Noname manuscript No.
(will be inserted by the editor)

Interlocking Directors Network Evolution in Turkey
High Churning Little Change

Alper Duman · Efe Postalcı ·

Received: date / Accepted: date

Abstract The ratios of the giant components to overall firm networks in years 2002, 2007 and 2013 have not changed despite a high churning rate of firms in terms of joining and leaving the giant components

Keywords Interlocking Directors · Business Groups · Trust ·

1 Introduction

Turkey has become one of the emerging economies that attracts global attention in the last decade. The GDP per capita in PPP (Purchasing Power Parity) terms increased from around 5000 $ in 1998 to around 18000 $ in 2014. Mergers and acquisitions as well as foreign direct investment flows have dramatically gone up. In 2015 the total number of mergers and acquisitions deals reached 265 . Annual foreign direct investment inflows have risen to % 2 of the GDP. The capital and credit markets have faced a major transformation.

According to OECD and World Bank ,Turkey has become an example for other developing countries. The overall success of the Turkish economy is largely attributed to the dynamic private sector of the country. In a short-period from 1990s onwards, some of the Turkish corporations have become global competitors. Corporations have become aware of the significance of sound corporate governance principles.

We Thanks nobody

Alper Duman
Department of Economics, İzmir University of Economics
E-mail: alper.duman@ieu.edu.tr

Efe Postalcı
Department of ZZZ, University of WWW
E-mail: djf@wef

Corporate governance structures can enhance the economic performances of corporations and influence the institutional settings in which the corporations thrive or struggle. Corporate board networks play central roles in corporate governance structures.

Ownership is crucial as owners pick and appoint board members. Board members in turn provide connections among different corporations if they hold positions in more than one board. The social networks formed up due to these connections constrain and affect the corporate governance structures. Overall economic performances of the corporations and the countries are influenced by the corporate governance systems.

% The early literature on corporate governance structures has been based on two different frameworks, that of law and politics. According to the first framework, legal origins of the countries (Anglo-Saxon or French) determine the corporate governance structures (La Porta et.al. 1998) . Financial development as a result of and coupled with the legal origins determine the corporate governance structures in each country. The framework based on politics on the other hand argues that social democratic countries with a social accord among workers and owners have different corporate governance structures than the liberal countries (Roe 2004).

The board of directors is the main unit for corporate governance [1]. Interlocking directors are the board members holding seats in at least two different boards. There are various studies on why interlocking directorships emerge and reproduce its structure.

Social network analysis offers a unique framework and a methodology over a very central issue that these frameworks could not handle . The main issue is how the corporate governance structures are coordinated when the ownership is distributed as in the firms listed in stock markets and ownership and management is separated. Social network topologies with high clustering and low average path lengths enable such a coordination.

The literature on the intersection of social networks and corporate governance underlines the fact that network configurations and topologies are closely related to the effectiveness of corporate board networks in affecting corporate governance structures. Coordination is achieved, information is diffused and robustness to shocks is maintained through "small network" nature of such networks [2].

The literature on corporate board networks uncovers that low average path length and high clustering coefficients of small world networks are typical topological characteristics of corporate board networks. A common factor that leads to higher clustering coefficient in corporate board networks is the existence of business groups in which corporations have cross-share holdings or form pyramids of ownership. Naturally, interlocking directors sit in multiple boards of the business groups firms.

Most of the studies focus on interlocking directorship networks in developed countries
[3], Heemskerk and Schnyder 2008, [4]. [5] and some chapters in [2] are exceptions.

One study [6] authors pursue a similar question as we do. They compare the interlocking directorship networks of Brazil, Chile, Israel, South Korea and Taiwan. All of these countries are dominated by business groups as in Turkey. They find that by early 2000s compared to mid 1990s, Brazil, Chile and Taiwan became more of a small world. But Israel and South Korea moved in the opposite direction, as their networks had become more fragmented.

Turkey is also interesting case as it is characterized by a mixed system of bank and market based credit system and "insider" corporate governance regime. Dominant diversified business groups own and control major banks and state managed corporations still play decisive roles in the economy [7].

We have three main goals in this paper. First, we document the evolution of interlocking directors networks in Turkey for the years 2002, 2007 and 2013. Second, we characterise basic motifs in the interlocking directors networks and compare the configurations across years. Third, we identify the firms persistently stay in the giant component for the three time periods as well documenting the high turnover of firms in the giant components.

2 Interlocking Director Networks in Turkey

After 1980s, Turkey has gone through a full fledged economic liberalization process in which early on import substitution was dropped in favour of export promotion and financial liberalization was initiated. In 1985, İstanbul Stock Exchange Market was established (later in 2015, renamed as BIST). In 1989, capital account liberalization was carried out. The corporate sector in Turkey has been transformed fundamentally [8].

The number of listed firms increased from 100 in 1990 to 435 in 2013. Stock market capitalization had risen from only % 5 of GDP in 1990 to about % 30 in 2013. The annual volume of transactions in the stock market reached % 80 percent of GDP.

In 1990s, but more particularly in 2000s privatization has become one of the pillars of economic reform package. Till 2015, 60 billion dollars worth of public corporations and assets have been transferred to private sector. Some of the corporations we analyse belong to these privatized group.

Mergers and Acquisitions activities as well as Foreign Direct Investment have increased record levels in the last decade. In late 2000s, Turkish corporations have undertaken outward FDI in considerable levels. The average annual FDI inflow in 2000s was 12 billion $, an amount 10 times of the annual average in 1990s. In conjunction with globalization process, liberalization of Turkish economy has brought corporate governance to the focal point for both the economic policy makers and for the major actors of the corporate world in Turkey. In 2006, Turkey indicated its willingness to adapt the OECD Benchmark Principles for Corporate Governance officially. In 2013, a decree for the appointment of independent directors on corporate boards was issued.

Network analysis is the analytical framework in which network theory is used to study both the configuration and the interactions among agents.

A network is bipartite if its nodes can be partitioned into two sets such that all edges are between the nodes in partitioned sets and there are no links between nodes within each set. There are three networks we can construct given our data set. First consider the network where a node can represent a firm or an individual. An edge (or a link) in this graph connects an individual to a firm, indicating that the individual either has a seat on the board of directors of the firm or is the general manager of the firm.

Note that this setting allows only links between individuals and firms, but not between individuals, or between firms. It is of course possible that an individual can have seats in different firms, thus have multiple links. The raw data, which consists of firms and board members of these firms, will lead to a bipartite network in which nodes are partitioned according to whether they are individuals or firms.

Degree distributions of nodes in this setting have specific meanings. The degree of a firm is the size of the board of directors of the firm. If the node is an individual, its degree represents the number of boards she/he is in. Following the literature we can construct two related networks from the bipartite network we defined. In the firm network nodes represent only firms, and an edge between two nodes exists only if there is at least one common member in board of directors. A subset of firms that have links in this manner is referred as interlocked. In the board of directors network nodes represent individuals, and a link between two nodes exists only if both of the individuals sit on the board of directors of at least one firm.

The firm network and the board of directors network are one-mode projections of the bipartite network. The literature notes that studying these networks as independent structures will be wrong, since the degree distribution of the firms (i.e. size of boards) together with the degree distribution of the directors (i.e. number of boards each director is a member) in the bipartite network will directly affect the degree distribution of the one-mode projection directors network (i.e. number of co-directors) and the firm network (i.e. number of interlocked firms).

The data on the listed firms and the directors is publicly available either in digital or in published form as in *Public Disclosure Platform* [1]. The main problem with the data is the haphazard nature of the names reported. For instance, Rahmi Koç is reported as “Rahmi M. Koç” as a board member in “Koç Holding A. Ş.” Rahmi Mustafa Koç” as a board member in “Tüpraş,” “Mustafa Rahmi Koç” as board member in Arçelik and “Mustafa Rahmi Koç” as a member of “Aygaz A. Ş.” As a vertex in the networks all these names should indicate the same person. Thus standardization and reformatting have been major issues in data management before a thorough network analysis could be carried out. The similar problems arise in terms of the company names with a considerable variation from one year to another.

Extensive care and effort were spent to clean and standardize the data. Consequently, a bipartite network with one set of vertices denoting the firms

[1] http://kap.gov.tr/en/companies/traded-companies/all-companies.aspx

and the other set denoting the directors (board members) could be obtained for each year. The Table 1 provides general statistics based on these the bipartite networks.

Bipartite Statistics	2002	2007	2013
Number of Firms	301	336	435
Number of Directors	1581	1762	2635
Number of Components	135	150	177
Total Number of Seats (number of edges)	2006	2223	3330
Mean Director Degree (mean firm board membership)	1.269	1.267	1.264
Mean Firm Degree (mean board size)	6.664	6.646	7.655
One board directors	1311	1466	2184
Two board directors	180	210	306
Three board directors	51	40	89

Table 1 Bipartite Statistics

The number of firms increased by a % 44.5 from 2002 to 2013. The number of directors (board members) went up by % 66 in the same period. The gap is partially explained by the increase in average board size from 6.66 to 7.65. About % 83 of the directors are board members in only one company so they do not connect any firms via interlocking directorships.

Assuming holding three memberships as the multiple interlocking then we can see that very tiny fraction of total directors are main agents. In 2013, only 89 directors, that is % 3.4, have at least three board memberships.

Bipartite GC Statistics	2002	3007	2013
Number of Firms	101	100	157
Number of Directors	498	530	964
Total Number of Seats (number of edges)	731	770	1345
Mean Director Degree (mean firm board membership)	1.468	1.453	1.395
Mean Firm Degree (mean board size)	7.24	7.77	8.56
One board directors	373	411	743
Two board directors	69	66	134
Three board directors	25	21	50

Table 2 Bipartite Giant Component Statistics

The largest connected component (Giant Component, henceforth GC) of the three bipartite constituted % 33 of the original bipartite network in 2002 and % 36 in 2013. The Table 2 displays that within the bipartite giant components board sizes are slightly greater than the original bipartite networks. The average board size is 8.56 in the giant component in 2013, implying one more person in the boards. The ratio of one board directors declines considerably in the giant component networks. In 2002 for example % 74 of the directors hold a single board membership in the giant component network compared to % 84 in the original bipartite network In the giant component of the bipartite network, % 5 of the directors hold multiple directorships. One can argue that

Firm Projection Statistics	2002	2007	2013
Number of Components	135	150	177
Number of Edges	370	416	536
Number of Firms	301	336	435
Maximum degree	17	17	14
Mean Firm Projection Degree	2.458	2.476	2.461
Mean / maximum possible degree	0.0082	0.0074	0.0057
Clustering Coefficient	0.60	0.68	0.59
Average path length	4.9	5.43	6.08

Table 3 Firm Projection Statistics

these 50 directors are the backbone of the interlocking directorship network in Turkey in 2013.

Since there are 135, 150 and 177 components respectively in the years 2002, 2007 and 2013 we have restricted our visualization to the giant components to avoid cluttering.

2.0.1 Firm Networks

Let A be a matrix of order FxN such that $a_{ij} = 1$ director \$ i\$ sits on the board of company j, $a_{ij} = 0$ otherwise. By using the matrix product we construct the n-square matrix $F = A^T A$, where the off-diagonal entries are the weights of the edges, whereas the diagonal entries are the sizes of the company boards, and the q-square matrix $D = MM^T$, where the off-diagonal entries are the weights of the edges, whereas the diagonal entries are the total number of board memberships. We set all the diagonal entries of F and D equal to zero and all the weights b_{ij} and d_{ij} equal to 1, obtaining exactly the adjacency matrices associated with these graphs.

The large number of components in the projected firm networks as is visible in Figure **??** is the direct consequence of the unconnected nature of the bipartite network.

According to Table 3 the average degree is around 2.5. The clustering coefficient increases from 2002 to 2007 then declines. Average path length continuously increases.

The Table 4 demonstrates that even though the projected firm networks are sparse (the mean/max degree is at most 0.058), the networks have high cohesive structures (clustering coefficients are about 0.6) and are reachable within a few steps (average path length is at most 6). The following sections will demonstrate that the giant components of the projected networks are largely the products of the strategic decisions of a small number of corporation and their directors.

The most striking finding is the comparatively low level of cohesiveness of the firm networks derived from interlocking directorships in Turkey. The fraction of firms in the giant component to the overall firm network is only about % 30. For only in Poland and in Spain this fraction is less than % 50. The other countries, developed or developing, have much higher fractions on the range from% 70-98.

Firm Largest Component Statistics	2002	2007	2013
Number of Edges	265	287	382
Number of Firms	101	100	157
Maximum degree	17	17	14
Mean Firm Projection Degree	5.247	5.74	4.866
Mean / maximum possible degree	0.052	0.058	0.031
Clustering Coefficient	0.57	0.66	0.57
Average path length	5	5.8	6.17

Table 4 Firm Giant Component Statistics

Director Projection Statistics	2002	2007	2013
Number of Components	135	150	177
Number of Edges	5849	6560	11207
Number of Directors	1581	1762	2635
Maximum degree	41	68	67
Mean Director Projection Degree	7.399	7.446	8.506
Mean / maximum possible degree	0.0049	0.0042	0.0032

Table 5 Projected Director Statistics

Director Largest Component Statistics	2002	2007	2013
Number of Edges	2252	2519	5082
Number of Directors	498	530	964
Maximum degree	41	68	67
Mean Director Projection Degree	9.044	9.506	10.543
Mean / maximum possible degree	0.0182	0.0179	0.0109

Table 6 Director Giant Component Statistics

2.0.2 Directors Networks

Let A be a matrix of order FxN such that $a_{ij} = 1$ director $ i$ sits on the board of company j, $a_{ij} = 0$ otherwise. By using the matrix product we construct the n-square matrix $F = A^T A$, where the off-diagonal entries are the weights of the edges, whereas the diagonal entries are the sizes of the company boards, and the q-square matrix $D = MM^T$, where the off-diagonal entries are the weights of the edges, whereas the diagonal entries are the total number of board memberships. We set all the diagonal entries of F and D equal to zero and all the weights b_{ij} and d_{ij} equal to 1, obtaining exactly the adjacency matrices associated with these graphs.

Table 5 is a summary of the projected director networks. Average degree has increased from 7.4 in 2002 to 8.5 in 2013.

In the giant component of the projected director network, the average degree is much higher. As Table 6 illustrates the average degree has increased from 9 in 2002 to 10.5 in 2013. Similarly, the most striking observation is that the fraction of directors covered in the giant component to the overall network is smaller than in other countries. In 2013, there were 964 directors out of 2635 potential directors, that is % 36.

3 Evolution of Networks

3.1 Network Motifs

We follow the methodology introduced in Robins and Alexander. We started with the observed networks for the three years. We then run the randomisation dynamics for 5 times the number of links for each of the 3 observed networks. We then take the resulting networks as initial random networks for the sampling stage. We follow the same procedure for 100.000 times for each network, and at each 1000'th pass we record the resulting network as a sample, ending up with 100 sampled networks that has the properties as the initial observed network.

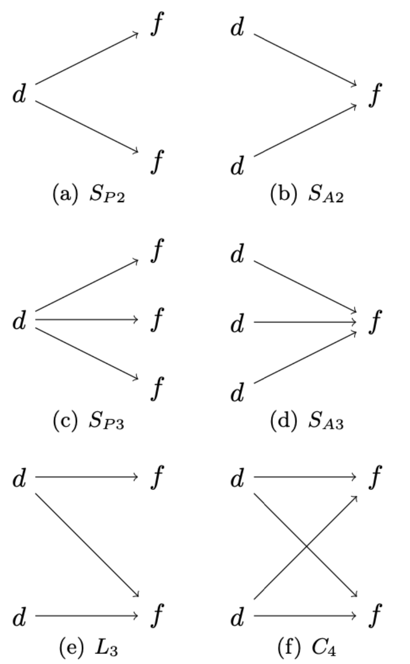

Figure 1: Motifs for bipartite graph

Fig. 1 Motifs in Bipartite Networks

There is slight increase in clustering of the projected firm network from 2002 to 2007. All the comparisons with the simulated random networks suggest that observed networks are non-random We will consider the small world features by incorporating the normalized average path lengths using the simulated random network average path lengths

Statistic	Observed	Simulated (std)	Z-score
S_{A2}	1233	1123.09 (24.8393)	4.42484
S_{A3}	1519	1194.12 (94.0901)	3.45286
S_{P2}	687	639.08 (8.909)	5.37825
S_{P3}	431	290.09 (24.9477)	5.64823
L_3	5152	4119.26 (116.674)	8.85152
C_4	624	8.3 (2.5125)	245.046
Clustering	0.4844	0.00805 (0.0024)	198.376
Projection Statistics			
S_{2A} (Firm 2 Stars)	772	3523.77 (148.137)	-18.5758
T_A(Firm Triangles)	401	321.44 (26.2553)	3.03025
Clustering	1.55829	0.273481 (0.0163)	78.6852
S_{2P} (Director 2 Stars)	1350	6333.75 (313.893)	-15.8772
T_P(Director Triangles)	1113	1226.03 (96.6704)	-1.16923
Clustering	2.4733	0.5803 (0.0282)	66.9792

Table 7 Year 2002

Statistic	Observed	Simulated (std)	Z-score
S_{A2}	1378	1214.94 (29.4247)	5.5416
S_{A3}	1766	1287.15 (116.96)	4.09414
S_{P2}	817	714.62 (9.23955)	11.0806
S_{P3}	698	332.47 (27.3139)	13.3826
L_3	6271	4528.48 (134.46)	12.9594
C_4	807	8.6 (3.01846)	264.506
Clustering	0.51475	0.0076 (0.0026)	191.474
Projection Statistics			
S_{2A} (Firm 2 Stars)	804	3945.72 (159.855)	-19.6536
T_A(Firm Triangles)	561	365.37 (28.9265)	6.76301
Clustering	2.09328	0.2777 (0.0175)	104.143
S_{2P} (Director 2 Stars)	1380	6862.13 (370.71)	-14.7882
T_P (Director Triangles)	1211	1320.61 (119.514)	-0.917132
Clustering	2.63261	0.5766 (0.0305)	67.2106

Table 8 Year 2007

Statistic	Observed	Simulated (std)	Z-score
S_{A2}	2360	1211.64 (28.7853)	39.8939
S_{A3}	3515	1271.74 (100.969)	22.2173
S_{P2}	1106	715.83 (9.86992)	39.5312
S_{P3}	686	335.38 (28.2653)	12.4046
L_3	9726	4521.72 (135.967)	38.2759
C_4	1276	8.68 (3.1619)	400.81
Clustering	0.5247	0.00766 (0.00274)	188.671
Projection Statistics			
S_{2A} (Firm 2 Stars)	1067	3945.55 (157.537)	-18.2723
T_A (Firm Triangles)	516	368.25 (29.3269)	5.03803
Clustering	1.4508	0.27986 (0.0168)	69.5703
S_{2P} (Director 2 Stars)	2866	6830.64 (376.207)	-10.5385
T_P (Director Triangles)	2411	1305.28 (104.264)	10.605
Clustering	2.52373	0.5728 (0.0249)	78.3133

Table 9 Year 2013

	2002	2007	2013
Firms	101	100	157
Stay 2002-2007	50		
Stay 2007-2013		72	

Table 10 Persistence in Firm Bipartite GC

	2002	2007	2013
Directors	498	530	964
Stay 2002-2007	131		
Stay 2007-2013		185	

Table 11 Persistence in Directors Bipartite GC

We provide the general characteristics of the interlocking directors networks above (see Sect. 2).

3.2 Churning and Persistence

3.2.1 Persistence

In order to anlayze the stability of firms in the giant component of the firm network we carry out k-core anlysis in each period. The biggest k-core sizes are 7,11 and 8 respectively in years 2002, 2007 and 2013. The 7 firms in 2002 are COMPONENTA DOKUMCULUK TICARET VE SANAYI A. S., FORD OTOMOTIV SANAYI A. S., IZOCAM TICARET VE SANAYI A. S., KAV DANISMANLIK, PAZARLAMA VE TICARET A. S., ,KOC HOLDING A. S., MARET MARMARA BESICILIK VE ET SANAYI VE TICARET A., and MARMARIS ALTINYUNUS TURISTIK TESISLER A. S.. These are all Koç business group firms, except İZOCAM and ALTINYUNUS. İş Bankası business group controls İZOCAM and ALTINYUNUS is a joint-venture with Yaşar business group.

There are only 39 firms in the firm GC that could keep all their links in all periods There are only 62 directors in the director GC that could keep all their links in all periods Neverthless, despite such a churning the clustering and average path lengths did not change.

3.2.2 Churning

4 Discussion and Conclusion

Paragraph headings Use paragraph headings as needed.

$$a^2 + b^2 = c^2 \tag{1}$$

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