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CORPORATE GOVERNANCE NETWORKS in TURKEY

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Abstract

We provide an analysis of corporate governance networks implied by members of board of directors of 319 companies listed in Istanbul Stock Exchange (ISE) for the year 2007. Our configuration yields a bipartite network for which we provide small world statistics in addition to the usual measures commonly used in network analysis. We find that the networks have low density. However, within the giant component, the average path among agents is very low and the clustering coefficient is considerably high.

Keywords: Corporate Governance, Networks
JEL Classifications: D21,D85

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1 Introduction

As is seen in other developing countries such as India and Mexico, the corporate sector in Turkey is largely concentrated and structured through cross-holdings and pyramidal control exercised by family ownership channels. The basic unit in most cases is the holding company in which the controlling shareholders are always within the family or from the closed circle of trustees.

Besides the advantages a holding group may enhance in terms of providing internal capital markets in a context characterized by high and highly volatile external cost of capital, the holding company also brings tax advantages to the controlling family. For example, the holding companies can pay taxes due to the revenues accruing from the subsidiaries a year later. The opportunity of using transfer pricing among the firms affiliated with the holding company is another benefit.

According to the Turkish Corporate Law, the firms need not to follow the one-share-one-vote principle. Shares with different cash flow requirements and voting rights can be issued. Orbay and Yurtoglu (2006) find that 43 percent of 218 firms in 2005 do not observe this principle. This degree of protection of the minority rights imply that diffusion of ownership shares would be limited.

One particular exception is a non-academic work. In an economics magazine called *Capital*, a study on the general characteristics of the board of directors in ISE reveals some important findings.

Although their sample may not be representative, 136 CEOs chosen for the study can shed light on basic issues. For example, 26.5 percent of the directors hold two directorships. Frequently the board size is small; boards with equal or more than nine directors constitute 17.4 percent of the total. In contrast to the average meeting number of 8.3 per year for the world, Turkish boards dominantly meet four times a year.

Family members sit on the boards in 54 percent of the firms. Merely one-fourth of the boards host an independent director. Board members posses shares significantly more than what can be regarded as symbolic in 37.8 percent of the firms. Compensation packages include stock options in majority of the firms, 62.2 percent.

Market capitalization in ISE constitutes about 40 percent of the Turkish GDP and these firms are central to the Turkish economy. These firms are leading in terms of institutionalization of the corporate governance principles in Turkey. We would like to analyze the diffusion of corporate practices. CEO compensation schemes is a particular case in point. The recent years have brought about a substantial increases in CEO wages and benefit. According to one study Turkey pays fifth highest compensation packages in terms of purchasing power parity. In times of great turmoil such as the current global financial crises, the sparsity of the firm networks mean that the national character of the ownership structure can be very fragile. We would also find out the effects of corporate restructuring and privatization on the network structure in 2007. Which firms have be-

come central? Which directors have emerged as hubs or influential?

This study will be the first focusing on a developing country context. Although there is a scant literature on corporate governance in Turkey, the existing works focus on mostly the effect of ownership structures on the performance. In this paper we compile a network data set from the public information declared by the firms listed in ISE in 2007 and analyze the statistics with regards to the directorship network and the implied firm network. We find that the there is a high fragmentation and a very low density within both networks. The giant component, a subgraph in which every node is accessible from another, make up to 30 percent of the networks We also document the most central directors and firms. For instance, OTOKAR A. S. has links with 17 other firms within its immediate neighborhood.

2 Related Literature

Yurtoğlu (2000) [13] is one of the few studies on ownership, control and performance of ISE firms. Firms in Turkey have a so-called one-tier board system, where managing executives are also represented on the board. The company law concerning joint stock companies requires that there must be at least three directors who need not necessarily be large shareholders, can not be incompetent or bankrupt and can not be appointed for more than three years.

He underlines the observation that the board members, other than controlling family members are mostly former politicians or military officers on the one hand and certain professionals. The board size is positively related to firm size and to the number of subsidiaries of the company and negatively to the logarithm of the size of the largest direct shareholder's holdings. Holding companies and financial companies have larger boards than manufacturing companies.

Heemskerk and Schnyder (2008) [5] compare the evolution of interlocking directorship networks in Switzerland and Netherlands within the period of 1990 and 2000. They reveal that the decrease in interlocking is stronger for Swiss companies than for Ductch companies. Shareholder value orientation is raised as a potential explanation for this difference. They also argue that two countries have interlocking directors networks exemplifying small world characteristics. Nevertheless, their finding should be taken with a grain of salt as they do not take into account of the special feature of the bipartite random graph model by which the small world statistics should be constructed.

Robins and Alexander (2004) [8] examine the *interlockers* as the group forming the network infrastructure. They argue that directors holding just one board seat make no interlocks and hence should not be directly taken into account in the analysis. Consequently the network infrastructure, by definition, has to have at least one interlocker on its board. They find that both in US and Australian data sets bipartite networks (firm and directors) have much higher than expected multiple connections. many pairs of interlockers find themselves sharing membership of more than one board. New members

with 'weak' ties may be introduced to firms by the existing board members who have experience with them on other boards.

As an alternative firms pick existing multiple interlocking directors and appoint them in their boards. Both processes tend to bring about small world effects.

We follow Conyon and Muldoon (2005) [2](CM)- as a benchmark study and extend their framework to the Turkish case. CM present a random graph model of the interlocking board of directors. They compare this random model with the observed 'small-world' model of real world economies such as United States, UK and Germany. They find that random graph model is remarkably good at explaining board structure and connectedness in the United States, the United Kingdom and Germany. There seems no peculiarity of interlocking directors constituting a small-world.

However, CM underline a common observation: the positive degree correlation among interlocking directors. The directors who sit on many boards appear to do so in the company of others who also sit in many boards.

3 Data and ISE

3.1 Firms

Istanbul Stock Exchange as an institution dates back to 1986. According to the latest report of Capital Market Board -the main body that governs ISE transactions- the number of firms listed in its first year was 80. After 1989, with the upward trend of newcomers the size of the market reached 315 firms in 2000. Thereafter the scale is stable. In the year we make our analysis, the number of listed companies is 319. The lack of interest in public offerings and being listed is attributed to the fear of losing control entertained by the family owners of the major firms.

The success is in the eyes of the beholder. According to the report published by OECD in 2006, *Corporate Governance in Turkey: A Pilot Study*, there existed merely 625 publicly held companies, namely companies with more than 250 shareholder in 2005. Out of 625 firm more than half of them, 315, were listed in ISE.

The market capitalization of the firms reveal a concentrated market. Fortysix firms constitute 84 percent of the total market capitalization in 2007. See Table 3 in Appendix

It will be illuminating to analyze the distribution of these 46 firms among the various components in firms and directors networks. However, we leave this issue for another working paper. We a priori expect that two possible scenarios. As each large firm (in terms of high market capitalization value) acts as a hub, these firms should be evenly distributed among different components. Or via preferential attachment, large firms would be within the same -and most likely the giant- component in order to communicate and coordinate their governance policies.

The driving force of the transactions in the ISE is arguably the interest of the foreign portfolio funds. the share of foreign holding of stocks went up from 41 percent in 2000 to 72 percent in 2007. The domestic investors hold on to the stocks for an average of one month. The duration of foreign holding of stocks is about 10 months.

3.1.1 Board of Directors

Boards are mostly populated by the professionals and family members of the controlling ownership group. Single board membership is the dominant form. 1426 individuals occupy only one seat in single boards. However as it can be seen from Table 1 in appendix 1 one director, namely Mr. Bulent Bulgurlu sits on 12 different boards. He is the CEO of the Koc Holdig company.

Robins and Alexander (2004) report that the US companies in their dataset have an average board size of 13.3 seats, whereas the Australian companies have an average of 8.

As Table 5 demonstrated Average board size in Turkey is 6.7 which is similar to UK and Germany. Average number of directorships on the other hand is statistically different than US, UK and Germany. Each individual in Turkey holds only 1.255 directorship position on average. The corresponding figure in Germany is 1.45, in USA 1.64 and in UK 1.84.

4 Network Analysis

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) 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).

4.1 Degree, Distance, Clustering and Components

The *node* (or a vertex) is the basic unit of a network and an *edge* is the link connecting two nodes. The number of edges connected to a node is called the *degree*.

The distance between two nodes in a network is the number of links in the shortest path that connects these two nodes. It is generally of interest to know the distance of a randomly chosen two nodes in a network. There are $n(n-1)/2$ unordered pairs of nodes in a network with n nodes. A *geodesic* is a shortest path that connects two nodes and the *distance* is between any given two nodes is the is the numbe of edges in a geodesic connecting them.

Clustering is a measure of how much a typical node's neighbors are also connected with each other. There are two commonly used methods to calculate clustering. They

both takes values in the range 0 and 1. A clustering of 1 indicates that every neighbor of a given agent are also neighbor with each other, therefore, every component in the network is a complete graph. A clustering degree of 0 indicates there exists no triplets that are connected with each other. The first method we shall be employing is due to Watts and Strogatz in [11] where clustering coefficient for node j is defined by

$$C_j = \frac{\text{actual number of links between neighbors of } j}{\text{potential number of links between neighbors of } j}$$

$$= \frac{\text{actual number of links between neighbors of } j}{d_j(d_j - 1)/2}$$

where d_j is the degree of node j, i.e. number of neighbors of node j. Then we can calculate the clustering coefficient for the overall network by taking the average,

$$C_{WS} = \frac{1}{n}\sum_{j=1}^{n} C_j$$

The second measure we employ here is due to [6, 4, 10, 1]. where the clustering coefficient is defined as

$$C_T = \frac{3 \times \text{number of triangles in the graph}}{\text{number of connected triplets}}$$

This measure is generally referred to as *transitivity*.

Component is a subgraph (or a subnetwork) in which each and every node can be reached directly or indirectly through via edges. Components generally have high clustering characteristics.

5 Analysis

In this sections we will be looking at the networks implied by the board of director membership of the firms. The raw data, which consists of board members of the firms will lead to a bipartite network which we illustrate partially in figure **??**. An edge (or a link) in this graph connects an individual to a firm, indicating that the individual either has a seat at the board of directors of the firm or is the general manager of the firm.

We then focus on two one-mode projections of this bipartite graph. In the director network, each node represents an individual and an edge between two individuals indicates that they have a seat in at least one firm's board of directors.

In the firm network, each node represents a firm, and an edge between two firms indicates that the two firms have at least one common individual in their board of directors. A subset of firms that have links in this manner is referred as *interlocked*.

We first look at the properties of the bipartite graph.

5.1 Board of Directors Network

There are 1703 board members (including the general managers) and 319 firms in our data set.

Average degree of the directors in the largest component in the bipartite graph , i.e. average membership is 1.453. The circles in right plot of Figure 6 shows the degree distribution of the director network.

There are 144 components in the projected director network. The largest one includes 520 directors. Figure 1 shows the size distribution of components.

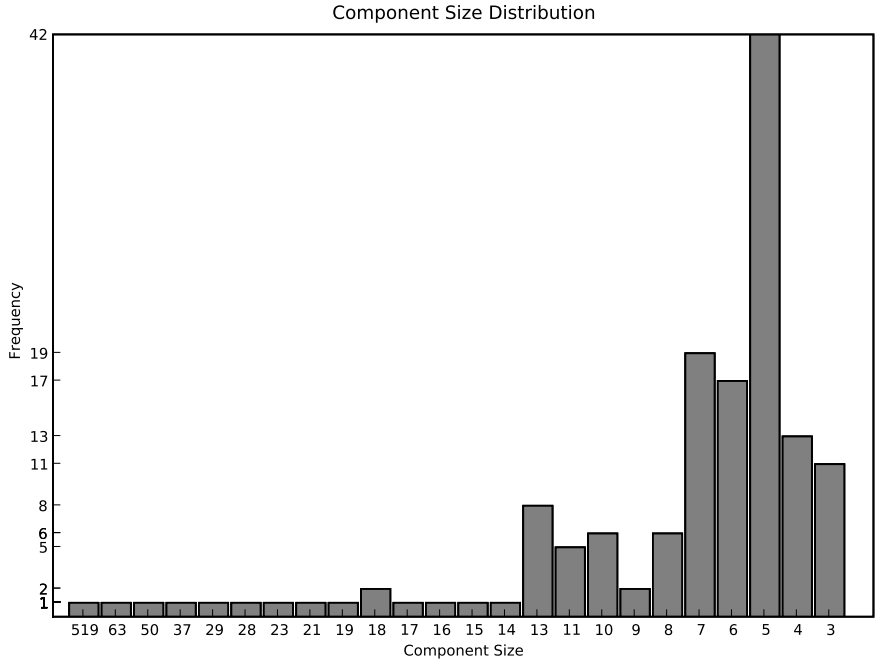


Figure 1: Board of Directors Network Component Size Distribution

Figure 2 shows the largest 6 components of the board of directors network.

5.2 Firm Network

The circles in left plot of Figure 6 shows the degree distribution of the firm network. Average degree of the firms in the largest component in the bipartite graph , i.e. average board size is 7.714.

There are 144 components in the projected firm network. The largest one includes 98 firms and there are 104 firms with no directors shared with any other firm. Figure 3 shows the size distribution of components.

Figure 4 shows the network structure of the largest 4 components of the firm network.

5.3 Small World Properties

In what follows we will be focusing on the properties of the largest component of the projected graphs. We use the methodology introduced in [7] to calculate statistics for the random bipartite network with the same degree distributions as the distribution we calculate from the empirical data shown in figure 5. It is of interest to identify how different the observed networks are from those that can happen only by chance. That is to say, if we have a set of firms with empty boards that are identical in size with the ones that we observe in empirical data, and same number of directors available for filling those seats, is it possible that pure random distribution of directors to those positions can create the structure we observe?

An obvious method to test these, which is employed by XX XX, is to generate a high number of such networks randomly in a computer and get the distribution of statistics we are interested. The approach of XX and XX provides another method to get the statistics (at least for those that we are interested) without any need of computer simulations. This approach builds on the generation functions XXX.

Define $f_0[x] = \sum_j p_j x^j$ where p_j is the (empirical) probability of observing a firm with degree j, be the degree generating function for the firms in the bipartite graph.[1] Using the empirical degree distribution (Table **??** in appendix) we calculate the function as

$$f_0[x] = \frac{3x^4 + 9x^5 + 14x^6 + 26x^7 + 19x^8 + 7x^9 + 11x^{10} + 4x^{11} + 3x^{12} + x^{13} + x^{15}}{98}$$

Similarly define $g_0[x] = \sum_j q_j x^j$ where q_j correspond to the (empirical) probability of observing a director with degree j be the degree generating function for directors in the bipartite graph.

Using the empirical degree distribution (Table **??** in appendix) this function can be calculated as

$$g_0[x] = \frac{400x + 67x^2 + 23x^3 + 12x^4 + 11x^5 + 5x^6 + x^8 + x^{12}}{520}$$

In order to get statistics for the projected graphs we need to derive the degree generating functions for the two projections. Using functions $f_0[x]$ and $g_0[x]$, the degree generating function for the (projected) firm network is given by $F_0[x] = f_0[g_1[x]]$, where $g_1[x] = \frac{g_0'[x]}{g_0'[1]}$. The corresponding degree generating function for the (projected) director network is $G_0[x] = g_0[f_1[x]]$ where $f_1[x] = \frac{f_0'[x]}{f_0'[1]}$.

We can use the functions $F_0[x]$ and $G_0[x]$ to calculate the complete degree distribution of the projected firm and director networks. The probability of observing a firm with a degree k in the projected network will be $\frac{1}{k!}\frac{d^k F_0}{dx^k}\Big|_{x=0}$. Similarly the probability of observing a director with a degree k in the projected network will be $\frac{1}{k!}\frac{d^k G_0}{dx^k}\Big|_{x=0}$. The mean degree

[1] For discussion on generating functions see [12]

for the firm network will be $F_0'[1] = 9,9387$. The mean degree for the director network will be $G_0'[1] = 10.5538$.

Figure 6 compares the empirical degree distributions of the projected graphs and the distributions suggested from the random network.

We can also calculate the clustering (transitivity) coefficient of the projected networks that should result from random bipartite network with the given degree distributions.

For the director network, the clustering coefficient can be calculated as

$$C_T^d = \Big(\frac{\#\text{ firms}}{\#\text{ directors}}\Big)\Big(\frac{f_0'''[1]}{G_0''[1]}\Big) = 0.425$$

For the firm network, the same statistic can be calculated as

$$C_T^f = \Big(\frac{\#\text{ directors}}{\#\text{ firms}}\Big)\Big(\frac{g_0'''[1]}{F_0''[1]}\Big) = 0.2684$$

Expected mean path length for the firm (L_f) and the director (L_d) networks can be calculated respectively as

$$L^f = 1 + \frac{ln\Big[\frac{\#\text{ firms}}{F_0'[1]}\Big]}{ln\Big[\Big(\frac{f_0''[1]}{f_0'[1]}\Big)\Big(\frac{g_0''[1]}{g_0'[1]}\Big)\Big]} = 2.0234$$

$$L^d = 1 + \frac{ln\Big[\frac{\#\text{ directors}}{G_0'[1]}\Big]}{ln\Big[\Big(\frac{f_0''[1]}{f_0'[1]}\Big)\Big(\frac{g_0''[1]}{g_0'[1]}\Big)\Big]} = 2.7432$$

We find that there are many individual firms without any connection. Hence the density is expectedly low. Nevertheless, there are both very well connected firms and directors. The giant components are as big as one-third of the firm and directors networks

6 Comparisons and Discussions

We find various dimensions reflecting peculiarity of Turkish case in international comparison.

Average board size in Turkey is statistically different from US but similar to UK and Germany. This is interesting. Germany, UK and Turkey have dramatically different cultures, instutions and history of corporate governance. The decision-makin process in these countries seem to follow the same pattern.

Average number of directorship that each board member holds is the lowest in Turkey. This may imply that controling groups, mostly the families are hesitant to include professionals in the board of directors.

According to Table 6 expected degree due to the constructed random bi-partite network and actual degree observed are statistically equal.

Expected and actual length diverge in Turkey as well as in Germany, but not in UK and US. Note that the measured length is a property of the giant component. Thus, within the giant component a firm on average can not be traced within the number of steps that is expected considering a random bi-partite graph. It requires a greater number of steps in reality both in Turkey and Germany. This may stem due to the lack of "weak ties" or "bridges" in these countries.

Expected and actual clustering coefficients differ considerably for both firms and directors network in Turkey and for firm network in Germany. Actual clustering is much higher in Turkey.

As Table 2 reveals many of the largest corporations have a holding company as the controlling shareholder. The holding companies are the flagships of the business groups formed by individual families or by a small number allied families. Almost every major holding company owns and controls a bank. The bank in turn owns and controls various firms within the business group firms. Thus cross-shareholding as well as pyramidal control by families structure corporate governance in Turkey as an "insider system". Hence the board of directors are appointed by the individual and families holding the 'ultimate control' of the corporations.

A higher actual clustering may be a sign of the strength of the cross-shareholding of the firms within the giant component. These firms are controlled by the few business groups that appoint common board members.

7 Conclusion

The insider system of corporate governance in Turkey leads to a relatively sparse network in terms of firms connectec by at least a board member. Neverthless, we find that in four steps a major decision rule, ie. a wage cut, can travel one-third of the total network.

We agree with Uzzi et. al. (2007) [9] that small-world analyis should be dynamic as well as comparative. Consequently, in the following paper we will be tracing the evolution of the ISE corporate governance networks through the period of 2002 to 2007.

As a new research question we will also follow Conyon and Muldoon (2007) [3] and ask whether the financial firms play the bridging roles in the corporate governance networks as expected by the theory or not.

References

[1] Stephen P. Borgatti and Martin G. Everett. Models of core/periphery structures. *Social Networks*, 21:375–395, 1999.

[2] M. J. Conyon and M. R. Muldoon. The small world network structure of boards of directors. University of Manchester, School of Mathematics, Working Paper MIMS Eprint 2005.15.

[3] M. J. Conyon and M. R. Muldoon. Ownership and control: A small-world analysis. The University of Manchester MIMS Eprint: 2006. 134, 2007.

[4] Scott Feld. The focused organization of social ties. *American Journal of Sociology*, 86:1015–1035, 1981.

[5] Eelke M Heemskerk and Gerhard Schnyder. Small states, international pressures, and interlocking directorates: the cases of switzerland and the netherlands. *European Management Review*, 5:41–54, 2008.

[6] Paul W. Holland and Samuel Leinhardt. Transitivity in structural models of small groups. *Comparative Groups Studies*, 2:107–124, 1971.

[7] S. H. Strogatz M. E. J. Newman and D. J. Watts. Random graphs with arbitrary degree distributions and their applications. *Physical Review E*, 64, 2001.

[8] Garry Robins and Malcolm Alexander. Small worlds among interlocking directors: Network structure and distance in bipartite graphs. *Computational & Mathematical Organization Theory*, 10:69–94, 2004.

[9] Brian Uzzi, Luis AN Amaral, and Felix Reed-Tsochas. Small-world networks and management science research: a review. *European Management Review*, 4:77–91, 2007.

[10] Stanley Wasserman and Ketherine Faust. *Social network analysis: Methods and applications*. Cambridge University Press, Cambridge, 1994.

[11] Duncan J. Watts. *Small Worlds: The Dynamics of Networks between Order and Randomness*. Princeton University Press, 41 William Street, Princeton, New Jersey 08540, 1999.

[12] Herbert S. Wilf. *Generating functionology*. Academic Press Professional, Inc., San Diego, CA, USA., 1990.

[13] B. Burcin Yurtoglu. Ownership, control and performance of turkish listed firms. *Empirica*, 27:193–222, 2000.

8 Appendix

Name	Centrality
Bulent Bulgurlu	68
Cem Kozlu	43
Tuncay Ozilhan	39
Temel Atay	39
Rahmi Koc	36
Ibrahim Yazici	33
Ozgun Cinar	32
Celalettin Caglar	31
Imre Barmanmek	31
Ali Tarik Uzun	29

Table 1: Centrality of Board Member

	Market Value	S1	Percent	S1 Type	S2	Percent	S2 Type	Public Share	Restrictions
Turkcell	24.173	Turkcell Holding	51	HC	Sonera Holding	13.07	FSI	29.38	?
Akbank	22.405	Sabanci Holding	31.38	HC	Citibank	20	FI	39.52	?
Garanti	18.928	Dogus Holding	26.22	HC	GE Aras. ve Musav.LTD.	20.85	FSI	48.63	?
Is Bankası C	17.392	Company Pension Fund	41.54	CPF	CHP	28.09	Political Party	30.38	PRIV
Halk Bankası	13.091	Privatization Ageny	70.98	State				24.98	?
Turk Telekom	12.487	OGER	55	FSI	Treasury	30	State	15	?
Yapı Kredi	12.120	KOC	81.79	HC				18.21	?
Sabancı	9.966	Sabanci Family	61.3	Family	Sakip Sabanci Holding	14.81	HC	21.64	?
Koç Holding	9.516	Temel Tic. ve Yat. A.S.	42.44	Family	Vehbi Koc Vakfi	7.17	Foundation	20.25	MV
Vakıfbank	8.884	Foundations	43	Foundations	Company Pension Fund		16.1	25.18	?

Table 2: Ten Largest Firms (2007)

Market Value (in millions)	Number of Firms	Total Market Value	Share in Total Market Capitalization (%)
1000 or more	46	242.381	84.03
500 – 1000	28	19.950	6.92
200 – 500	50	15.349	5.32
100 – 200	37	5.312	1.84
50 – 100	43	3.137	1.09
25 – 50	42	1.455	0.50
25 or less	73	860	0.30
Total	319	288.444	100.00

Table 3: Concentration of Market Capitalization.(Source: ISE Annual Report)

Number of Firms	3	9	14	26	19	7	11	4	3	1	1
Degree	4	5	6	7	8	9	10	11	12	13	15

Table 4: Firm Degree Distribution in bipartite graph largest component.

Number of Directors	400	67	23	12	11	5	1	1
Degree	1	2	3	4	5	6	8	12

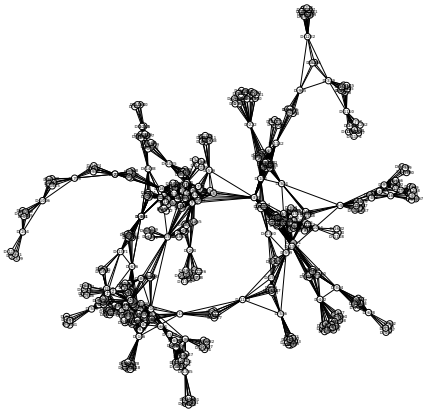
Table 5: Director Degree Distribution in bipartite graph largest component.

	Turkey	**USA**	**UK**	**Germany**
Director seats	2136	17,277	14,552	14,904
Number of unique directors	1703	13,330	11,541	12,747
Number of firms	319	1,733	2,236	2,354
Average board size	6.7	9.97	6.51	6,33
Average number of directorships	1.255	1.63	1.84	1.45
One-board director (%)	83.79	80.37	84.25	88.33
Two-board director (%)	11.50	13.02	10.08	8.92
Connected component - directors	520	11,057	8,850	4,185
Connected component - firms	98	1473	1732	582

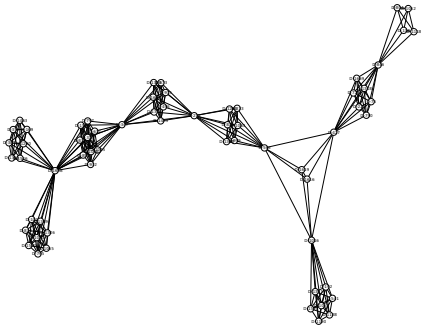
Table 6:

	Vertices	*Degree*		*Length*			*Clustering*	
Network	*N*	*Expected*	*Actual*	*Expected*	*Actual*	*Expected* (C_T)	*Actual* (C_T)	*Actual* (C_{WS})
Turkey								
Director projection	520	10.55	9.54	2.74	6.29	0.425	0.60	0.895
Firm Projection	98	9.938	5.612	2.023	5.45	0.268	0.67	0.596
United States								
Director projection	11,057	13.616	13.460	4.228	5.188	0.560	0.556	0.871
Firm projection	1473	8.050	7.275	3.510	4.327	0.163	0.167	0.225
United Kingdom								
Director projection	8,850	9.069	8.981	4.795	6.462	0.546	0.612	0.889
Firm projection	1732	6.073	5.709	4.116	5.579	0.327	0.376	0.376
Germany								
Director projection	4,185	15.103	14.546	3.504	6.398	0.622	0.719	0.926
Firm projection	582	7.337	4.553	2.947	6.108	0.318	0.577	0.413

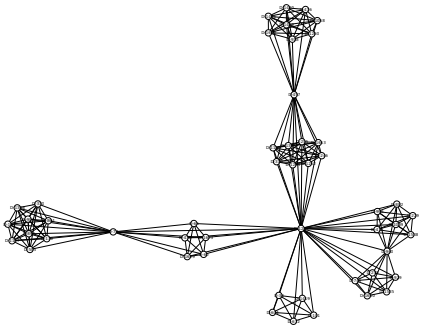
Table 7:



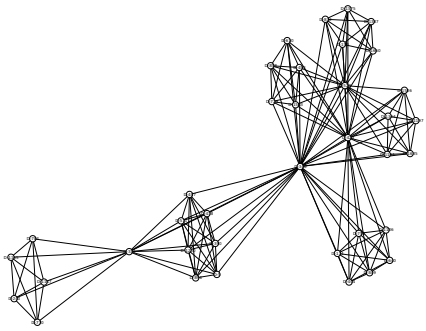
i. Component 1 (519 members)



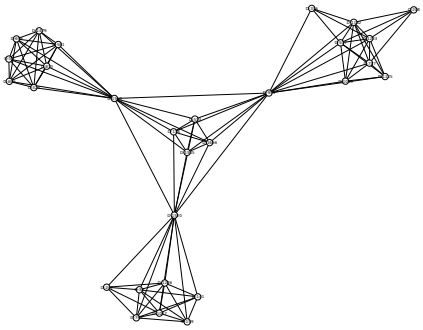
ii. Component 2 (63 members)



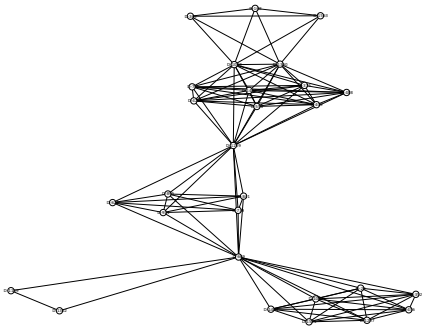
iii. Component 3 (50 members)



iv. Component 4 (37 members)



v. Component 5 (29 members)



vi. Component 6 (28 members)

Figure 2: Director Network Top 6 Largest Components

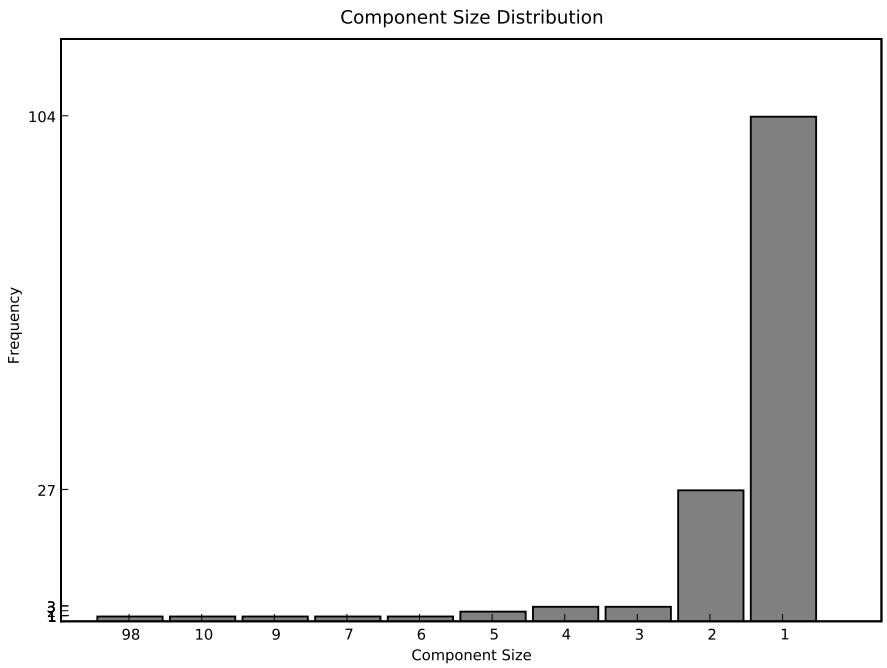
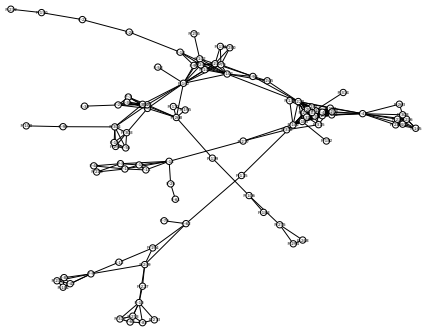
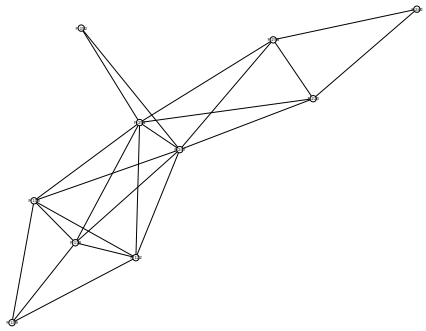


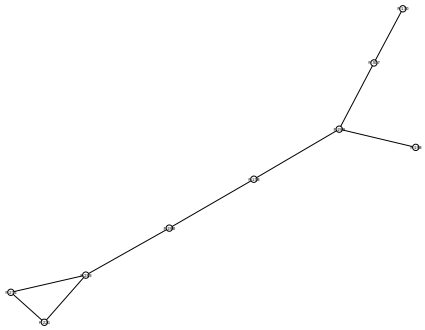
Figure 3: Firm Network Component Size Distribution



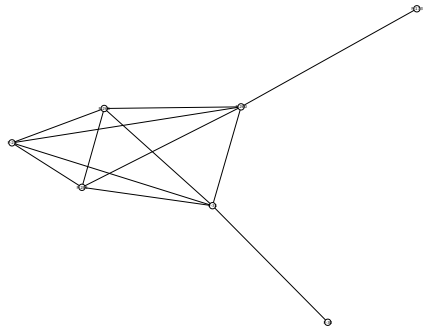
i. Component 1 (98 members)



ii. Component 2 (10 members)



iii. Component 3 (9 members)



iv. Component 4 (7 members)

Figure 4: Firm Network Top 4 Largest Components

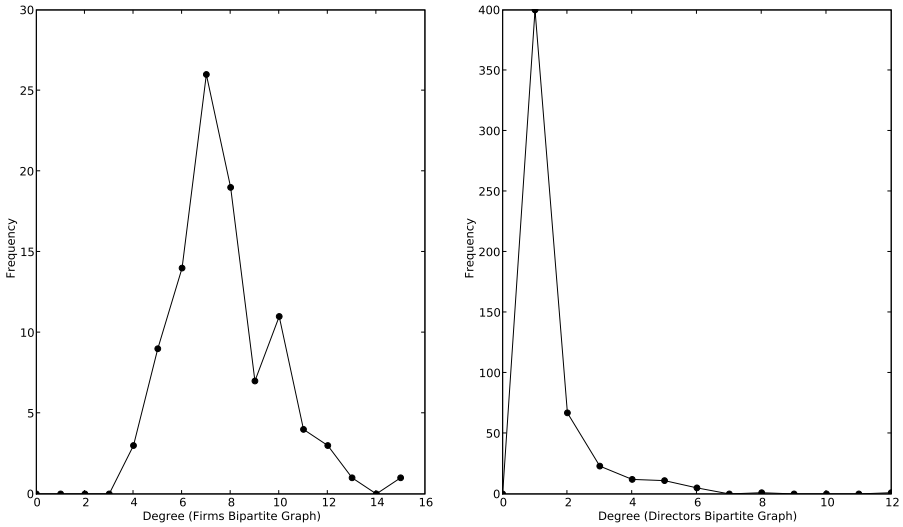


Figure 5: Degree distributions of the bipartite graph. Left panel: the numbers of directors on each firm. Right panel: number of boards on which each director sits.

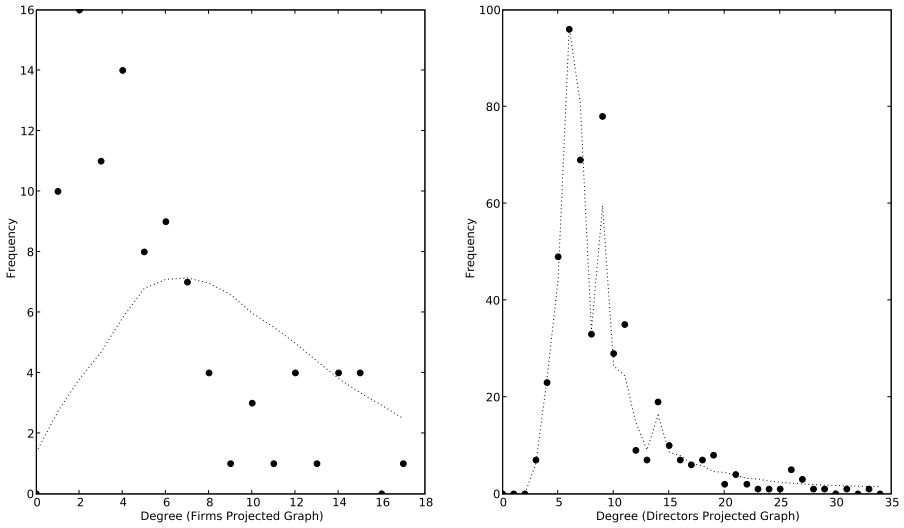


Figure 6: Degree distributions of the projected graphs. Circles show actual frequencies, doted curves show the expected frequency.