Analyzing Board Network in Iran's Capital Market

Reza Taghizadeh[*]

Department of Accounting and Finance, Faculty of Economics, Management and Accounting, Yazd University, Yazd, Iran

Amin Nazemi, Mohammad Sadeghzadeh Maharluie

Department of Accounting, Faculty of Economics, Management and Social Sciences, Shiraz University, Iran

ARTICLE INFO	Abstract
	This research analyzes the board network of the companies in Iran's capital market from 2019 to 2022. The research results indicate that despite the difference in the level of communication, most units are related to each other. However, some units are in a better position to establish this relationship. Even in the communication network, there is a gap between the positions of the units and the difference between them becomes considerable, creating a class structure. The better position of some units has caused them to encounter fewer mediators in gaining access to other units, to have faster access, and to have a higher ability to gain access to information through the cluster of network members. In addition, some units are on the communication path of other units, so they have a power of influence. Since these units are in the flow path of information, they have more accessible and faster access to information. These units can play the role of key actors in the governing structure.

NUMBER OF REFERENCES
35

NUMBER OF FIGURES
20

NUMBER OF TABLES
3

1. Introduction

According to theorists studying agency theory, corporate governance is considered a systematic provision that provides some degree of control over agents' actions, such as managers and subcontractors (Marie L'Huillier, 2014). It guides businesses to operate ethically and responsibly. This notion has evolved due to economic, social, and legal changes. Companies can continuously create value for their stakeholders (shareholders, customers, and other partners), increase their visibility, and provide clarity without requiring shareholders (owners) to be directly involved in the company's day-to-day operations. Corporate governance practices aim to ensure the responsibility for achieving intended results (AbuSen and Saad, 2023). Corporate governance practices are considered essential for the success of today's companies, whether they are listed on a stock exchange or not. Are they a large or small corporation? Is there a separation of management and the board of directors? (AbuSen and Saad, 2023). The basic concept of the governance pillars is broadly defined as a network of relationships encompassing not only a company and its owners but also all stakeholders, including employees, customers, people, society, etc. (Hashemi and Bakrani, 2010). The existing definitions of corporate governance fall into the bounded views on one side and the broader views on the other. In the bounded views, corporate governance is limited to the relationship between the company and shareholders. On the other hand, corporate governance can be considered as a network of relations not only between a company and its shareholders but also between the company and most of its stakeholders, such as staff, customers, sellers, company bondholders and all stakeholders within the company (Hasas Yeganeh, 2005). Also, according to Mazraeli et al. (2016), the corporate governance system in Iran is more like an intra-organizational (relational) system.

In addition, there is growing evidence that the board of directors also play an active role in determining the company's direction. According to Hambrick and Mason's (1984) Upper Echelons Theory, the organization reflects its top managers and corporate outcomes due to collective choices by top management teams (Abatecola and Cristofaro, 2018). One of the challenging accounting issues is the joint members (or joint owners) in the structure of a company's board of directors (Richardson, 1987). The joint members of the board of directors mean those who have simultaneously held the position of a member of the board of directors of another company (Mizruchi, 1996). While the board members undoubtedly play a critical role in the company (Fama and Jensen, 1983), the board members' performance has a positive and negative impact on the company.

There is no unanimous definition of complex systems. One informal definition suggests that It is a large network of relatively simple components with no central control, exhibiting emergent complex behaviour (Mitchell, 2006). Some examples of complex systems are the brain, ant colonies, economic markets, and human social networks (Mitchell, 2006). Also, the stock markets are considered multi-actor complex networks according to the interaction between various companies and investors (Huang et al., 2009). Observing the features of complex networks in real networks has led to taking advantage of complex networks' analyses in analyzing real networks. However, in most accounting research, the features of companies and the relations between information and features of companies have been studied (Namazi and Nazemi, 2005), while the companies' relationship to each other, regardless of their characteristics, can have a deterministic effect on the financial state and the trends of the stock market which has been less taken into account. In the companies' board of directors, some owners might be able to determine the board of directors members in other companies. The existence of these owners establishes a relationship among different companies, which can create a complex network of relationships across companies. Therefore, according to the importance of relationship patterns in the decision-making of investors

and creditors, the present study analyzes the structure of the relations network of companies in Iran's capital market where these relations are made by joint shareholders or owners who have the capability of determining the board members in different companies. Indeed, this research attempts to answer two key questions: a) which pattern is followed by the companies' relations structure created by their joint owners? b) Which companies are the key actors in this structure?

Accordingly, the theoretical basis, literature and questions, methodology, research findings, conclusions, and future study suggestions are presented.

2. Literature review

Companies in most countries have a board of directors; in particular, the board of directors is responsible for protecting the interests of shareholders and is principally created for hiring, dismissal, supervision, and rewards for management, all of which are aimed at maximizing shareholder value. The board of directors might include intra-organisational individuals; in some cases, they or their supporters form the majority of the board of directors. Furthermore, it is not unusual for the CEO to be the chairman of the board of directors. Lastly, selecting the board members is one in which most managers have more potential to determine the subsequent members. The significant issues of the board of directors studied in the USA include board members' integration and executive directors' reward. The features of integrating the board members include its size and structure, the number of directors that formed the board of directors, the ratio of non-executive members of the board of directors and the combination of the role of CEO and the chairman of the board of directors.

Competing theories defining corporate governance include agency, stewardship, managerial hegemony, resource dependency, stakeholder, and multi-governance theories (Marie L'Huillier, 2014). In this regard, the dominant view of the relationship between the board of directors and management is based on the assumptions of the agency theory (Arabi and Hassanpour, 2015). Accordingly, it is believed that to protect the shareholders' rights, the board of directors should be smaller and include a higher percentage of non-executive members. Moreover, the roles of the chairman and CEO are separated, and one of the non-executive members is the chairman of the board of directors (Lasfer, 2006). In other words, the non-executive directors must control the company's board. However, one of the controversial issues in the board of directors' structure is the presence of joint members. The joint members of the board of directors mean the percentage of the members of a company's board of directors who are also in the position of a member of another company's board of directors. The joint board of directors may have positive and negative consequences for the company (Mazraeli et al. 2016).

On the other hand, the behavior of the stock markets reflects the results of the mutual interactions among the participators in the market, which tries to maximize its own benefits. Such mutual interactions lead to an increase in the complexity of the behavior of financial markets. The network effect in stock markets provides a better understanding of how individuals have access to information about events and how the reaction of individuals to events affects the stock market. Network analysis reveals the internal structure of stock markets and their evolution over time (Babu Roy and KumarSerkar, 2011). Also, the relationships between ownership and control among companies and the change in ownership affect the power of companies and trends in the stock market and eventually, these relationships reveal their corporate governance network (Moebert and Tydecks, 2007).

The social network analysis focuses on the objective pattern of relationships that bind the individual and collective members of the community (Ritzer, 2004). People rely on their personal

relations and their relatives to access information, resources and positions. These relations form the individual's social network, creating the social system (Sharepour, 2005). In social network theory, actors can be different groups such as individuals, unions, communities, and organizations. The social network, or the source of creating social capital, is a combination of actors and relations (Sharepour, 2007). The social network analysis seeks to encourage researchers from studying social groups to investigate the relations among the actors (Ritzer, 2004). The graphical perception of network theory is related to combining a wide range of sciences such as mathematics, computer science, psychology, geography, communication science and sociology.

A network is defined as a set of nodes connected by lines. Nodes are usually actors. The ties or edges connect actors, each of which can affect network dynamics (Garton et al. 1999). On the other hand, the stock markets are considered a type of complex network due to the interaction between various companies and investors. A financial market is a network in which the nodes represent financial institutions (e.g. stocks) and the edges represent the relation between their returns (Boginski et al., 2005; Mantegna, 1999). Considering the features of complex networks in real networks makes it possible to take advantage of the analyses of complex networks to analyze real networks.

Sankowska and Siudak (2016) studied the networks of boards of directors and corporate executives of big companies in the Polish capital market in 2014. They have also investigated the real networks of the board of directors and corporate executives compared to the randomly constructed networks. 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.

Singh and Delios (2017) studied the relationship between the structure of the board of directors and the risky behaviour of emerging companies. Their focus was 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 and companies central to the other corporate networks are more likely to develop through new domestic or foreign investments.

Dastkhan and Gharneh (2018) have studied how the ownership structure becomes inclusive in financial markets. They have also introduced an ownership network-based simulation model for analyzing systematic risk events. Research results have shown that the network structure influences the probability and extension of financial systems. For each network structure, different parameters have different values, leading to a significant difference in the systemic risk measurements. Furthermore, the obtained results represent that the proposed model is suitable for systematic risk analysis and permeation in financial markets, identification of important systematic companies, and estimation of the loss of the market when the primary failures occur.

Withers et al. (2018) have studied the evolution of the board of directors' network after Sarbanes-Oxley. They examined the impact of the Sarbanes-Oxley law on the evolution of the interaction of the board of directors of 300 Fortune companies from 1998 to 2006. According to the specific emphasis on the directors' responsibilities and the board's independence, Sarbanes-Oxley has created a significant difference in the demand and supply of the labor market for corporate executives. Therefore, they examined whether the supervision changes have led companies to pay more attention to social processes involved in choosing a board member such as reciprocity, transparency and multiplicity after Sarbanes-Oxley. The results of their research have shown that following the Sarbanes-Oxley law, the tendency of companies to abuse the interactions of the board of directors has been reinforced. Similarly, companies have trusted more to their existing partners to

fill their board chains after Sarbanes-Oxley.

Taghizadeh et al.(2019a) analyze the Tehran Stock Exchange shareholder network from 2013 to 2017. The research results posited that many shareholders are connected, although a class structure governs their relations. In comparison with others, some shareholders have a better position, which in turn causes them to encounter fewer mediators in gaining access to other shareholders and, therefore, easier access to available resources.

Fan et al. (2021) investigated the impact of social networks between independent directors and the CEO on firm risk. They found that social networks between the board and CEO positively impact firm risk. In particular, CEOs who are socially connected to their independent directors are motivated to pursue riskier investment, operating and financing strategies. This positive influence is more pronounced for prior under-performing firms and CEOs with low power or overconfidence.

Taghizadeh et al. (2021) analyze the interpersonal relationships network in the Tehran Stock Exchange (TSE) from 2013 to 2017. The research results posit that some individuals, compared to others, have a better position in communicative networks. Therefore, it might be concluded that these individuals are key actors in the 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.

Luong et al. (2023) investigated the relationship between CEO-director ties and female representation on the board in U.S. firms. They find a significant and negative effect on this relationship, suggesting that socially connected directors are detrimental to gender parity in senior management.

Fan et al. (2023) examined the impact of CEO network centrality on bank risk. They find that CEO network centrality is negatively related to bank risk because CEOs with higher network centrality implement less risky policies. In addition, they document that information flow and CEO power are two channels through which CEO network centrality reduces bank risk.

2.1. Research questions

As mentioned above, this research aims to analyze the communication network between shareholders and managerial owners (this communication created by common shareholders and owners that can determine the board of directors members) involved in Iran's capital market.

To achieve the research goal, the following questions have been addressed:

Which pattern does the companies' relation structure in the stock market follow?

Which companies are the key actors in this structure?

3. Research methodology

This research is practical. Its methodology is quasi-experimental, using a retrospective approach (through past information). Also, according to the collected and analyzed data type, the research is quantitative research with network analysis types. The main approach of this study is to use graphical techniques based on graph theory (a branch of topology). Applying matrix algebra allows the notion of relationships among actors (nodes) in a network to be studied visually, algebraically or logically. The concepts used in this theory include node (point), line or edge, line direction, line sign, path, path distance, bridge break point, connector etc. The details of the research method are put forward as follows:

3.1. Network analysis method

Network theory is a mathematical framework for modeling interacting systems as networks (or

graphs) formed by a set of relations (edges) between discrete entities (nodes). Additionally, nodes can carry time varying dynamical processes or signals, including the activity of neurons or a behavioral feature (e.g., velocity) of individual animals. Because of their generality, ability to encompass different datasets, and favoring of interactions rather than spatial layouts (in physical or state space), network models are uniquely suited to bridge across the neuroscience of individual and collective animal behaviors. They can also discover universal structure-function relationships robust to uncharacterized interaction parameters.

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, studies the importance and influence of individuals on the network. The network node centrality can be studied using three indicators: degree, betweenness and proximity. The centrality degree of a node in a social network represents the number of links a node has with other nodes. 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). The centrality degree of node k (p_k) is calculated by eq. (1):

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

Where n is the number of nodes in the 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 have a central position in the network. The betweenness indicator of node k (p_K) is obtained by eq. (2):

$$C_B(p_K) = \sum_{i<1}^{n} \frac{g_{ij}(p_k)}{g_{ij}} ; i \neq j \neq k \tag{2}$$

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 proximity indicator of a node represents the average length of the shortest paths between that node and other nodes in the network. Nodes with high proximity indicators have a greater influence on the network, play a key role, and have higher availability for other nodes. The proximity indicator of node k (p_k) is obtained by eq. (3):

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

where $d(p_i, p_k)$ is the shortest path between two nodes p_i and p_k (Abbasi et al. 2012).

Eigenvector in network analysis is known as a measure of network centrality and is calculated as follows (Bienenstock and Bonacich, 2021):

$$\sum_{j} a_{ij} x_j = \lambda x_i \tag{4}$$

Or in compact form:

$$Ax = \lambda x \tag{5}$$

λ is the principle eigenvalue for an adjacency matrix A, and x is the eigenvector associated with the eigenvalue. This eigenvector is interpretable as a measure of centrality. Intuitively, a position is central, with respect to eigenvector centrality, if it is connected to other positions with several connections.

3.2. Conceptual and operational definition of research variables
    In this research, according to Sankowska and Siudak (2016), Singh and Delios (2017) and Withers et al. (2018), the names of shareholders who are the members of the board of directors (or, in other words, they determine the members of the board) have been used to obtain the board of directors and network of the involved companies in Iran's capital market. Therefore, the relationship among companies is studied based on those shareholders who have the power to determine the board members. If a shareholder determines the members of the board of directors in two companies, it makes interaction between two companies through either the same shareholder or joint ownership. The interactions among companies are studied at two levels: a) board of directors and b) board of directors. This means that once the interactions among companies are studied via shareholders, who have the power to determine the board members in multiple companies, the interactions among companies are studied through stakeholders who have the power to determine the board members. To analyze the network of the board of directors as well as the board of directors, the general network, the isolated units, proximity based network, proximity, betweenness based network, betweenness, degree based network, degree (degree, proximity and betweenness are the criteria related to the centrality indicator. This indicator refers to the location of particular nodes within the network) are discussed and analyzed.

3.3. Data, research period, and sample
    All the companies listed on Iran's capital market were selected as the study's statistical population. In this regard, all active companies from 2019 to 2022 and their information were available to be studied. It must be mentioned that no sampling is performed. Therefore, according to the terms and conditions, 618, 744, 794, and 806 companies have been selected to be reviewed from 2019 to 2022, respectively. The necessary data and information have mainly been collected through the Tehran Stock Exchange websites and Rahavard Software databases. In addition, the results were analyzed using the network analysis method, as well as Excel 2016, PreMap v1, and UCINET v6, as well as its complementary package, NetDraw.

4. Findings
4.1. Descriptive statistics
    As mentioned above, the research analyzed the companies' network of relations among the board of directors. Table (1) lists the descriptive statistics of the studied quantitative data for research patterns. These statistics are related to the interactions made among companies through their joint board of directors.

Table 1. Descriptive statistics of the research period

|	2019	2020	2021	2022
Mean	4.580	4.860	4.960	4.970
Median	5.000	5.000	5.000	5.000
Standard deviation	1.2000	0.810	0.680	0.660
Minimum	2.000	2.000	2.000	2.000
Maximum	11.000	8.000	8.000	8.000
Total	2834	3622	3944	4010
Number of observation	618	744	794	806

    The number of observations illustrates how many companies were selected and investigated annually. The total shows the number of boards of directors each year that connection was created through them. As it shows, the maximum number of companies and board members is 2022. The

average shows that each year, and each company how many boards of directors existed that connection on average. The maximum (minimum) shows the most (least) number of boards. In general, descriptive statistics illustrate that from 2019 to 2022, the frequency of board members, a common factor for a relationship, is increasing.
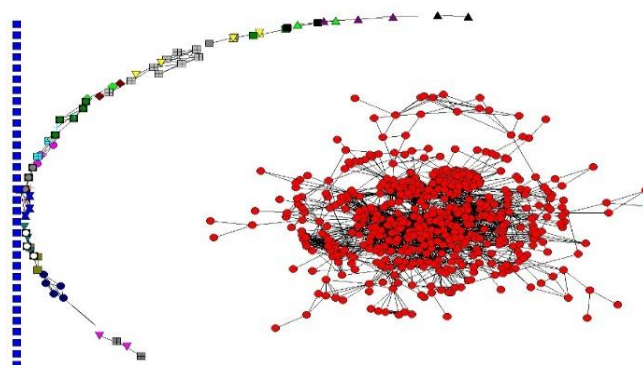
4.2. Overall networks

Figures (1), (2), (3), and (4) represent the overall network of corporates' interactions through their joint board of directors. The corporate network usually consists of three parts: the main, marginal and isolated. The number of marginal and isolated units is less than the main one, which means that most companies are connected and the number of companies without any relation is few. There are companies with different degrees of relations in the main part.

The main part of the network is divided into three levels: core, semi-periphery and periphery, where the relations are dense, semi-dense and scattered. The main part has a closed structure and a gap between the successive levels; there is also a class-based structure. The core level has a dense structure. It has high relations and centralized and monopoly power; the semi-periphery level is more open and semi-dense. The monopoly is lower in this part. The peripheral level has a scattered and open structure. The structure of the peripheral part is more open and robust than the semi-peripheral level and the semi-periphery is more open and robust than the core level.
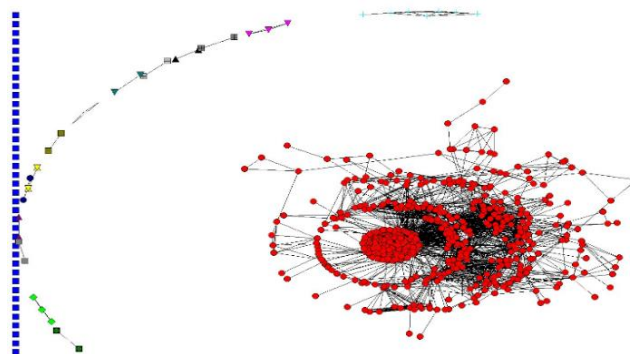
Figure 1. Overall Network 2019
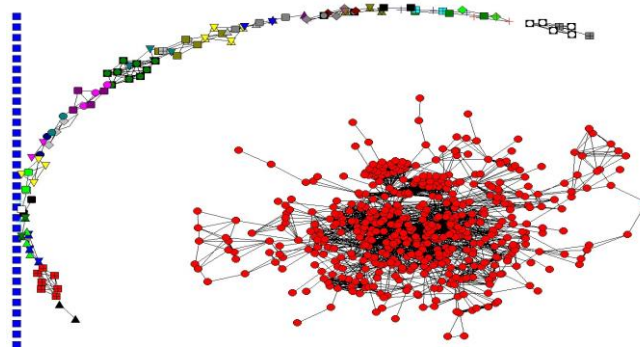

Figure 2. Overall Network 2020
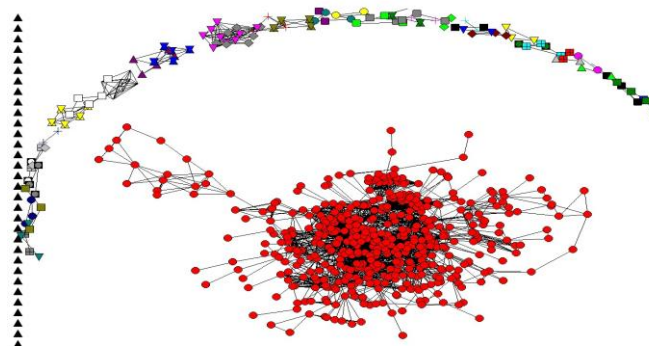
Figure 3. Overall Network 2021

Figure 4. Overall Network 2022

4.3. Isolated Unit

Table (2) lists the number of isolated units per year. Isolated units do not relate to others (the blue units at the margin of Figures 1, 2, 3, and 4 are isolated units). For example, in 2022, 175 companies at the board of directors level do not have any relation with other companies through any other board member. As can be seen, the maximum number of isolated units belongs to 2022.

Table 2. Number of Isolated units

	2019	2020	2021	2022
Board of directors	55	132	159	175

4.4. Cliques

The larger the number of groups, the more units are gathered together; so the relations have been transformed from dual state into multiple states, and to some extent, the dispersion is lower and coherence is higher. The maximum number of groups belongs to 2021. Table (3) lists the number of groups per year.

Table 3. Number of Cliques

|	2019	2020	2021	2022
Board of directors	258	248	266	256

4.5. Degree

The degree of centrality is simply the number of direct relationships that a node or entity (here the company) 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 degree of centrality of an individual, the more effective relations and connections there are. Figure (5) shows a network based on degree centrality (degree).
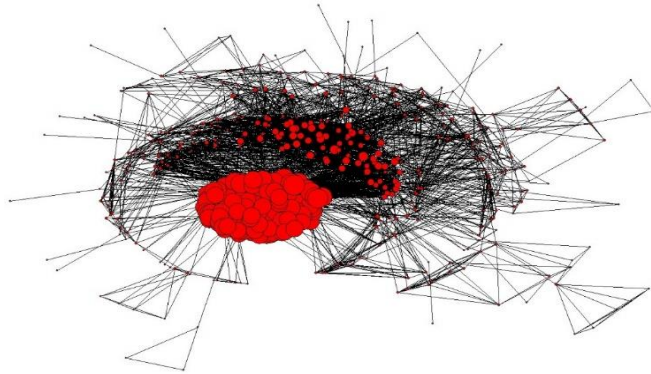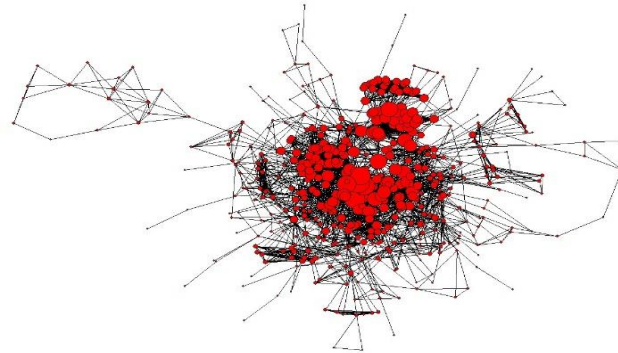

Figure 5. Network Related to Degree 2019
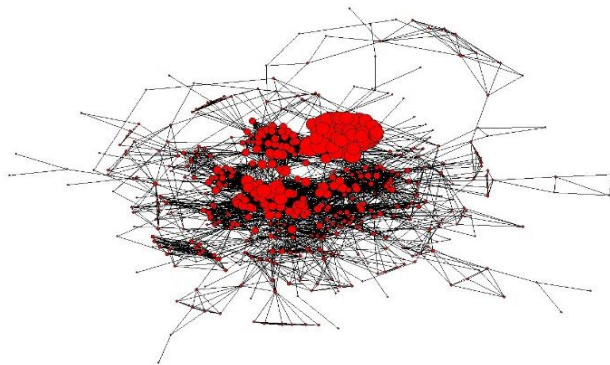
Figure 6. Network Related to Degree 2020
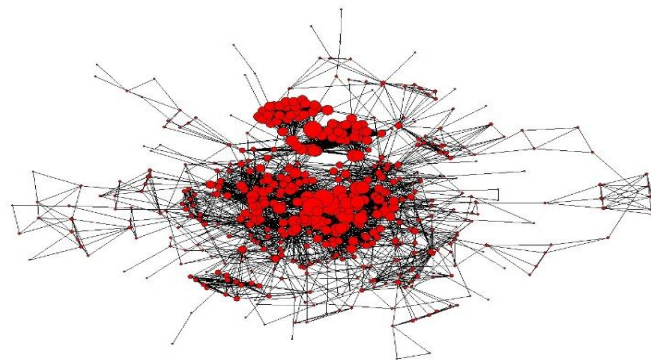

Figure 7. Network Related to Degree 2021

**Figure 8.** Network Related to Degree 2022

As can be seen in Figures (5), (6), (7), and (8), in terms of the degree, there are three levels of core, semi-peripheral and peripheral, which are dense, semi-dense and scattered, respectively. The difference across levels is significant, but the difference in units at each level is lower, leading to a class-based structure. There are high-level companies with relationship degrees, with a significant difference between them and the next level. This can lead to the formation of relational colonies and the creation of a monopoly rent space among the high level units. It should be noted that a high level of relationship does not necessarily mean that they can affect each other's common actions.
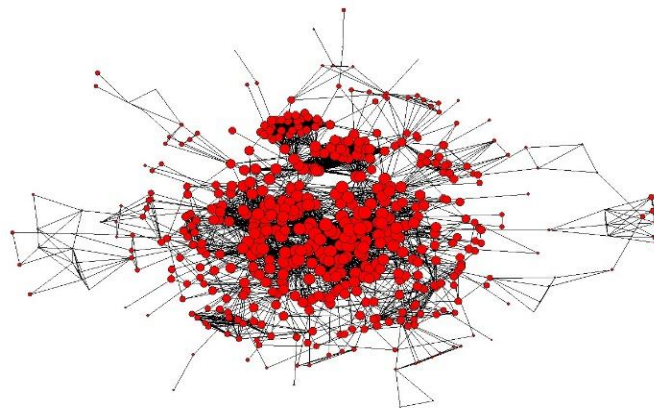
4.6. Closeness

The centrality of proximity implies that a node or entity (here, company) can quickly access more nodes or entities in the network. The shorter the path a node has to access to all the nodes, the closest node to all the other nodes, the higher the centrality of closeness is. This indicator reflects the ability to obtain information through the cluster of network members. In general, an entity with a higher centrality of closeness has quick access to the other entities on the network, a shorter path to the other entities, and high visibility on what is going on in the network. Figures (9), (10), (11), and (12) represent the network based on the centrality of closeness (closeness).
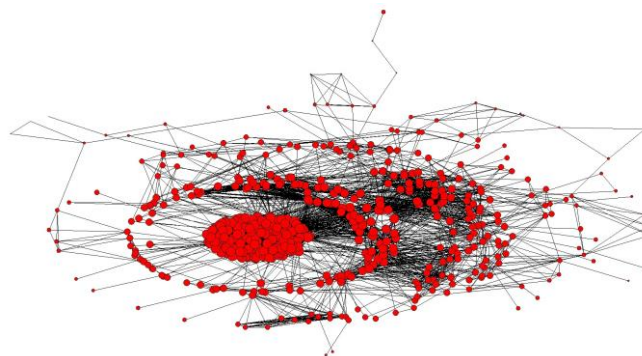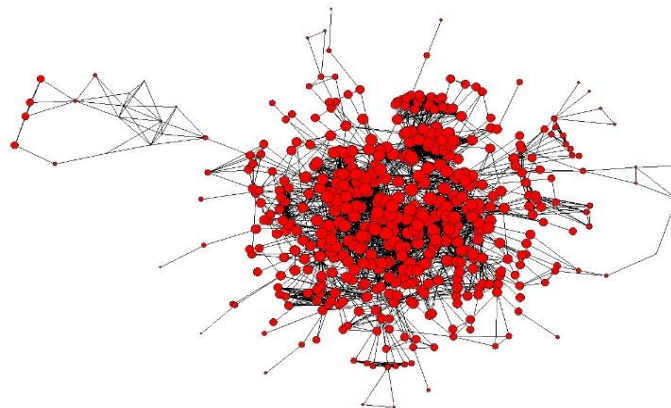

Figure 9. Network Related to Closeness 2019
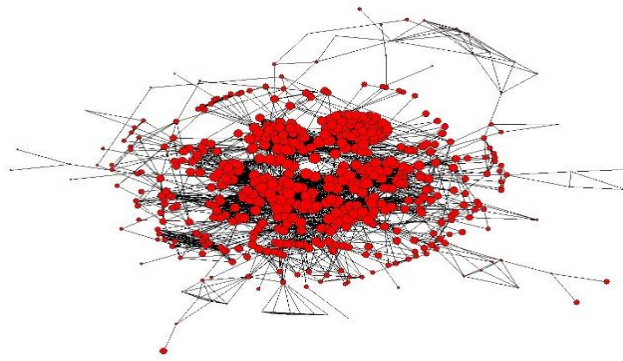
Figure 10. Network Related to Closeness 2020

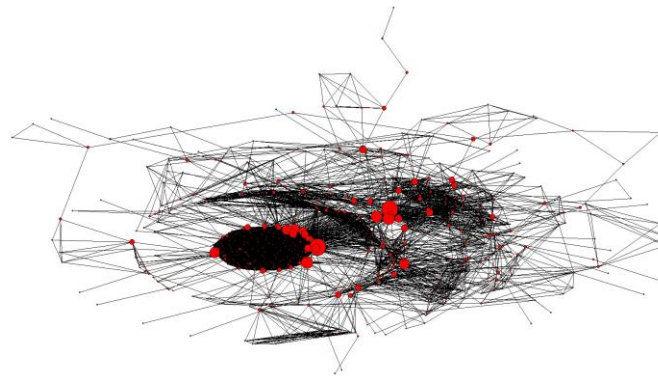
Figure 11. Network Related to Closeness 2021

Figure 12. Network Related to Closeness 2022

Figures (9), (10), (11), and (12) show three levels of core, semi-periphery and periphery, which can be seen in closeness. The difference across levels is significant, but the difference in units at each level is lower, leading to a class-based structure. Some companies interact with fewer mediators and have relatively fast accessibility. On the other hand, some companies have difficulty accessing them with more mediators. This can lead to monopoly rent across high level units and impose high costs on the peripheral units.
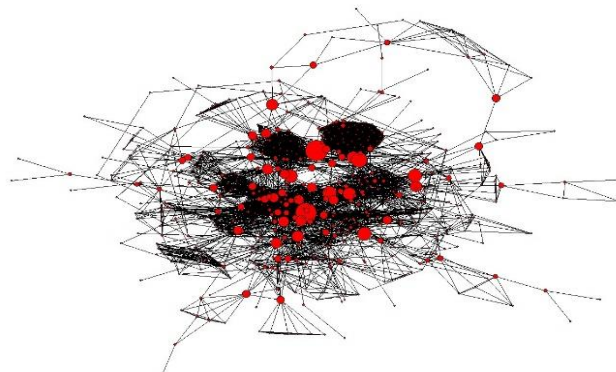
4.7. Betweenness
The centrality of betweenness refers to the position of a node or entity (here company) within the

network regarding 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 (Taghizadeh et al., 2019b). 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, the exchange of information and knowledge between these two nodes or groups is disrupted. Figures (13), (14), (15), and (16) represent the network based on the centrality of betweenness (betweenness).
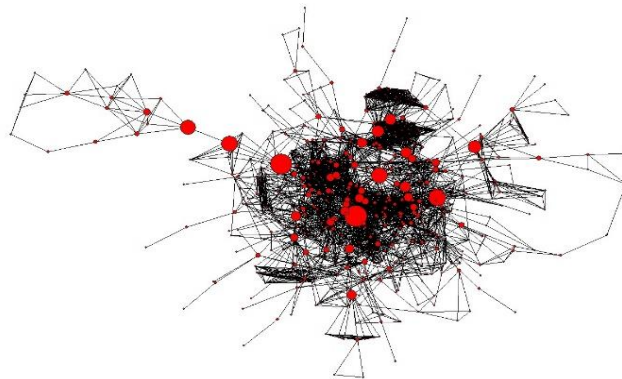

Figure 13. Network Related to Betweenness 2019

**Figure 14**. Network Related to Betweenness 2020
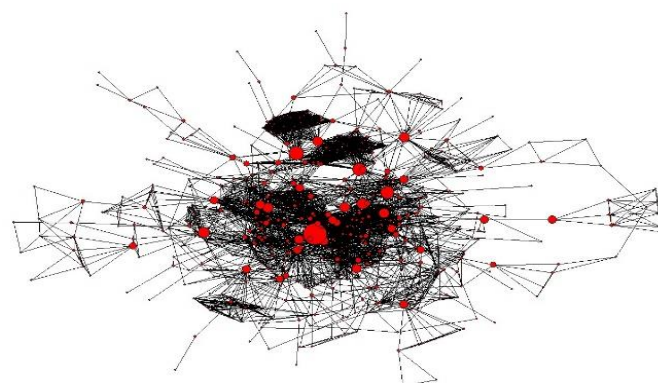
**Figure 15.** Network Related to Betweenness 2021

Figure 16. Network Related to Betweenness 2022

As shown in Figures (13), (14), (15), and (16), there are three levels of core, semi-periphery and periphery in terms of betweenness. The difference between the levels is not necessarily high. Still, the difference of units at each level is very high, and there are units with high betweenness power within the network, which are units that do not necessarily belong to the network core. Some units in the network belong to the semi-periphery and periphery levels but have high betweenness power (points represented by large circles). These are units through which other units pass them. These units are able to isolate or enhance the communication. On the other hand, units with high betweenness affect the joint action of other units. Namely, if the given unit does not exist, that common behavior would not occur. In practice, each of these units has common behavior since they act according to the behavior of the given (major) unit. In general, the betweenness feature is observed to be significantly different among companies, and the number of companies with high betweenness is low over the entire network. This shows that there are units in the network with more and easier access to the information stream and higher effective power that can lead to a proper decision and, on the other hand, lead to economic rents. The companies with the highest betweenness and significant difference from others are presented later (shown in red circles).
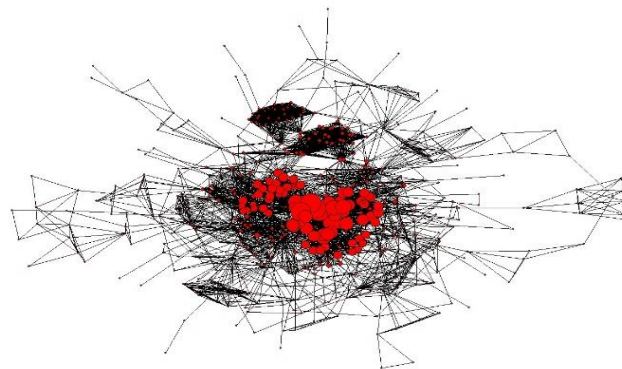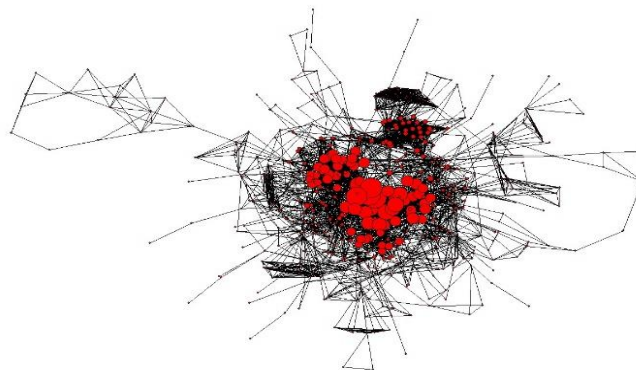
4.8. Eigenvector
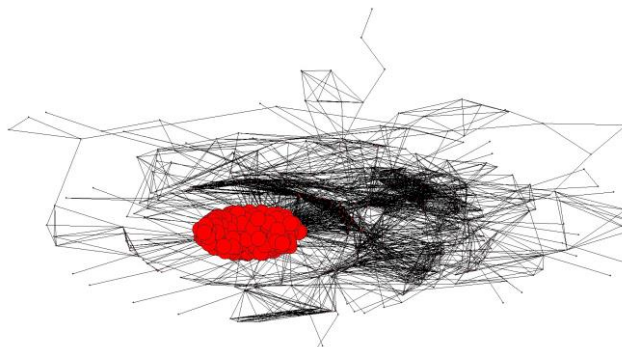
Figure 17. Network Related to Eigenvector 2019
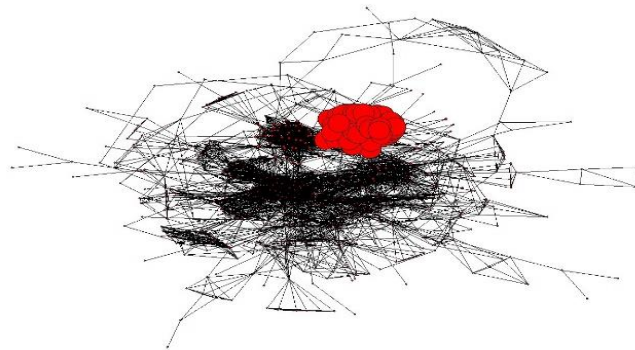
Figure 18. Network Related to Eigenvector 2020

Figure 19. Network Related to Eigenvector 2021

Figure 20. Network Related to Eigenvector 2022

Furthermore, from Figures (17), (18), (19), and (20) (network based on eigenvector-vector centrality), we can see that highly influential units in the network are better positioned than other units. In graph theory, eigenvector centrality is a measure of the influence of a node in a network.

Every node in the network is assigned a relative score based on the assumption that connections to nodes with higher scores contribute more to a given node's score than the same connections to nodes with lower scores. A high eigenvector value means the node is connected to many nodes with high values (large red circles indicate the diagram's companies).

5. Conclusion and discussion
The basic concept of governance principles is broadly defined as a network of given

relationships that includes a company and its owners and all stakeholders, including employees, customers, people, society, etc. Furthermore, the board of directors is one of the major pillars of the corporate governance system that can influence corporate decisions. On the other hand, stock markets are considered a complex network due to the interaction of various companies and investors. Viewing the properties of complex networks in real networks makes it possible to analyze complex networks in these networks. Observing the features of complex networks in real networks has led to taking advantage of the analyses of complex networks in analyzing these networks. Also, studying the relationship among companies can have a determinative effect on the financial situation and stock market trends. Therefore, this research aims to study and analyze the company's relationship network structure. These relations are created by the joint shareholders or owners who have the power to determine the board of directors members in different companies. In this regard, the network analysis method and the concept of board members of the involved companies in the stock market in 2019-2022 are used. This research tries to answer two key questions: a) what is the pattern of the relations among companies created by their joint owners? b) Who are the key actors in this structure?

Research findings show that the companies' network usually consists of three parts: main, margin, and isolates. The number of isolated units is low in this network; those units have no interaction with other units. The network's main part consists of an interconnected structure where the extent of interaction is high and the power is centralized and individualized. There is a gap among levels, and the structure is class-based. Also, there are three main levels: core, semi-periphery, and periphery, where the relations are dense, semi-dense, and scattered. The difference among levels is so high, but the difference in units is low. The indicators related to position, importance, and impact (centrality indicators: degree, proximity, and betweenness) of the network represent that the central companies have the highest network relation and significant differences from other units. These extensive relations can lead to appropriate communication and business space for the central units. On the other hand, it may result in a monopoly rent space for those units. Furthermore, the central companies communicate with each other with fewer mediators and have relatively fast access. However, for peripheral companies, more mediators provide access. In fact, high level companies have more ability than the peripheral networks to acquire information through the cluster of network members which can lead to a monopoly rent space for high level units and will impose a high cost for the peripheral units.

Communication among companies happens via some units. Through their communication, these units make other units behave in certain ways. Therefore, they are key players. In fact, how different companies communicate generally depends on their path, which indicates the higher influence of these units over others. In addition, they have easier and more access to the information. It must be noted that these units do not necessarily belong to the network's core, which means that there are units in the network that are at the semi-peripheral and peripheral levels but with high influencing power. Indeed, in the companies' relation network, the betweenness feature is more tangible and visible than degree, followed by degree and proximity.

The methodology used in this research can also be used to identify and analyze key players in other realms of finance and accounting. In total, according to the findings, it can be said that understanding the macrostructure of connections among companies is vital. Therefore, according to the obtained results and the importance of connection structure and influence of key players in decision making, it is advised to all users to consider the governing rules related to existing companies in capital markets and their roles and positions in reaching their goals.

In addition to the benefits obtained from the network analysis method, the above method also has some constraints, so improving and eliminating these constraints can be the starting point for future

research. The present research has only been limited to using widely used criteria of network analysis, while other criteria relating to network analysis can be used. Furthermore, other methods related to the network or a combination of these methods, such as graph theory, can be employed. In future works, the investment strategies in stocks and other networks between companies can be studied.

In fact, the results of this paper can lead to a better understanding of players who create the relation structure among companies and boost the usefulness of the decision-making of politicians and main players. Furthermore, considering that there are companies with special situations in regard to the other companies, it is advised that the authority of market capital continuously monitors the companies with unique positions in the network. In other words, it is recommended that investors and other users use social network analysis in decision-making about selling and buying stocks, decreasing portfolio risks, and making other decisions.

References

1. Abatecola, G. and Cristofaro, M. (2018). Hambrick and Mason's "Upper Echelons Theory": evolution and open avenues. *Journal of Management History*, 26(1), pp. 116-136. https://doi.org/10.1108/JMH-02-2018-0016
2. Abbasi, A., Hossain, L., Leydesdorff, L. (2012). Betweenness centrality as a driver of preferential attachment in the evolution of research collaboration networks. *Journal of Informetrics*, 6(3), pp. 403-412. https://doi.org/10.1016/j.joi.2012.01.002
3. AbuSen, M. A. and Saad, M. (2023). Corporate Governance Effect on Corporate Performance, through the Moderation Role of Organizational Culture. *Journal of Business*, 11(2), pp. 90-100.
4. Arabi, M., S. hassanpour (2015). The Relationship between Board Characteristics and Timing of Financial Reporting, *Financial accounting knowledge*, 1(3), pp. 107-124. (In Persian)
5. Babu Roy, R and U, Kumar Sarkar (2011). Network Approach to Capture Co-movements of Global Stock Returns. Indian Institute of Management Calcutta, Working Paper. Kolkata, West Benga, India
6. Bienenstock, E. J. and Bonacich, P. (2021). Eigenvector centralization as a measure of structural bias in information aggregation. *The Journal of Mathematical Sociology*, 46(3), pp. 227-245. https://doi.org/10.1080/0022250X.2021.1878357
7. Boginski, V., Butenko, S., P.M, Pardalos (2005). Statistical Analysis of Financial Networks. *Computational Statistics & Data Analysis*, 48, pp. 431-443. https://doi.org/10.1016/j.csda.2004.02.004
8. Dastkhan, H. and N. SH. Gharneh (2018). How the ownership structures cause epidemics in financial markets: A network-based simulation model. *Physica A: Statistical Mechanics and its Applications*, 492, pp. 324-342. https://doi.org/10.1016/j.physa.2017.09.089
9. Fama, E. and Jensen, M. (1983). Separation of ownership and control. *Journal of Law and Economics*, 26(2), pp. 301-325. https://doi.org/10.1086/467037
10. Fan, Y., Boateng, A., Ly, K. C. and Jiang, Y. (2021). Are bonds blind? Board-CEO social networks and firm risk. *Journal of Corporate Finance*, 68, A. 101922. https://doi.org/10.1016/j.jcorpfin.2021.101922
11. Fan, Y., Jiang, Y., Jin, P. and Mai, Y. (2023). CEO network centrality and bank risk: Evidence from US Bank holding companies. *Journal of Corporate Finance*, 83, A. 102501. https://doi.org/10.1016/j.jcorpfin.2023.102501
12. Garton, L., Haythornthwaite, C. and Wellman, B. (1997). Studying online social networks. *Journal of computer-mediated communication,* 3(1), pp. 75–105.

https://doi.org/10.1111/j.1083-6101.1997.tb00062.x

13. Hambrick, D. C. and Mason, P. A. (1984). Upper echelons: The organization as a reflection of its top managers. *Academy of Management Review*, 9(2), pp. 193-206. https://doi.org/10.5465/amr.1984.4277628

14. Hasas Yeganeh, Y. (2005). Corporate governance concepts, *Accountant*, 167, pp. 30-33. (In Persian).

15. Hashemi, A., and Bakrani, K., (2010). An overview of the influential literature of capital decisions on ownership structure and corporate governance mechanisms, *Journal of Accounting and Financial Management*, 2(1), pp. 111-128. (In Persian)

16. Huang, W. Q., Zhuang, X. T. and Yao, S. (2009). A network analysis of the Chinese stock market. *Physica A: Statistical Mechanics and its Applications*, 388(14), pp. 2956-2964. https://doi.org/10.1016/j.physa.2009.03.028

17. Lasfer, M. A. (2006). The interrelationship between managerial ownership and board structure. *Journal of Business Finance & Accounting*, 33(7-8), pp. 1006-1033. https://doi.org/10.1111/j.1468-5957.2006.00600.x

18. Luong, H., Khedmati, M., Nguyen, L. A., Nigmonov, A., Ovi, N. Z. and Shams, S. (2023). CEO-director ties and board gender diversity: US evidence. *Journal of Behavioral and Experimental Finance,* 40, A. 100861. https://doi.org/10.1016/j.jbef.2023.100861

19. Mantegna, R. N. (1999). Hierarchical structure in financial markets. *The European Physical Journal B-Condensed Matter and Complex Systems*, 11, pp. 193-197. https://doi.org/10.1007/s100510050929

20. Marie L'Huillier, B. (2014). What does "corporate governance" actually mean?. *Corporate Governance,* 14(3), pp. 300-319. https://doi.org/10.1108/CG-10-2012-0073

21. Mazraeli, Y, Aghabeygi, M., and Z. Javanshirinejad (2016). Investigating the Impact of Having a Joint Managing Board on the Level of Disclosure and Earnings Quality of Companies Listed in Tehran Stock Exchange, *Economics and Tax*, 1, pp. 57-78. (In Persian)

22. Mitchell, M. (2006). Complex systems: Network thinking. Artificial intelligence, 170(18), pp. 1194-1212. https://doi.org/10.1016/j.artint.2006.10.002

23. Mizruchi, M. S. (1996). What do interlocks do? An analysis, critique, and assessment of research on interlocking directorates. *Annual review of sociology*, 22(1), pp. 271-298. https://doi.org/10.1146/annurev.soc.22.1.271

24. Moebert, J. and Tydecks, P. (2007). Power and Ownership Structures among German Companies, a Network Analysis of Financial Linkages. Darmstadt discussion papers in economics 179, Working Paper, Technische Universität Darmstadt, Darmstadt

25. Namazi, M., and Nazemi, A., (2005). An analytical review of the research in the Tehran Stock Exchange, *Journal of Financial Research*, 19, pp. 135-166. (In Persian)

26. Richardson, R. J. (1987). Directorship interlocks and corporate profitability. *Administrative Science Quarterly*, 32(3), pp. 367-386. https://doi.org/10.2307/2392910

27. Ritzer, G. (2004). Modern sociological theory. [Transalated by M Salasi], Elmi publications, Tehran, Iran. (In Persian)

28. Sankowska, A. and Siudak, D. (2016). The small world phenomenon and assortative mixing in Polish corporate board and director networks. *Physica A: Statistical Mechanics and its Applications*, 443(1), pp. 309-315. https://doi.org/10.1016/j.physa.2015.09.058

29. Sharepour, M. (2005). The Dimensions and Functions of Social Capital and the Consequences of its Erosion. From the book Social Studies of Iran, Payam Noor University Publication, Tehran, Iran. (In Persian)

30. Sharepour, M. (2007). The Role of Social Networks in Reproduction of Educational Inequality,

Journal of Education, 23(3), pp. 165-180. (In Persian)

31. Singh, D. and Delios, A. (2017). Corporate governance, board networks and growth in domestic and international markets: Evidence from India. *Journal of World Business*, 52(5), pp. 615-627. https://doi.org/10.1016/j.jwb.2017.02.002

32. Taghizadeh, R., Nazemi, A. and Sadeghzadeh Maharluie, M. (2021). Network Analysis of Interpersonal Relationships in Tehran Stock Exchange. *Advances in Mathematical Finance and Applications*, 6(1), pp. 43-55.

33. Taghizadeh, R., Nazemi, A. and SadeghzadehMaharluie, M. (2019a). Analyzing Shareholder Network in the Tehran Stock Exchange. *Iranian Journal of Finance*, *3*(4), pp. 113-134. https://doi.org/10.22034/ijf.2020.207802.1084

34. Taghizadeh. R., Nazemi, A. and Sadeghzadeh Maharluie, M., (2019b) An Analysis of the structure of audit relationships using the social network analysis method, *Journal of Audit Science*, 19(75), pp. 101-122. (In Persian)

35. Withers, M., Kim, J. Y. R. and Howard, M. (2018). The evolution of the board interlock network following Sarbanes-Oxley. *Social Networks*, 52, pp. 56-67.