; each intersection represents the number of times the authors of the row and column collaborated in an article. Thus, it is a symmetric matrix.

In order to be used in the Ucnet software, the co-authorship matrix files which were taken from Primp in text form must have been converted to Excel.

To analyze the articles' co-authorship network, Ucnet software (version 6) and its complementary package (i.e., Net draw) were used. This software, designed by Borgatti, Evert and Freeman at Harvard University, is one of the most comprehensive and most popular social network analysis softwares (Sadatmoosavi et al., 2018). The software was used to draw different graphs of degree, closeness and betweeness metrics; how they were estimated through Ucnet software is explained below. Each of the centrality metrics was estimated through Ucnet software and was converted to Net draw format (## H). Then, they were retrieved, and each graph was plotted separately.

The validity and reliability of any research should be considered at the beginning stages. In fact, research is valid when the interpretations are appropriate; it is reliable when the findings are consistent.

In bibliometrics studies, reliability is not usually estimated since these studies are based on well-known and well-established mathematical equations; repetition of the calculations will result in similar results; the studies are reliable. In addition, since the equations and formulas of this study are based on authoritative sources, and many studies have been conducted using these formulas (e.g., Newman, 2001; Barabasi, Jeong, Neda, Ravasz, Schubert & Vicsek, 2002; Kretschmer, 2004; Liu, et al., 2005; Yin, et al., 2006), this study has the required validity.

The data were analyzed using descriptive and inferential statistics; to test the hypotheses regarding the structure of co-authorship networks, Spearman correlation coefficient was used; the macro and micro indices of researchers' co-authorship social networks were analyzed by social network analysis software (Borgatti, Evert & Freeman, 2002). Other formulas used in this study are mentioned below.

The formula for estimating degree centrality (Yan & Ding, 2009)

$$C_D(v_i) = \sum_{k=1}^{n} a(v_i, v_k)$$

The formula for estimating closeness centrality (Freeman, 1989, 2006 & 2007)

$$C_C(v_i)^{-1} = \sum_{k=1}^{n} d(v_i, v_k)$$

The formula for estimating betweeness centrality (Rumsey-Wairepo, 2006)

$$C_B(v_i) = \sum_{j=1}^{n} \sum_{k=1}^{j-1} g_{jk}(v_i)/g_{jk}$$

Network density (Pril, 2011)

$$d = \frac{L}{n(n-1)/2}$$

Clustering coefficient (Newman, 2003)

$$C = \frac{3 \times number\ of\ triangles\ in\ the\ network}{number\ of\ connected\ triples\ of\ nodes}$$

## Findings

**There is a significant relationship between the centrality of degree and the productivity of researchers in the structure of co-authorship social network of Persian language and literature.**

To investigate the relationship between the degree centrality and the productivity (i.e., number of articles), Pearson correlation coefficient was estimated. The results of this test are presented in Table 1.

Table 1. The relationship between the degree centrality and the productivity of researchers

| variable | productivity | | Relationship-type of relationship |
|---|---|---|---|
| | Spearman correlation | | |
| | Correlation (r) | P | |
| **Degree centrality** | .306** | .000 | Yes-direct |

At .05 significance level

As Table 1 shows, there is a significant positive relationship between the centrality of degree and the productivity of researchers in the structure of co-authorship social network of Persian language and literature. In other words, as the researcher's productivity in the co-authorship social network increases, his centrality degree will increase.

**There is a significant relationship between the centrality of closeness and the productivity of researchers in the structure of co-authorship social network of Persian language and literature.**

The results of Spearman correlation (Table 2) show that there is a significant negative relationship between the centrality of closeness and the number of published articles of researchers (r = -.171, P <0.05). In fact, there is an inverse relationship. In other words, by increasing the closeness centrality, the number of articles published by a researcher decreases, and vice versa.

**Table 2. The relationship between the closeness centrality and the productivity of researchers**

| variable | productivity | | Relationship-type of relationship |
|---|---|---|---|
| | Spearman correlation | | |
| | Correlation (r) | P | |
| closeness centrality | -.171 ** | .000 | Yes-inverse |

At .05 significance level

**There is a significant relationship between the centrality of betweeness and the productivity of researchers in the structure of co-authorship social network of Persian language and literature.**

The results of Spearman correlation (Table 3) show that there is a significant positive relationship between the centrality of betweeness and the number of published articles of researchers (r = 0.448, P < 0.05). In fact, there is a direct relationship. In other words, by increasing the betweeness centrality, the number of articles published by a researcher increases.

**Table 3. The relationship between betweeness centrality and the productivity of researchers**

| variable | productivity | | Relationship-type of relationship |
|---|---|---|---|
| | Spearman correlation | | |
| | Correlation (r) | P | |
| closeness centrality | .448-.** | .000 | Yes-direct |

At .05 significance level

**Discussion and conclusion**

The results of the correlation showed that with the increase in degree centrality, the number of researchers' published articles increases. In a social network, individuals who interact with a large number of people (i.e., high degree) are likely aware of the information within the network (Freeman, 1979; 2006), and since they have more options to choose, they have more opportunities and choices than do other researchers. This opportunity makes them independent; they do not depend on specific authorship. Therefore, they can take advantage of structural

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capital and receive more information, knowledge and resources. In other words, they have a prominent status in the network; since they have many colleagues, they have more ways to meet their needs. If their relationship with a researcher breaks up, they maintain their relationship with other researchers. Thus, researchers with high centrality have the maximum access to all resources and information in the network, and have the ability to retrieve information from the network. On the other hand, since the high degree centrality of an individual is affected by the number of researchers with whom he directly interacts, the number of his scientific output will naturally increase. The findings in this section support those of Badar, Hite and Badir (2012) who showed that there was a relationship between degree centrality and the number of papers published by the researchers in the field of chemistry in Pakistan.

Direct links can have many benefits, including sharing knowledge and complementary skills (Acedo, et al., 2006). For instance, if two or more authors publish an article, each adds a certain amount of knowledge to the article; each author acquires new knowledge through direct interactions and intergroup discussions. If authors have similar knowledge background, they will benefit from commenting on the topic; these comments will deepen the discussions (Abbasi & Altmann, 2012). If authors have the complementary knowledge, they will benefit from the research study and each other's experiences. Authors with completely different background knowledge can benefit from each other's expertise in order to develop their own expertise without investment (Tajedini & Sadatmoosavi, 2018); it is quite possible to create new knowledge which results from the combination of two different knowledge backgrounds. Sharing and creating knowledge subsequently may lead to the promotion of the quality and quantity of the authors' articles (Li, Liao & Yen, 2013). Therefore, it is expected that direct links increase, combine and exchange knowledge and resources, and provide researchers not only with new knowledge but also with new experiences; it may increase the scientific outputs.

The results of the correlation showed that if closeness centrality increases, the number of articles published by the researcher will decrease, and vice versa. Closeness centrality means that a researcher is linked to all other individuals through multiple paths (Otte & Rousseau, 2002). It represents the average distance of a researcher from other researchers (Lu & Feng, 2009). Although occupying a central position in a co-authorship network gives strategic importance to the researcher in terms of closeness, it does not necessarily increase his research outcomes. Therefore, if an individual who does not have direct co-authorship but can access other researchers through co-authorship paths has the shortest distance with researchers (closeness centrality), his scientific outputs may be negatively affected.

The results of the correlation showed that with the increase in the researcher's betweeness centrality, the number of his articles will increase. The findings of this part of the study are in line with those of Jan and Ding (2009), as well as those of Li, Liao and Yen (2013), who showed that it is essential to eliminate structural cavities in the context of a co-authorship network. In other words, obtaining non-repetitive resources from other research groups is more important than obtaining the required resources from immediate colleagues because from a source-based point of view, it has a competitive advantage.

According to the results of this study, the following implications are proposed.

1. Participating in international congresses and conferences is one of the best ways to contact potential researchers to establish links for co-authorship. If researchers in the field of Persian language and literature participate in such meetings, they should try to establish a scientific relationship. It is suggested that universities and research centers provide the researchers in this field with opportunities to participate in the congresses.
2. It is recommended that researchers in the field of Persian language and literature expand their scientific cooperation and collaborate with different researchers from different universities and research institutes. It will lead to the increase in their productivity and degree centrality.
3. It is suggested that Iranian researchers in the field of nuclear science and technology improve their productivity by linking structural cavities through communicating with diverse and new research groups, such as interdisciplinary groups.
4. It is suggested that Iranian researchers in the field of nuclear science and technology establish a strong relationship with a researcher from a strong group. The productivity of the researchers following this method will increase more than that of the researchers who have more connections with members of the same network.

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