



# Network Analysis of Interpersonal Relationships in Tehran Stock Exchange

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## ABSTRACT

The stock market has an important role in growth and development of countries. Network analysis is one of the latest methods in analyzing the stock market. In quantitative science literature, it is a new concept for a macro view to whole market. Therefore, this research analyzes the interpersonal relationships' network in the Tehran Stock Exchange (TSE). From the type of data collected and analyzed point of view, this study is a quantitative research in network analysis domain. The research period is from 2013 to 2017. Softwares such as PreMap and UCINET used for analyzing data. The research results indicated that some individuals, in comparison with others, have a better position in communicative networks. Having better position has caused these individuals to encounter fewer mediators in gaining access to others, and in turn easier access to available resources. In addition, their ability in gaining access to information enhanced via the cluster of network members. Therefore, it might be concluded that these individuals are key actors in governing structure of the TSE. Furthermore, this network follows a kind of bus morphology i.e. individuals act as a bridge for other units and connect them to the core of the communication network.

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## 1 Introduction

As yet, most researches have focused on stock market, the characteristics of companies, and the relationships between information and the given characteristics. Jamkarani and Lalbar [11] same as other researchers investigated the relationship between the financial incentives of board members. It means that the issues have been studied thorough the viewpoint of characteristics and features. The relations of companies, regardless of their features, can have a determinative effect on the financial situation and stock market trends. These relations have been less considered until recently. For example, if a research was conducted upon the board of directors, factors such as the number of board members, executive and non-executive members, members' educations and etc. have been taken into account, but it does not regard the impact of a person who is a board member of two or more companies simultaneously. This matter is not investigated in papers. In addition, the main beneficiaries of this relationship or the key actors have been ignored. Furthermore, several researches have been carries out on the key issue of

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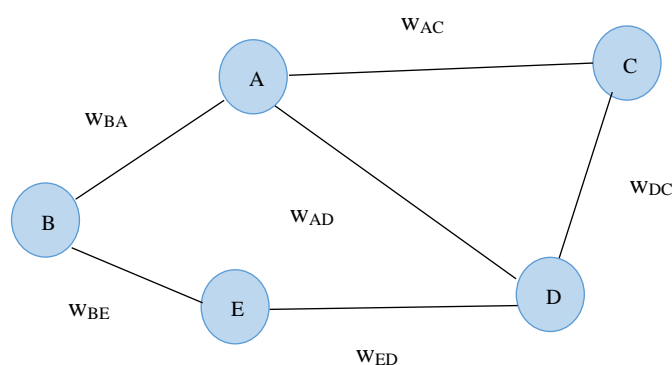
the board of directors as an effective and important supervisory factor [16, 28]. However, the structure of the board of directors' relations (made by the joint members) has not been considered. In other words, determining which pattern is followed by the relations' structure and who are the effective or key actors is not studied well. In fact, this research tries to answer two key questions: a) which pattern is followed by the relationships among individuals in Tehran Stock Exchange (TSE)? b) Who are the key actors in this structure? The first and most important difference between the network data and other data researches is in the data type. It means, the network data consists of testing one or more types of relationship among the set of actors [29]. Therefore, since the network analysis is performed with the aim of generating and analyzing the relation-driven data and seeks to recognize the structural pattern of communications and the structural characteristics, this method is used to answer these questions and perform the research. In fact, the innovation of this research lays in the type of data used (relational data) and the analysis method (network analysis method). In addition, the researchers could have not found a research, which has been examined the communication structure of board members in the Tehran stock Exchange so far. This study seeks to fill this research gap by using network analysis and relational data.

## 2 Theoretical Backgrounds and Literature Review

Corporate governance system is the regulatory mechanism that controls financial and managerial behavior which is responsible for controlling financial and managerial behaviors and it is developed in accordance with the legal and cultural system of each corporate [12]. Over the past decades, studies provide inconclusive evidence on the relationship between corporate governance and performance across the countries [15]. One of the most important mechanisms of corporate governance is board of directors. It plays the role of supervisor on the tasks of executive managers to maintain the ownership benefits of shareholders [14]. A joint board of directors exists whenever a person affiliated with an organization is a member of the other organization's board of directors too. From the social network view, the joint board of directors that serves for other companies simultaneously is a form of social capital which provides the information access through a stream of social relations made by management. The joint board of director affects many of the organization's operations including the rights and benefits of the board of directors, governance system, organizational structure and quality control. The related literature focuses on the role of the joint board of directors as an important source of information exchange among organizations.

From the information viewpoint, it seems that the joint board of director is effective in decision making and has more control and access over other information sources, since they have valid and reliable information [3]. On the other hand, the behavior of the stock markets reflects the results of the mutual interactions among participants who are trying to maximize their interests. Such mutual interactions lead to increased complexity in the behavior of financial markets. Stock markets are considered as a type of complex networks due to the interaction among various companies and investors. The network effect in stock markets provides better understanding on how people have access to the information about events. Also, it represents that how the response of individuals to events affects the stock market. The network analysis plays a role in revealing the internal structure of stock markets and their evolution over time [2]. In fact, social network analysis focuses on the objective pattern of links that bind the members of the society (individually and collectively) [19]. Individuals rely on their personal and relative relationships to access information, resources and situations. These relationships form the person's social network, which in turn establishes the social system [23]. A network is defined as a set of nodes connected by lines. Nodes are usually actors. The edges or ties connect actors to each other [8]. One

type of relational content is the boundary permeation relations. It shows the link among actors with the joint members such as the companies' board of directors who are the members of several boards simultaneously [4]. In social network theory, the network analysis is not merely a theory of social science, but rather an approach to study the social structures. That is why social network analysis is often referred as structural analysis. The content of an actor or the relationship of actors is the main concern in the network analysis, while traditional researches mainly address the individuals' features. In fact, a network analyst tries to find out the way of creating an entity and its connection to the network [27]. In figure 1, a very simple network is represented which each letter shows a point or node (e.g. individual) in the network. The lines connected to the letters indicate that these points are connected to each other by specific patterns (e.g. a board member or joint shareholder). The concept of link is the most important and permanent way to denote this feature of the network. In figure 1, there are links between B-A (a member of board or joint shareholder B and A;  $W_{BA}$ ), A-C (a member of board or joint shareholder A and C;  $W_{AC}$ ), A-D (a member of board or joint shareholder A and D;  $W_{AD}$ ), B-E (a member of board or joint shareholder B and E;  $W_{BE}$ ), D-C (a member of board or joint shareholder D and C;  $W_{DC}$ ) and E-D (a member of board or joint shareholder E and D;  $W_{ED}$ ). Not only it is necessary to identify the points of the network that are connected, but also the ideas about the nature of communication among these points must be specified.



**Fig. 1:** A Simple Network

Peng et al. [18] have studied the relationship among the joint board of directors and performance of Chinese companies listed in the Hong Kong Stock Exchange. Their research results show the involvement of the joint board of director's help to improve the companies' performance. Sankowska and siudak [21] have studied the networks of board of directors and corporate executives of big companies in the Polish capital market in 2014. The experimental results have represented that real networks have the characteristics of small world networks. Furthermore, the networks are organized and classified and certain behaviors are applied over them. Singh and DeLose [24] have studied the relationship between the structure of the board of directors and the risky behavior of emerging companies. Their focus were on examining the individual and joint effects of the board structure, the centrality of the network by communication and the ownership structure in the company's development strategies. The research results have shown that companies with non-executive members of the board of directors and CEO duality, as well as companies that are central to the other corporate networks, are more likely to develop through new domestic or foreign investments. Helmers et al. [9] have studied the role of joint board of directors in the amount of expenditure on realization, development as well as patent, representing the

company's innovation in India. Their results indicate that the board of directors has a positive effect on the costs of research and development cost and inventions. In other words, their evidence has shown that these positive effects are due to the information transferred by the joint board of directors. Witters et al. [30] have studied the evolution of the board of directors' network after Sarbanes-Oxley. The experimental results have shown that after Sarbanes-Oxley, the tendency of companies to abuse the board of director's connections has been enhanced. Similarly, the companies are more likely to rely on their existing partners to fill their board chairs after the Sarbanes-Oxley. Khajavi et al. [13] in a research of "accounting information systems and social network analysis" have studied that how social network analysis helps to evaluate the users of accounting information systems. They have shown several cases of using social network analysis in accounting information systems.

### 3 Research Method

As mentioned earlier, the aim of this research is to analyze the communication networks between individuals who are members of the company's board in TSE. To achieve the research goal, the following questions have been addressed:

1. Which pattern does the individual's relationships structure in stock market follow?
2. Who among the board members are the key actors in this structure?

This research uses practical method. Its methodology is quasi-experimental by using retrospective approach (through past information). In addition, according to the type data which collected and analyzed, the research is quantitative research of network analysis. The main approach of this study is to use graphical techniques based on graph theory (a branch of topology). In the graph theory, by applying matrix algebra the notion of relationships among actors (nodes) in a network would be studied in a visual, algebraic or logical manner.

#### 3.1 Network Analysis Method

The network analysis focuses on the interactions and relationships of individuals or groups. It tries to recognize the structural pattern of communication and the structural characteristics of these relationships and its subsets [7]. Some of the most commonly used concepts in social network analysis are as follows:

- **Network:**  
The concept of network refers to this fact that every individual has node connection with others whom in return have small, medium, and large node connection with others [29].
- **Social network:**  
It refers to a set of actors, communications and their linking nodes. The network analyst will attempt to represent the group structure by designing a model for these relationships [6, 29].
- **Nodes:**  
Individuals or agents involved in the network are called nodes. Nodes can be individuals, groups, organizations and even countries.
- **Links:**  
The relations between nodes are called links.
- **Graph:**  
To analyze the social relations, it is necessary to have an explicit representation and pattern

about these social relations and in return comprehend what is about. Therefore, the need for a tool and a theory for analyzing these relations turned attention to the graph theory. Actors represented by nodes and relations shown by lines and drawn as a graph or social network [5, 6, 17, 22].

- **Relational Data:**

The two major types of data are attributal data and relational data. Relational data includes communications, nodes, links, etc. which connects one person to another person and cannot be reduced to only the characteristics of individual agents. The relational data are the major issue of research related to the structure of social action. Relations create structures, so structural issues can be solved by collecting and analyzing relational data. In contrary, most literature on research methodologies have focused on variable analyses for research on attributal data [6, 22]. The first and foremost difference between the network data and other researches is that the network data consists of testing one or more types of relations among the set of actors [29].

In addition to the overall analysis of the shareholding network, the performance of each node in the network is also studied using the micro indicators. Centrality, as one of the most important concepts of network analysis, investigate the importance and influence of individuals on the network. The network node centrality can be studied using three indicators of degree, betweenness and closeness. The centrality degree of a node in social network represents the number of links that a node has with other nodes in the network. In other words, in a shareholding network, the centrality degree of each individual represents the number of his/her relations with other members involved in the network through joint corporates (the corporates in which shareholders have determined the members of the boards of directors or CEO). The centrality degree of node  $k$  ( $p_k$ ) is calculated by eq. (1):

$$C_D(p_K) = \sum_{i=1}^n a(p_i, p_k) \quad (1)$$

Where  $n$  is the number of nodes in network,  $a(p_i, p_k)=1$  if two nodes  $p_i$  and  $p_k$  are connected and otherwise it is zero. The betweenness indicator of a node indicates the number of times that node is located in the shortest path between two other nodes in the network. Nodes with high betweenness play a key role in information stream and network connectivity and also they have a central position in the network. The betweenness indicator of node  $k$  ( $p_k$ ) is obtained by eq. (2):

$$C_B(p_K) = \sum_{i < j}^n \frac{g_{ij}(p_k)}{g_{ij}} ; i \neq j \neq k \quad (2)$$

Where  $g_{ij}$  is the shortest path between  $p_i$  and  $p_j$  link; and  $g_{ij}(p_k)$  is the shortest path between  $p_i$  and  $p_j$  link passing through  $p_k$ . The closeness indicator of a node represents the average length of the shortest paths between that node and other nodes in the network. Nodes with high closeness indicator have greater influence on the network, play a key role in the network and have higher availability for other nodes. The closeness indicator of node  $k$  ( $p_k$ ) is obtained by eq. (3):

$$C_C(p_K) = \sum_{i=1}^n a(p_i, p_k)^{-1} \quad (3)$$

Where  $d(p_i, p_k)$  is the shortest path between two nodes  $p_i$  and  $p_k$  [1].

### 3.2 Research Variables Definitions

According to the researches of Sankowska and Siudak [21], Singh and DeLose [24], Withers et al. [30], Rossoni and Gonçalves [20] and Carney et al. [5] the names of real members who are the members of board of directors or CEOs have been used to obtain the relational network among the involved individuals in the TSE. Therefore, the individuals' relationships are studied based on the companies in which there are the members of the board of directors of CEOs. In fact, if several people are the members of the board of directors or CEO, it will lead to establish a relationship among them through that joint company. To analyze the individual's network, in the case of general network, the researchers discussed and analyzed the isolated units, closeness, betweenness and degree.

### 3.3 Data, Research Period, and Sample

The statistical population of this research is all individuals who are board members or CEO in companies listed in TSE. In this research, the researcher studied all individuals who were board member or CEO in stock market in the period of 2013 to 2017, and their information were available. It must be mentioned that no sampling is performed. Therefore, according to the terms, 2287, 2444, 2560, 2633 and 2645 people have been selected to be reviewed in period of 2013 to 2017. The necessary data and information have mainly collected through the databases of TSE and Rahavard Software. In addition, the results were analyzed using the network analysis method as well as Excel 2016, PreMap v1 and UCINET v6.

## 4 Research Findings

As above mentioned, in this research, the analysis of relationships network in TSE is discussed (Fig. 2 to 6 represent the sample network for 2015).

### Descriptive Statistics

The descriptive statistics of the quantitative data used for research patterns are rendered in Table 1. These statistics relate to relationships between individuals based on companies in which they are members of the board of directors or CEO.

**Table 1:** Descriptive Statistics of the Research Period

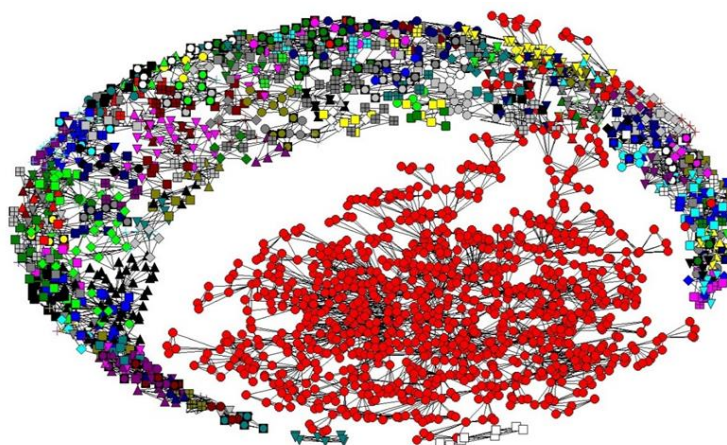
	2013	2014	2015	2016	2017
Mean	1.20	1.19	1.17	1.19	1.12
Median	1	1	1	1	1
Standard deviation	0.55	0.52	0.49	0.43	0.42
Minimum	1	1	1	1	1
Maximum	6	6	6	6	6
Total	2750	2915	3017	2999	2979
Number of observation	2287	2444	2560	2633	2645

The maximum frequency in in 2013 belongs to A. H, and M.A; in 2014 to F. R; in 2015 to A. H; in

2016 to H. S; and in 2017 to B. GH.

### Overall Networks

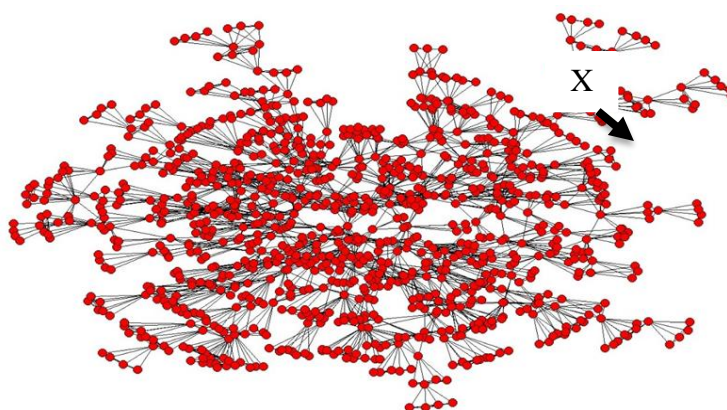
Fig. 2 represents the general network of relationships between individuals based on companies in which they are the members of the board of director or CEO. This network consists of two parts: the main part (red) and margin (other shapes with different colors). The number of marginal units is lower than the main part, but it has a significant number.



**Fig. 2:** Overall Networks

### Main Part of Network

The following figure represents the main part of the entire network. As it can be seen in Fig. 3, the main part of the network can be divided into three levels: the core, semi-periphery and periphery where the relations are dense, semi-dense and scattered, respectively. The core level has a closed structure. It has high relation and centralized power; however, it has a relation with the next level and the power exists among different layers. The semi-periphery level has a more open and semi-dense state. The monopoly is lower in this part.



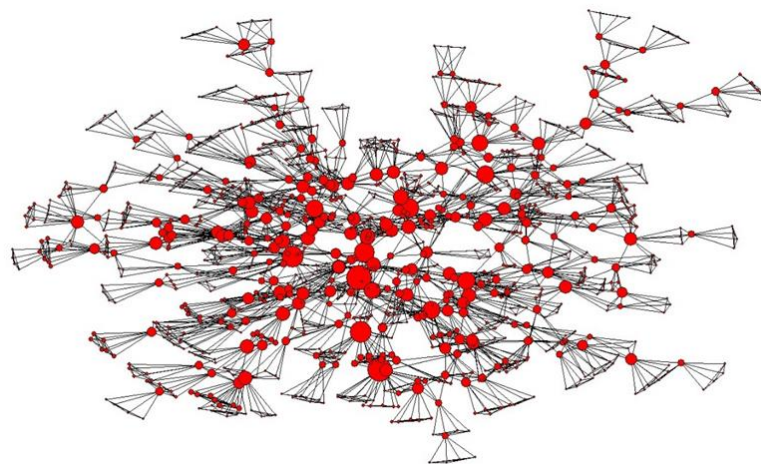
**Fig. 3:** Main Part of the Network

The peripheral level has a scattered and open structure. The peripheral level has a scattered and open structure. The structure of the peripheral part is more open and less powerful than the semi-periphery level and the semi-periphery is more open and less powerful than the core level. The density of relations

is reduced by gradually going away from the center of the network. Also, the relational structure represents that this network follows the bus morphology and many people play the role of bridge (e.g. X in Fig. 3) in this network so that by removing each person, more of them will be removed from the network; in other words, they will lose their connection with the main part of the network.

**Degree**

The degree centrality is simply the number of direct relationships that a node or entity (here the individual) has; a node or entity has a high degree of centrality; in general, it is the active actor in the network, often it is a relation or axis in the network, but it is not necessarily the most relevant entity or node within the network, it may be in a privileged position on the network, it may have alternate ways to satisfy or meet the organizational requirements, and therefore it may be less dependent on other individuals and can often be considered as a handler. The higher the centrality degree of an individual, the more and effective relations and connections exist [25]. Fig. 4 shows a network based on degree centrality (degree).



**Fig. 4:** Network Related to Degree

**Table 2:** The Name of Individuals with Most Degree

2013	2014	2015	2016	2017
A. M. A.	A. F. R.	A. A.	H. S.	B. GH.
A.H.	A. KH.	H. S.	A. H.	H. S.
A. KH.	R.S.	R. S.	A.SH.	R. S.
-	G. S.		E. KH.	-

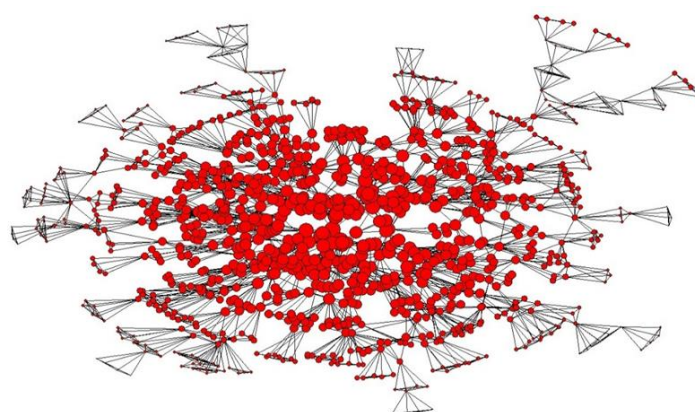
As shown in Fig. 4, in terms of degree, individuals represented by large circles have the highest relations in the network and have significant differences with other units. On one hand, for the central units, these extensive relations can lead to appropriate communication and business space and on the other hand, it can lead to monopoly rent space for those units. It must be noted that the high relation does not necessarily mean that they can effect on the common action of each other. In the following,



the representatives with the highest degree who have significant differences with the other representatives are presented (shown by large red circles).

### Closeness

The closeness centrality implies that a node or entity (here the individual) can quickly access more nodes or entities in the network. The shorter the path a node has to access to all the nodes, the closer node to all the other nodes, the higher the closeness centrality is. This indicator reflects the ability to obtain information through the cluster of network members. In general, an entity with higher closeness centrality has a quick access to the other entities on the network, shorter path to the other entities, and a high visibility on what's going on in the network [26]. Fig. 5 represents the network based on the closeness centrality (closeness).



**Fig. 5:** Network Related to Closeness

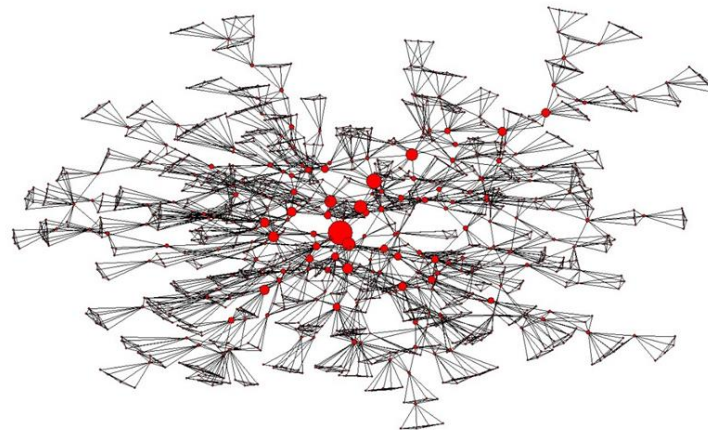
As shown in Fig. 5, although there are individuals with high and very low levels of closeness and the difference between three levels of core, the semi-periphery and periphery is high, but there is not much difference among the units at each level. There is no gap between each level and the next level and there is a relationship among the levels. As the distance from the center of the network increases, the units' closeness decreases. This indicator shows that people in the center communicate with few mediators and there is a relatively quick access for them and the access is provided with more mediators for the peripheral people which can lead to a monopoly rent among the high level units and will impose high cost on the peripheral units.

### Betweenness

The centrality of betweenness refers to the position of a node or entity (here the individual) within the network in terms of its ability to link other pairs, colonies or groups. Also, it shows how far the node is in the relational path of the other nodes and the communication is made through it. As the network nodes depend on a node to communicate with others, that node will have more power on the network. If a node that is the only connector between two nodes or groups is lost for any reason, the exchange of information and knowledge between these two nodes or groups is disrupted [26]. Fig. 6 represents the network based on the centrality of betweenness.

As shown in Fig. 6, in terms of betweenness, the units with high betweenness power exist within the network (show by large circles). In fact, there are units through which the relational path of other units passes thorough them. These units are able to isolate or enhance the relations. On the other hand, units

with high betweenness have an impact on the common action of other units. It means that if the given unit is not included, that common action is not taken place. In practice, each of these units has a common action due to this fact that they act according to the behavior of the given unit (main). In general, the betweenness feature can be seen with significant difference among units and the number of the representatives with high betweenness is very low over the entire network. This shows that there are units in the network that have easier access to the information and have high effect which can lead to a proper decision on one hand, and on the other hand it lead to the monopoly rent. In Fig. 6, people with the highest betweenness and significant difference are presented (shown by large red circles).



**Fig. 6:** Network Related to Betweenness

**Table 3:** The Name of Individuals with Most Betweenness

2013	2014	2015	2016	2017
A. H.	A. H.	M. F.	A. D.	R. S.
M. A.	M. F.	M. S.	H. M.	M. A.
H. S.	A. B.	A. H.	R. B.	H. S.
R. S.	M. D.	M. M.	M. P.	P. A.
A. B.	A. R.	-	V. B.	-
R. A	A. D.	-	H. S.	-

## 6 Conclusion and Discussion

The aim of this research is to study the structure of the company’s relationship network among individuals who are the member of the board of directors or CEOs on the companies involved in the TSE. In this regard, the network analysis method and the names of the real board members and CEOs of the involved companies in the stock market are used during 2013-2017. In fact, this research tries to answer two key questions: a) which pattern is followed by the individuals’ relation in TSE? b) Who are the key actors in this structure? In general, research findings represent that the representatives’ network consists of two parts: main and margin. The number of the marginal units is less than the main part; but it has a significant number. The main part of the network consists of a dense structure where the relation is high

and the power is centralized. In addition, the results of the indicators related to the position, importance and impact (centrality indicators: degree, closeness and betweenness) of the involved individuals show that the individuals at the center of the network have the highest relation in the network and have significant difference with other units. For the central units, these extensive relations can lead to appropriate communication and business space on one hand, and on the other hand, it may result in a monopoly economic rent opportunity for those units.

Furthermore, the individuals at the central layers communicate with fewer mediators and there is a relatively quick access for them. However, for the peripheral individuals, access is provided with more mediators. In fact, high level individuals have more ability than the peripheral individuals in acquiring information through the cluster of network members which can lead to a monopoly economic rent opportunity for high level units and will impose high cost for the peripheral units. On the other hand, some units play a key role in making relation among individuals and have significant effect on the common action of other units. Indeed, the ways other individuals communicate generally depend on their path, which indicates the higher influence of these units over others. Therefore, they can play the role of key actors. Overall, in the individuals' relation network, the betweenness feature is more tangible and visible than degree and the degree is higher than closeness. Furthermore, the relational structure among individuals represents that this network follows the bus morphology and many people play the role of bridge in this network so that by removing each person, more of them will be removed from the network; in other words, they will lose their connection with the main art of the network. In addition to the obtained benefits from using network analysis method, the above method also has some constraints so that the improvement and elimination of these constraints can be the starting point for future research. The present research has only been limited to the usage of widely used criteria of network analysis, while other criteria relating to the network analysis can be used. Furthermore, other methods related to the network or a combination of this method with other methods such as graph theory can be employed.

In future works, the investment strategies in stocks and also the network of board of directors and ownership can be studied. On the other hand, according to the importance of the relational patterns in decision-making and the obtained results, it is recommended to the investors, supervisory and legislative institutions in the stock market and other users to use the network analysis method to evaluate decisions and etc. It is also suggested that they pay more attention to the relational structure of individuals in the stock market. In addition, it is recommended to pay more attention to the role, position and influencing power of these units in the dominated structure.

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