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Corporate boards, interorganizational ties and profitability: The case of Japan

by Matthias Raddant and Hiroshi Takahashi

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Corporate boards, interorganizational ties and profitability: The case of Japan

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Abstract

We analyze the ties between 4,000 Japanese corporations in the time period from 2004 until 2013. We combine data about the board composition with ownership relationships and indicators of corporate profitability. We find that both the network of corporate board interlocks as well as the ownership network show a high degree of persistence. The overlap between these two networks is surprisingly small. In the analysis of the board composition we find that the number of outside board members is low yet increasing. Firms with large foreign shareholdings are at the forefront of this development. Upon retirement board members in central positions are replaced with similarly central executives, maintaining the general structure of the network. Women in corporate boards remain scarce. The connectivity of firms in the ownership and board network can be related to firm profitability. Firms that are linked to peers with above average profitability are likely more profitable than firms in other relationships.

Keywords: corporate board interlock, firm performance, firm networks

1. Introduction

We study the interorganizational networks of Japanese corporates from 2004 until 2013. We focus on corporate board interlocks and ownership ties. We investigate the network structure and we analyze if and under which

conditions ties in either network are related to firm profitability.

Board interlocks emerge when directors serve on the board of more than one company. These interlocks have been investigated in the literature for several reasons. Some studies have analyzed to which extent shared directors exist as a natural consequence of ownership and control. More importantly however board interlocks and other interorganizational networks have been analyzed as influencing factor for firm profitability, strategy, managerial practice and corporate governance (see, e.g., Hermalin and Weisbach, 2003; Provan et al., 2007; Mizruchi, 1996; Gulati and Gargiulo, 1999). Our analysis therefore combines the analysis of corporate boards with the analysis of ownership relationships and corporate profitability. In the literature firm connectivity is mostly regarded as necessary to provide opportunities for firms to develop (see, e.g., Uzzi, 1996). Yet, many studies also stress that ties should be carefully managed since they can have a positive or negative effect on firm performance (Barroso-Castro et al., 2016; Sullivan and Tang, 2013). Most of these studies analyze samples of limited size or focus on specific aspects of firm behavior. Our approach is comparably general and is applied to a large sample of firms. We show that while the board composition and the number of interorganizational ties might vary, it is ultimately the performance of ties that influences firm profitability.

Corporate interlocks are also an interesting phenomenon for social networks science, since the networks of directors with multiple mandates are (partly by construction) very dense and show high degrees of clustering, even though the average connectivity is very low (Conyon and Muldoon, 2006; Davis et al., 2003; Battiston and Catanzaro, 2004). This raises the question how the structure of this network might influence decision making and the formation of interest groups. (Haunschild and Beckmann, 1998; Kramarz and Thesmar, 1992). Less research has focused on the dynamics of corporate interlocks, but it seems clear that some amplification mechanisms are in place that foster multiple mandates at highly capitalized firms

and that imply replacement of very central directors with alike peers when managers retire or leave the company (Milaković et al., 2010; Bellenzier and Grassi, 2014; Mariolis and Jones, 1982).

The dynamics of corporate interlocks have also been analyzed with respect to changes in the relationship of public and private companies as well as the changes in funding policies and capital market requirements. The privatization of former public companies and the emphasis of shareholder value principles are forces that tendentially lead to the desolution of dense clusters of board interlocks (Heemskerck, 2007). Current research has however shown that rather a quantitative but not a qualitative decrease of board interlock can be observed (Kogut and Walker, 2001; Raddant et al., 2017).

A topic that is specific for the Japanese economy are the fading effects of the so-called *keiretsu* (Lincoln and Shimotani, 2001). This term describes six historic conglomerates of corporations that have dominated the Japanese economic landscape after the second World War. Studies found that today only very few traces of their former structure can be found even though the names of the original concerns persist. Risk sharing mechanisms within ownership structures are likely to influence performance and will therefore be part of our analysis. Previous studies on Japanese corporate ties include Schaeede (1995); Lincoln and Gerlach (2004); Nakano and Nguyen (2012) and Lincoln et al. (1992). An older yet seminal paper is Asanuma (1985) who focuses on ties in the automotive industry. Kanamitsu (2013) finds that the relationship between having long-serving CEOs and high firm centrality is fading, which could indicate a restructuring of the Japanese board and ownership networks towards more relationships within specific business sectors.

A different facet of this debate is the composition of the board. There is no consensus on the question if the appointment of outside board members is of any benefit to ensure good governance and accurate reporting (see the survey by Petra, 2005). And even if an independent board is generally regarded as best practice, a link to performance can mostly not be established

(Dalton and Dalton, 2011). Nevertheless, we observe an increasing number of outside board members in Japan. Traditionally they often come from banks, related corporations or are retired government officials. There is however no evidence that this leads to significant differences in firm performance (Miwa and Ramseyer, 2005). There is however evidence that foreign ownership has an effect on firm valuation (Mian and Nagata, 2015), which leaves the question if the growing number of outside board members can be connected to such influences.

In our study we find that the Japanese board network exhibits some clustering, which however is probably not a keiretsu remainder. Ownership relationships explain only a very small amount of board network ties. In general, ties between companies are very persistent and we show that this is likely an effect of selective executive replacement. There is some increase in the number of outside board members, even though these are more likely to be replaced than regular board members. In our analysis of firm profitability we find that ties in the board or ownership network can only be beneficial under one condition: links have to be formed to firms with above average profitability.

In the following we will first review the data set and the methods that we have applied in section 2. After this we will discuss the structure of the network and the determinants of the survival of ties and board members in section 3. In section 4 we discuss board composition and the role of outside board members. At last we will analyze dependencies between firm connectivity and profitability.

2. Materials and Methods

2.1. Company data and network generation

The Japanese system of corporate boards used to be a very special one at least until the 1990s. Boards used to be large and had limited intend to care about international governance standards or even shareholder value.

Really important decisions were taken within smaller groups of senior board members anyhow. The crisis of the 1990s lead to some change and influence from the US system. Following Sony, boards mostly shrank to a size of about 10 *corporate executive officers* plus 2 to 3 externals, including the auditor. An alternative system is the *company with committees*. In this system additional to a board of directors three committees would handle audit, nomination and remuneration duties (Buchanan and Deakin, 2009). Hence, in our analysis we look in the very large majority at cases where the board of directors consists of 6 to 15 corporate executive officers, one auditor and possibly 1 or 2 outside board members. Only few mainly very large corporations report up to 35 total board members.

For our analysis we have collected data of all publicly listed companies in Japan. Most of these are listed at the Tokyo Stock Exchange (TSE). This means that our sample includes all the roughly 1,700 firms of the so-called first section together with a similar amount of slightly smaller firms. We combine the data on the composition of corporate boards available from Toyo Keizai with financial data obtained from Nikkei Needs and Thompson Reuters Datastream. In particular we use the information on market value, income, total assets, the business sector, largest shareholders and share holder composition.

The information on the composition of the board is updated annually in the middle of the year. Besides the names of the board members we have obtained information on the age, gender and role of the board member. The naming and numerical identifiers of board members are unanimous within each year, but not necessarily throughout the years. Hence we have developed an algorithm to trace the destinies of board members over time based on parts of their names, date of birth and affiliations.¹ The financial data of the firms

¹We have confirmed the validity of this algorithm by manual checks. The only known limitation of this method is that we may lose traces of board members who exit the data set and re-appear at a later year at a different company. We are however confident that

is matched using the same yearly frequency.

The basics of the treatment of the board composition data are simple. For each year we observe a set of board members and a set of firms. Board members serve on the boards of one or more firms. This creates relationships (incidences) between the set of board members and the set of firms and resemble a bi-partite graph. Incidences can be described by positive entries in a matrix I , where the dimensions of I are given by the number of firms and the number of board members within a year. Hence, if a manager i works for firm j the element I_{ij} is 1, and 0 otherwise.

From the incidence matrix I we can obtain two different un-directed networks by projection. $A_D = II'$ creates an adjacency matrix for the network of board members, where positive entries resemble cases where board members know each other from serving on at least one board together. In the following we will however focus on a different interpretation of the data, namely a network of firms.

By multiplying $I'I = A_B$ we obtain an adjacency matrix that describes the network of the firms based on board interlocks. A_B is a square matrix with as many rows and columns as we have firms in our sample. A positive entry A_{ij} describes a connection between the firms i and j that is given by at least one shared board members. In the following we will refer to this network as the board network.

2.2. Basic descriptive statistics over time

The networks that we look at naturally show some churning over time, caused by entry and exit of firms as well as retirement and replacement of board members. Nevertheless, the basic statistics provided in table 1 show that the number of firms varies steadily between 3,532 and 3,943 (distinct: 4,505). In the same time the average number of board members is slightly

this problem applies only to a very limited number of board members who did not play a decisive role in the board member network anyhow.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
counts										
no. firms	3,767	3,849	3,943	3,887	3,767	3,672	3,595	3,543	3,532	3,545
no. b. members	42,175	42,635	43,121	41,998	39,907	38,759	37,731	36,884	36,452	36,697
no. mandates	45,119	45,760	46,257	44,991	42,693	41,461	40,318	39,458	39,103	39,503
avg. board	11.98	11.89	11.73	11.57	11.33	11.29	11.22	11.14	11.07	11.14
avg. mandates	1.070	1.073	1.073	1.071	1.070	1.070	1.069	1.070	1.073	1.076
max mandates	11	9	8	8	8	8	7	7	7	7
board network										
edges	3,221	3,498	3,415	3,266	3,045	2,956	2,883	2,869	2,984	3,240
density	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00012	0.00013
mean degree	1.71	1.81	1.73	1.68	1.62	1.61	1.61	1.62	1.69	1.83
companies g.c.	1,408	1,571	1,547	1,495	1,387	1,383	1,373	1,380	1,490	1,625
edges g.c.	2,598	2,931	2,800	2,633	2,387	2,343	2,309	2,303	2,490	2,779
density g.c.	0.00066	0.00060	0.00059	0.00059	0.00062	0.00061	0.00061	0.00060	0.00056	0.00053
mean degree g.c.	3.69	3.73	3.61	3.52	3.44	3.39	3.36	3.34	3.34	3.42
clustering	0.1441	0.1416	0.1304	0.1184	0.1130	0.1082	0.1037	0.0985	0.1000	0.1023
avg. clust. loc.	0.3192	0.3334	0.3241	0.3264	0.3032	0.2840	0.2806	0.2690	0.2628	0.2698
max degree	27	27	25	25	26	24	27	26	23	22

Table 1: Network statistics

The table shows annual statistics for the board members (top part), the board networks created by board members (middle part), and the giant component of the board network (bottom part). The networks become slightly less dense and less clustered over time. The number of companies and executives is slightly decreasing in the years after the financial crisis.

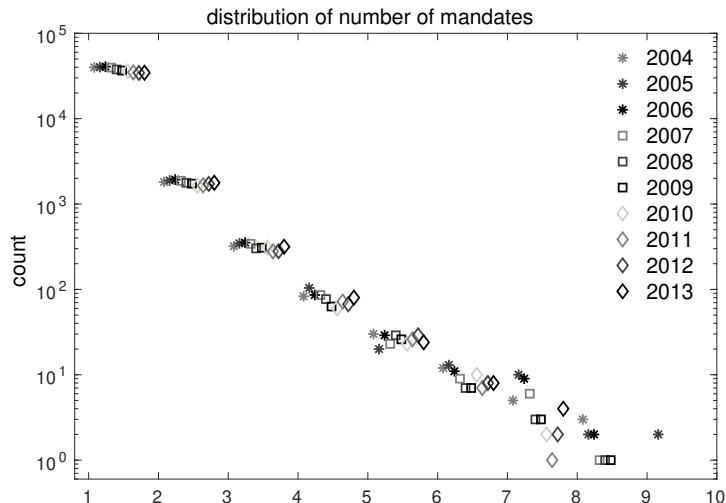


Figure 1: Mandates statistics.

We print the number of mandates with an offset and use a log-scale for the count. The tail of the distribution shows similarity to a power-law. The highest numbers of mandates are only observed until 2009.

declining from almost 12 in 2004 to 11.1 in 2013. The number of board members we observe per year lies around 40,000 (distinct: 95,192).

The middle part of table 1 shows some statistics for the unweighted board network. The mean degree and the very low density reveal that in fact most firms do not share any board member. Hence, for many investigations of the board network we will focus on those firms which form the giant connected component of this network. The statistics of this part of the board network are given in the bottom part of the table. This network is still a sparse one, yet it reveals features of a social network, for example some clustering.

All of these figures show a slight dip that falls in the period of 2006 – 2008. In this period we observe of drop of the (global) clustering coefficient, the number of firms, and the connectivity. The degree distribution of the board network roughly follows a power-law. The low range of degrees however prevent a sensible estimation, for details see figure A.8 in the appendix.

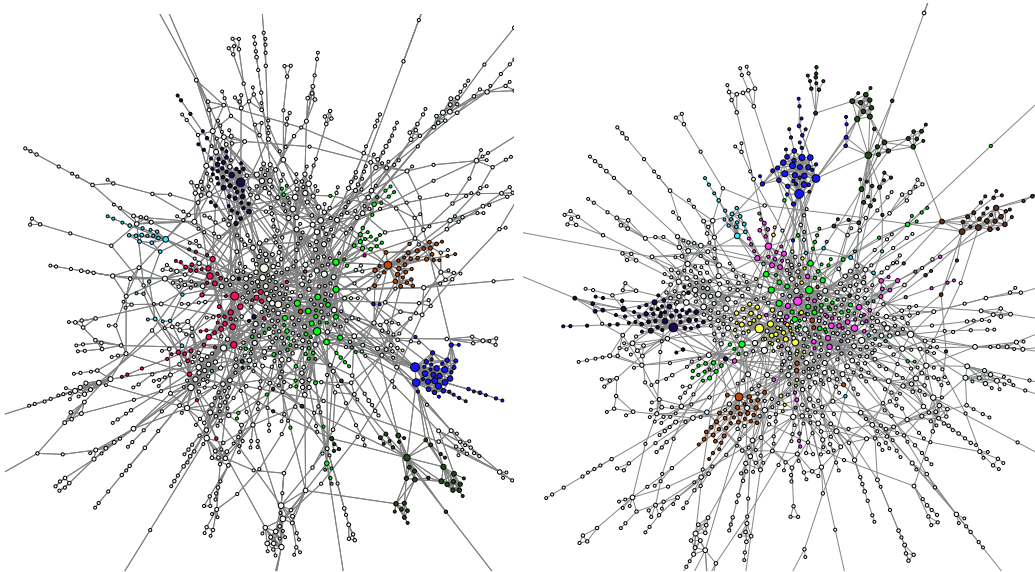


Figure 2: Board networks

Visualisation of the giant components of the board network in 2004 (left) and 2013 (right). The node size is proportional to the firm's degree. Colors represent communities. The visualization was performed in Gephi with the Force Atlas algorithm (see Jacomy et al., 2014).

The disparity between the average number of mandates and its maximum demand a short look at the distribution of the number of mandates. Figure 1 shows that this distribution is also heavy-tailed. While around 40,000 board members have 1 mandate, only around 200 have 3 mandates, and only a handful of board members find themselves with 8 or more.

2.3. Visualization

A good starting point for the analysis of any network is to look at a visualization and to check for structures that indicate pronounced deviations from random connectivity. We have already verified that the degree distribution of the board network is close to a power-law, and in fact the visualizations in figure 2 look like rather typical scale-free graphs. The center is densely connected, including some hubs, the periphery thins out and shows the typical

hair-like ends composed of degree two nodes.

The network visualizations shows some grouping, which however is not too pronounced. The details for a visualization therefore admittedly depend on the choice and parametrization of the algorithm that is used. The same holds for the identification of communities. We used the 'fast unfolding' algorithm (Blondel et al., 2008) to search for communities in the networks and have color-coded the nodes based on the results. The left panel shows the giant connected component of the board network in 2003, the right panel shows 2013. The visual impression confirms our statistics, the network in the right panel is a bit less dense, the left panel shows slightly more clustering.

We will only discuss the largest and most significant communities here and we have also omitted findings where communities are based on trivial 'holding & subsidiary' structures. All such firms appear as plain white nodes. In general the board networks have very few closed communities, even in the periphery we do have firms that provide shortcuts between groups. For example, for 2004 we can find three rather obvious communities outside the center of the network. To the top left of the center we find one group which is arranged around the company Toyota (dark purple). On the right side of the network we find a group (in blue) around Aeon. In the center of the network we find companies arranged around Fuji Kyuko (red), Hitachi (brown), and Mitsubishi (green).

In 2013 the clusters in the middle of the network overlap even more. In the right panel we still see groups around Toyota, Aeon and Hitachi a bit distanced from the center of the network. In the center we see (slightly changed) intertwined areas around Fuji Kyuko (pink), Tokyu (yellow) and Mitsubishi (green). In the periphery some weaker structures exist around Softbank and SBI (beige), Rakuten (dark green), and Pioneer and Seiko Epson (brown). For more details see also figure A.10 in the appendix.

2.4. Ownership network

Links in the board network are to some extent of course the result of business relationships between firms. An example are relationships between producers and suppliers. For studies of such networks we refer the reader to Krichene et al. (2019) and Chakraborty et al. (2018). For our purposes, the analysis of this level of connectivity would however delve too deeply into a very specific topic. However, business relationships that are more elaborate often result in some kind of shareholding or even cross-shareholding relationship. Hence, to control for influences on the board network that stem from such relations we have obtained data that reports the five largest shareholders (and their exact shareholding) for all of the firms in our sample. This might at first seem a little restrictive, yet in practice significant influence onto a company is unlikely to be performed by more than five owners. Also, since this data is reported from the point of the owned company this still results in a rather complete picture of the ownership network.

In the following we will refer to the firm networks based on ownership simply as the ownership networks. The ownership networks differs from the board networks by the fact that they are directed networks. The densities are however comparable, the ownership network in 2004 contains 2,574 directed links and we see a steady increase until 2013 when the network has 3,695 links.

The ownership network is very stable, about 90 percent of the links survive from each one year to the next. However, the overlap between links in the firm network and the ownership network is with about 10 percent relatively small, as is shown in the left panel of figure 3.

One can condition this relationship on the level of shareholding. For this reason we have binned pairs of firms with similar ownership percentage ($N = 30$) and have calculated how many of those are also linked in the

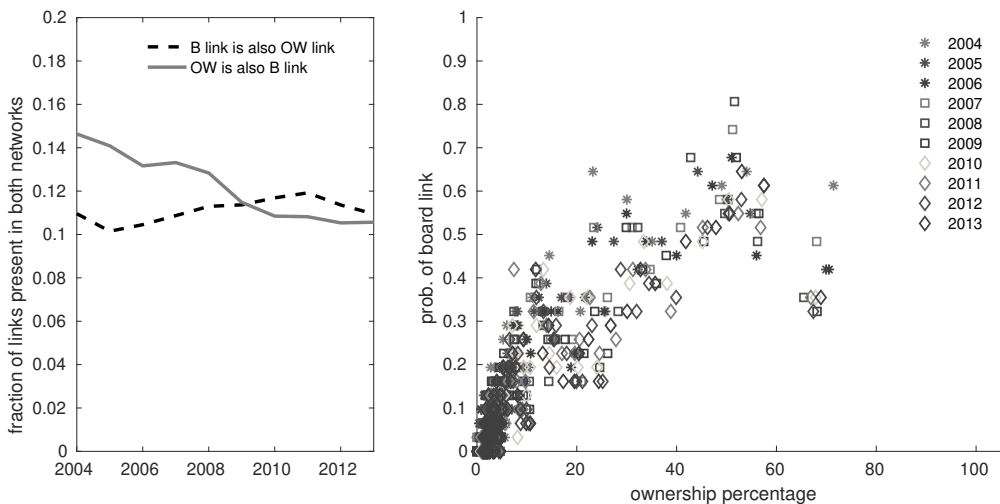


Figure 3: Ownership statistics

The left panel shows the fraction of board links for which the respective link is also present in the ownership network, vice versa. The right panel shows the relationship between the percentage of ownership of two firms and the conditional probability of having a link in the board network. The calculation is based on subsamples of 30 firms with similar ownership.

board network.² Results are shown in the right panel of figure 3. We can observe that the probability of having a board link increases with ownership and passes the unconditional probability once we reach about 10 percent ownership. Interestingly, at the high end when ownership reaches 50 percent this relationship slows down and might even slightly drop. It is likely that since this represents a majority ownership, there is less demand for control by shared board members once we reach this level of ownership.

A particular difference between the ownership and the board network is that a handful of life insurers and securities companies appear as very connected hubs in this network. Their shareholdership in a firm is normally small but their activity is very spread out. In fact much of their holdings

²For this comparison we consider an undirected version of the ownership network. In the directed version of the network about 10 % of the links are reciprocal.

are likely on behalf of their clients. Apart from this obvious observation, communities in a classical sense do not exist, and if they do they overlap. Not surprisingly large companies like Toyota, Mitsubishi, Fujitsu, Honda, Mitsui and Nippon Steel can be classified as smaller hubs. A visualization of the ownership network in 2013 can be found in figure A.11 in the appendix.

3. Dynamics of the board network

3.1. Survival of board members and firms

In the last sections we have checked for the existence of communities in the networks. Even though these are not very pronounced we have observed that certain groups in the board network that existed in 2004 still exist in a very similar form in 2013. This raises questions about the persistence of the board network and the mechanisms that make it persistent.

We start by looking at two very basic properties of firms, namely their size and centrality. First we calculate the persistence of firm's market values over time. We find that the correlation coefficients of the year-to-year market value are above 0.9 (details in the top part of table B.10 in the appendix). We further checked if this translates to a similar behavior in firms' board network centrality. We have thus calculated the eigenvector centrality of all firms that stay part of the giant component in all years and calculate the rank cross-correlations of the eigenvector centrality. The results show that there is also persistence in these figures, although weaker than for the market values. Persistence mostly fades after two years, however, the variation is high. Larger changes in centrality seem to have happened in 2009 and 2012–13. The complete results are shown in the bottom part of table B.10.

The reasons for this persistence in firm centrality can be the strategic maintenance of ties in the board network, which we will analyze later, but of course some of it also stems from firm characteristics. One would for example expect that larger firms have larger boards and are also generally

better networked. In fact we find that the rank-correlation between the eigencentality and the market value is significantly positive around 0.35.

Before we can investigate the determinants for the maintenance of ties in the board network we have to look at the general survival rates of firms and board members. For this reason we have counted how many of the firms that are present in a given year are also present in any year in the future. The firm identity in this case is determined by the existence of the stock identifier code. We observe that the unconditional survival probability of the firms in our data set is very stable and lies around 96%. Slightly lower values are only observed around 2007, which is in line with the weak GDP growth at that time (details in table B.9).

The same exercise can be done for the board members. The survival rates for them are also rather stable and vary around 83 %. Slightly lower figures are observed around 2007–08 and slightly higher values are observed towards the end of the sample period (see also table B.8 in the appendix).

3.2. Determinants of board member survival

Since we have seen that some board members have multiple mandates it is useful to investigate how the survival figures change when we condition the survival on the number of mandates that a board member has. These conditional survival probabilities are shown in figure 4. The probability for board members with one mandate differs only insignificantly of that from the entire population (83%). The likelihood to survive increases to around 93% with another mandate, further additional mandates only lead to marginal improvements. So even if directors with multiple mandates are of course more likely to survive, one can easily see that the losses of mandates are not independent.³

³We can verify this by using the probability of survival with one mandate p_1 to calculate $(1 - p_2)$, the probability that a board member with two mandates loses both of them. Assuming independence, from the probability of losing one mandate we know $(1 - p_1) = 1 - 0.83 = 0.17$ and hence $1 - p_2 = (1 - p_1)^2 = 0.0289$, which would predict a survival

year	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
MF R^2	0.0071	0.0180	0.0068	0.0101	0.0108	0.0156	0.0148	0.0162	0.0183
LR	257.7	722.0	274.7	405.0	368.9	546.3	497.5	498.9	510.9
N	42,175	42,635	43,121	41,998	39,907	38,759	37,731	36,884	36,452
survivors	35,589	34,998	35,488	34,276	33,769	32,266	31,548	31,469	31,764
const	1.9569 (32.26)	1.8349 (28.86)	1.5866 (26.46)	1.3504 (26.92)	1.8192 (32.37)	1.9528 (34.70)	2.1018 (37.29)	2.2074 (37.20)	2.4642 (36.29)
log mand $_{t-1}$	0.5069 (10.51)	0.6577 (14.02)	0.5495 (12.18)	0.6095 (12.82)	0.5903 (11.46)	0.6800 (13.20)	0.6704 (12.74)	0.7582 (12.79)	0.7959 (12.20)
age	0.0003 (1.82)	-0.0348 (-21.03)	0.0005 (4.32)	0.0002 (1.83)	-0.0185 (-10.49)	-0.0293 (-16.66)	-0.0286 (-15.85)	-0.0258 (-13.49)	-0.0286 (-13.98)
female	0.3158 (2.13)	-0.0314 (-0.25)	-0.0888 (-0.80)	0.0260 (0.22)	0.1092 (0.80)	0.4961 (3.31)	0.2913 (2.10)	0.4529 (3.03)	0.6935 (4.08)
log MV	-0.0228 (-3.87)	-0.0018 (-0.30)	0.0077 (1.35)	0.0251 (5.24)	0.0063 (1.16)	-0.0064 (-1.16)	-0.0201 (-3.64)	-0.0189 (-3.27)	-0.0287 (-4.35)
outs. board	-0.4197 (-6.64)	-0.5002 (-8.72)	-0.4112 (-7.31)	-0.5475 (-10.36)	-0.4586 (-7.96)	-0.3224 (-5.56)	-0.2243 (-3.84)	-0.4197 (-7.43)	-0.2781 (-4.64)
outs. audit	0.2885 (7.28)	0.0668 (1.92)	-0.0555 (-1.66)	0.2167 (6.19)	0.2633 (6.73)	0.0360 (0.99)	0.0209 (0.56)	0.2054 (5.03)	0.2771 (6.27)

Table 2: Determinants of board member survival

The table shows the results of a logit regression. t -values are shown in parentheses. Although survival is to a large part random, we find significant influence for holders of multiple mandates (mand), outside board members and outside auditors. The age, gender and the market value of the company (log MV) are of changing importance.

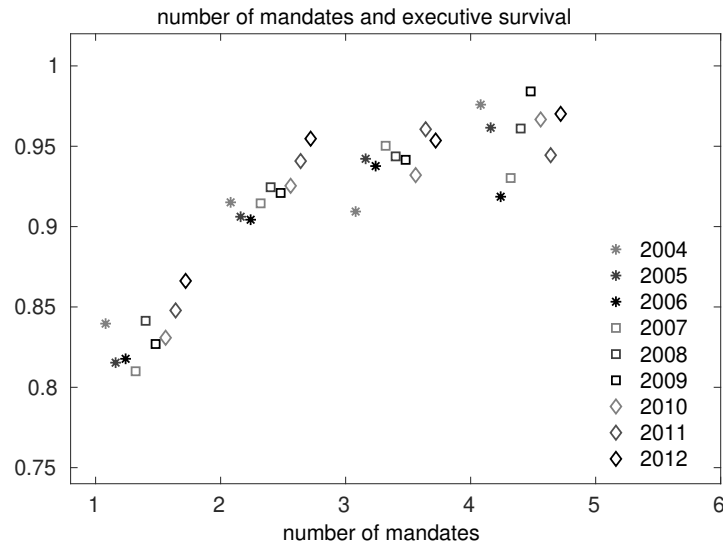


Figure 4: Influence of number of mandates on survival
The figure shows the survival of board members with 1,2,3 and 4 mandates. The results are printed with an offset for the years 2004–2012.

Based on these results about board member survival we can have a more detailed look at determinants of their destinies. Since the large number of board members prohibited us from collecting detailed information on each of their career paths we have to confine ourselves to some of their basic characteristics together with details on the firms for which they work.

We can check if the role of a board member has an influence on his survival probability. We can further check if gender or the size of the company are important aspects of director survival, while we control for the number of mandates⁴ and age. Since survival is a binary variable this demands for a logistic regression where the observed survival or death (in the sense of leaving the data set) depends on the above mentioned variables.

probability of close to 97% for managers with 2 mandates.

⁴In particular: the log of the deviation from the average number of mandates plus 1.

The results in table 2 show that the survival of directors is mostly a matter of luck and individual decisions that are in fact not captured by these variables. The number of previously held mandates is of course important but the overall exploratory power is limited still. The impact of age is mostly negative or insignificant, as expected, with exception for the years 2006/07. Only very few women are serving as board members, less than 2%, and only at the end of our sample period we see a slight tendency of higher survival. It does not matter too much if board members work at firms with high or low market values, if at all there seems to be a tendency to replace directors more often at large (highly capitalized) firms.

Rather clear however are the effects for board members who are not executives. Outside board members are being dropped with a higher likelihood throughout the sample period. This intuitively make sense since they are a more dispensable part of the board. On the other hand it is common practice to stick to an auditing company once relations are established and thus outside auditors stay on the board longer than executives. The outlier in 2006/07 for the survival of auditors is at first sight puzzling, but is in fact easily explained by the ChuoAoyama PricewaterhouseCoopers accounting scandal (Skinner and Srinivasam, 2012) that lead to a temporary increase in auditor replacement.⁵ In addition to the results presented in the table we have checked if the existence of ownership ties increases the probability of board member survival. We could not find proof of such a relationship.

3.3. Tie structure and tie maintenance

When we speak about structure in the board network one of the first questions has to be whether there are preferences with respect to the type of firms that are linked. One can ask if firms from certain sectors are more connected than others. For this reason a closer look at the 33 TOPIX sector classifications is useful. We test two important hypotheses: The first one is

⁵See also: The Economists, May 11th 2006, Auditors in Japan.

year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
MF R ²	0.0725	0.0622	0.0627	0.0661	0.0719	0.0692	0.0664	0.0652	0.0594	0.0597
AIC	33,467	38,714	37,045	34,676	31,012	30,584	30,233	30,246	33,259	37,439
N	990,528	1,233,235	1,195,831	1,116,765	961,191	955,653	941,878	951,510	1,109,305	1,319,500
links	2,598	2,931	2,800	2,633	2,387	2,343	2,309	2,303	2,490	2,779
const	-6.2579 (-246.22)	-6.3386 (-267.56)	-6.3291 (-263.01)	-6.3311 (-255.32)	-6.2965 (-240.17)	-6.3126 (-237.96)	-6.2750 (-239.68)	-6.3066 (-238.17)	-6.3491 (-255.17)	-6.4176 (-272.41)
b size	0.3000 (23.59)	0.3831 (28.27)	0.3723 (28.15)	0.3773 (27.37)	0.3894 (27.20)	0.3970 (25.48)	0.4183 (25.50)	0.4422 (26.01)	0.4229 (26.52)	0.4640 (30.39)
fin lk	0.2347 (3.97)	0.2260 (4.05)	0.1580 (2.78)	0.2530 (4.39)	0.2780 (4.62)	0.3848 (6.55)	0.2411 (3.88)	0.3183 (5.29)	0.2767 (4.65)	0.2785 (4.92)
same sec	1.5102 (29.07)	1.3711 (27.55)	1.2373 (23.60)	1.2080 (21.77)	1.2548 (21.60)	1.1996 (19.98)	1.0773 (17.40)	1.1457 (18.82)	1.0572 (17.57)	1.0341 (18.09)
owner lk	0.2304 (25.60)	0.1979 (26.30)	0.2046 (26.11)	0.1944 (26.81)	0.1994 (25.01)	0.1815 (25.99)	0.1811 (27.03)	0.1680 (27.90)	0.1538 (30.28)	0.1476 (32.72)

Table 3: Determinants of board network ties

Results of the ERGM estimation. Z-scores in parenthesis. All variables are highly significant ($p < 10^{-4}$) except fin lk in 2006. Controlling for company board size (b size) we find that corporate boards have a tendency to form links to boards of other companies when ownership ties exist or if they come from the same sector (same sec). Also links to the financial sector are overrepresented (fin lk), yet to a lesser extent.

to evaluate if firms tend to have more links to firms from the same sector. This would speak in favor of hiring board members that might bring some special expertise. The second hypothesis is that ties to the financial industry are reflected in additional ties. This would for example speak in favor of relationships of firms to a main bank who sends a board member to monitor the bank's exposure.

We have employed an exponential random graph model (Strauss and Ikeda, 1990) to estimate these effects in the giant connected component of the board network. We assume that a firm's likelihood to form ties to another firm is proportional to the product of the number of board members of the two firms. We further assume that ownership relations influence ties.⁶

In other words, our regression tests the assumption that links within the same sector and to the financial sector are over-represented against the hypotheses that links are randomly distributed between firms and that their likelihood just depends on the number of members on the respective boards and ownership relationships.⁷

Our results are shown in table 3 and basically confirm both our hypothesis. There is a slight but constant tendency of links to the financial industry and a more obvious tendency for links to firms with the same TOPIX sector code. The latter effect is declining gradually. Hence, these two effects influence the structure of ties in the board network, but the results also show that the majority of links do not depend on them (and also not on board or firm size). We further confirm that there is a slight overlap between the ownership and the board network. However, this effect is small and roughly similar to that of within-sector ties. A gradual increase of the ownership effect is observed over time. This stems partly from the increase of ties in the

⁶The board size variable is measured as the deviation from its mean divided by 100. Ownership is a percentage value.

⁷We note that we have compared our results also with those of logistic regressions and found that the results are very similar, details are presented in Appendix C.

	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
links _{t-1}	3,221	3,498	3,415	3,266	3,045	2,956	2,883	2,869	2,984
firms alive _t	3,207	3,491	3,405	3,260	3,035	2,949	2,879	2,867	2,978
links alive _t	2,499	2,569	2,530	2,519	2,373	2,272	2,281	2,343	2,487
in %	77.58	73.44	74.08	77.13	77.93	76.86	79.12	81.67	83.34
same b. member	2,376	2,423	2,398	2,401	2,259	2,176	2,184	2,250	2,399
in %	73.77	69.27	70.22	73.52	74.19	73.61	75.75	78.42	80.40
new b. member	123	146	132	118	114	96	97	93	88
in %	3.82	4.17	3.87	3.61	3.74	3.25	3.36	3.24	2.95
mand _{t-1}	2.94	2.91	2.58	2.70	3.00	2.69	2.65	2.70	2.72
former b. member	68	79	83	67	58	63	49	63	54
in %	55.28	54.11	62.88	56.78	50.88	65.63	50.52	67.74	61.36

Table 4: Persistence of board network links over time

The top part of the table summarizes how many of the links between two firms survive from one year to the next. Next we summarize how many of these links are preserved by the same board members vs. new board members. In the bottom of the table we report how many mandates those new board members held in the last year and how many of them have been part of at least one of the two companies' boards.

ownership network. One can interpret this as a signal of a slight shift from informal ties in the board network towards more formal ties that incorporate also significant shareholding.

This leads to the question where the persistence of the network structure in the board network comes from. If it were just a matter of board members with multiple mandates at highly capitalized firms then we should see higher survival rates of executives at these companies. We have however seen that this is not the case. This implies that there must be mechanism of upkeep of board network ties that go beyond the existence of central board members.

For this reason we use the same method as in Raddant et al. (2017) and compute how many links between companies are being kept from one year to the next and look into how this link is maintained if board members retire. The findings are summarized in table 3.3. We observe that only very few links are being lost because firms disappear. About 76% of the links survive from one year to the next and about 73% do so because at least one of the board members who was bridging the two boards is still there. Another 3% of links however is being kept because a new board member is replacing this function, in more than half of the cases he/she was already member of one of the boards. In any case the board member was already a central player in the board network, with typically 2-3 mandates in the year before, much more than the average. We can conclude that much of the persistence of the board network comes from the fact that board members with multiple mandates are being replaced by other board members that also hold multiple mandates.

4. The role of outside board members and multiple mandates

We have already mentioned that the composition of Japanese corporate boards still differs noticeably from other western countries. Therefore it is useful to have a look at changes in the general composition of corporate boards. This will include a closer look on the role of outside board members.

First, it is worth stressing again the still very low share of women on the boards of Japanese corporations. Table 5 shows that their number has grown significantly, though only on a very low level. Even in 2013 less than 2% of board members are women.

The average age of board members is increasing slightly from 57.2 years in 2004 to almost 59 years in 2013. Female board members are on average younger, but the gap is slowly closing.

We also see a clear trend towards having outside board members in the boardroom. The share of members who are labeled as outside board members

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
b. members	42,175	42,635	43,121	41,998	39,907	38,759	37,731	36,884	36,452	36,697
female	439	506	533	515	493	514	536	571	623	713
% female	1.04	1.19	1.24	1.23	1.24	1.33	1.42	1.55	1.71	1.94
avg. age	57.2	57.3	57.2	57.4	57.7	58.1	58.3	58.4	58.7	58.9
avg. age f.	51.3	50.9	51.6	52.0	52.3	52.8	52.9	53.3	53.8	54.1
outside b.m.	1,823	2,044	2,194	2,276	2,214	2,277	2,355	2,474	2,603	3,028
mult b.m.	2,268	2,383	2,423	2,338	2,194	2,141	2,039	2,040	2,108	2,206
both	527	554	593	591	571	569	545	564	596	678
% outside	5.57	6.06	6.34	6.64	6.73	7.11	7.39	7.86	8.32	9.60
% mult	11.03	11.50	11.41	11.26	11.06	11.14	10.90	11.09	11.50	12.00

Table 5: Board composition

The first 5 rows give information about the number of female board members and the average age of board members. The next three rows give the total numbers of board members who are labeled as an outside director, have multiple mandates according to our data set, or where both applies. Rows 9 and 10 state the average percentage of outside board members and board members with multiple mandates in a corporate board.

has almost doubled to 9.6% until 2013. Additionally we can count how many board members have multiple mandates according to our data set. We note that in the majority of these cases board members are not officially reported as being outside board members, as the table also shows. Thus, the increase in the percentage of board members with multiple mandates is much lower, namely from 11% to 12%.

The increase in the number of outside board members demands a closer look. Our data set allows us to look more closely into which board rooms these additional outside members go. Therefore we perform a Poisson regression in which our dependent variable is the number of outside board members in a firm. The number of outside members should depend on the size of the board, which is also a proxy for the size of the firm (which we therefore cannot account for in isolation). We test for the influence of the composition of a firm's shareholders. The data allows to differentiate between the percentage of shares held by financial institutions, by security companies, by other corporations and held by foreign corporations (the remainder is held by individual investors).

The results are summarized in table 6. We show the results separately for each year, always with and without sector dummy variables. We calculate a pseudo R^2 value by calculating the ratio of correct predictions of the number of outside board members using the predictions rounded to integer values.

As expected, the number of outside board members varies with board size. More interestingly, the shareholder characteristics are highly significant. A high fraction of foreign shareholders increases the likelihood of having outside board members noticeably. The influence of shares held by other corporations is also significant, though slightly weaker.

These results hold when we include dummy variables for the most populated sectors according to the TOPIX classification. These variables add slightly to the explanatory power since in some sectors outside board members are still not that common. This includes firms from the sectors con-

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
N	2628	2662	2702	2706	2640	2565	2502	2459	2432	2433
ps. R ²	0.4365	0.4065	0.4049	0.4352	0.3703	0.4180	0.3765	0.4083	0.3269	0.3857
disp.	1.2323	1.2124	1.2248	1.2057	1.1699	1.1595	1.1502	1.1372	1.1352	1.1166
const	-2.0030	-1.9970	-1.9214	-1.8519	-1.8297	-1.7852	-1.7801	-1.7362	-1.5914	-1.4955
board	(-21.70)	(-16.45)	(-22.12)	(-20.80)	(-20.87)	(-15.35)	(-19.64)	(-14.17)	(-19.15)	(-13.82)
size	(14.80)	(15.01)	(16.97)	(17.03)	(18.33)	(17.28)	(17.44)	(16.66)	(14.66)	(14.18)
share	1.8339	1.8132	1.5450	1.4457	1.4656	1.3345	1.3729	1.4751	1.1078	1.1764
corp.	(13.23)	(13.19)	(11.91)	(11.83)	(11.31)	(10.69)	(10.30)	(10.00)	(8.56)	(8.01)
share	-0.3633	-0.1468	-0.5668	-0.9005	-0.5773	-0.8994	-0.5635	-0.3810	-0.0513	-0.6596
fin.	(-1.88)	(-0.73)	(-4.77)	(-2.77)	(-4.66)	(-4.61)	(-4.89)	(-2.60)	(-1.72)	(-2.04)
share	3.3419	3.3039	3.1159	2.9022	2.9972	2.8790	2.8523	2.7847	2.7229	2.7085
foreign	(19.13)	(17.58)	(15.53)	(17.43)	(16.86)	(16.33)	(16.02)	(14.91)	(14.42)	(15.22)
share	3.2552	3.1806	2.9309	4.3778	4.4931	5.3443	5.5209	4.4666	5.8376	4.4168
sec.	(6.40)	(5.74)	(5.27)	(5.50)	(5.25)	(7.02)	(5.93)	(5.65)	(5.60)	(4.53)
Constr	-0.3475	-0.4484	-0.3807	-0.4300	-0.4864	-0.6742	-0.6849	-0.7673	-0.6805	-0.5302
Food	(-0.1323)	(-3.73)	(-0.2291)	(-0.0925)	(-0.1560)	(-0.1656)	(-0.2159)	(-5.84)	(-5.55)	(-4.89)
Text.	(-0.93)	(-1.66)	(-0.73)	(-0.73)	(-1.21)	(-1.24)	(-1.12)	(-1.61)	(-0.85)	(-1.32)
	-0.0846	-0.1523	-0.3897	-0.4480	-0.2973	-0.1711	-0.2439	-0.1262	-0.1288	-0.2499
Chem	(-0.48)	(-0.85)	(-2.02)	(-2.29)	(-1.54)	(-0.94)	(-1.27)	(-0.69)	(-0.75)	(-1.48)
	-0.1866	-0.3046	-0.3379	-0.3909	-0.3673	-0.4052	-0.3944	-0.3689	-0.3622	-0.2313
Pharm	(-1.53)	(-2.60)	(-2.99)	(-3.53)	(-3.27)	(-3.67)	(-3.62)	(-3.49)	(-3.60)	(-2.53)
	0.1362	0.1523	0.2066	-0.1358	-0.0052	0.1030	0.1088	0.0897	0.2155	0.2417
Glass	(0.82)	(0.92)	(1.34)	(-0.79)	(-0.03)	(0.68)	(0.73)	(0.61)	(1.64)	(2.01)
	-0.6486	-0.6376	-0.5023	-0.4423	-0.3730	-0.4549	-0.3887	-0.4084	-0.3970	-0.3064
IronS	(-2.69)	(-2.85)	(-2.39)	(-2.22)	(-1.93)	(-2.32)	(-2.04)	(-2.15)	(-2.19)	(-1.91)
	-0.1808	-0.3710	-0.2794	-0.4186	-0.4541	-0.4739	-0.4716	-0.5690	-0.5287	-0.4725
MetalP	(-0.98)	(-2.00)	(-1.68)	(-2.48)	(-2.63)	(-2.76)	(-2.79)	(-3.12)	(-2.91)	(-2.79)
	-0.3943	-0.4230	-0.3475	-0.4955	-0.4117	-0.4965	-0.4420	-0.4424	-0.5553	-0.4696
Mach	(2.08)	(-2.31)	(-1.98)	(-2.73)	(-2.27)	(-2.75)	(-2.48)	(-2.57)	(-3.17)	(-2.97)
	-0.3121	-0.4820	-0.5866	-0.5521	-0.4893	-0.4891	-0.3767	-0.3935	-0.3301	-0.3230
ElAppl	(-2.49)	(-3.91)	(-4.79)	(-4.83)	(-4.34)	(-4.45)	(-3.53)	(-3.72)	(-3.32)	(-3.47)
	0.1089	0.0440	0.0135	-0.0822	-0.1141	-0.1554	-0.1584	-0.1600	-0.1514	-0.0753
TransE	(1.08)	(0.47)	(0.15)	(-0.91)	(-1.23)	(-1.70)	(-1.71)	(-1.79)	(-1.76)	(-0.94)
	-0.9209	-1.0968	-1.1406	-1.2784	-1.2238	-1.1965	-1.0749	-0.9154	-0.8376	-0.6338
OtherP	(-5.39)	(-6.26)	(-6.45)	(-7.15)	(-6.92)	(-7.02)	(-6.57)	(-6.03)	(-5.87)	(-5.05)
	-0.2901	-0.4637	-0.3847	-0.4441	-0.3884	-0.4093	-0.3895	-0.3816	-0.3546	-0.2091
LTrans	(-1.68)	(-2.70)	(-2.38)	(-2.83)	(-2.50)	(-2.60)	(-2.45)	(-2.45)	(-2.39)	(-1.59)
	0.3364	0.2389	0.1876	0.1395	0.1050	0.0635	-0.0043	-0.0298	-0.0297	0.0264
WHT	(2.41)	(1.74)	(1.36)	(1.04)	(0.76)	(0.47)	(0.27)	(0.22)	(0.23)	(0.22)
	-0.0738	-0.0112	-0.0730	-0.2156	-0.1604	-0.2620	-0.2531	-0.1622	-0.2210	-0.2481
IT	(-0.35)	(-0.06)	(-0.38)	(-1.13)	(-0.85)	(-1.37)	(-1.35)	(-0.90)	(-0.90)	(-1.46)
	0.4020	0.3953	0.2163	0.2244	0.2599	0.2779	0.3634	0.3435	0.3386	0.2675
WTrade	(4.03)	(4.35)	(2.37)	(2.53)	(2.90)	(3.16)	(4.16)	(4.03)	(4.03)	(3.31)
	-0.0898	-0.1941	-0.2055	-0.2429	-0.2195	-0.3371	-0.3817	-0.2997	-0.3310	-0.2602
RTrade	(-0.83)	(-1.88)	(-2.04)	(-2.46)	(-2.20)	(-3.36)	(-3.76)	(-3.08)	(-3.51)	(-3.00)
	-0.2243	-0.1832	-0.1353	-0.2379	-0.1236	-0.1934	-0.1878	-0.1140	-0.2564	-0.1849
Banks	(-1.54)	(-1.39)	(-1.08)	(-1.91)	(-1.04)	(-1.57)	(-1.56)	(-1.00)	(-2.18)	(-1.74)
	-0.4943	-0.4512	-0.3829	-0.3546	-0.2992	-0.3233	-0.3371	-0.2366	-0.2374	-0.1218
RealE	(-3.12)	(-2.93)	(-2.72)	(-2.69)	(-2.25)	(-2.40)	(-2.58)	(-1.92)	(-2.05)	(-1.18)
	0.2593	0.0012	0.0030	-0.2810	-0.2653	-0.2113	-0.0956	-0.0600	-0.0348	-0.0526
Services	(1.65)	(0.01)	(0.02)	(-1.86)	(-1.72)	(-1.46)	(-0.67)	(-0.41)	(-0.25)	(-0.39)
	0.1287	0.1087	0.0967	0.0598	0.1404	0.1359	0.0884	0.0884	0.0693	0.0693
	(1.10)	(1.00)	(0.92)	(0.60)	(1.39)	(1.12)	(1.36)	(0.89)	(0.91)	(0.76)

Table 6: Poisson regression results for the number of outside directors of a firm

The Poisson regression explains the number of outside directors of a firm by the ratio of shares held by other corporations, shares held by financial institutions, shares held by foreign investors and shares held by security houses. We control for the firms's board size. For each year we estimate this model and with and without additional controls for the (most populated) sectors based on the TOPIX classification in the odd and even columns. *t*-values are shown in parenthesis.

struction, glass, machinery, transportation equipment and (for most of the time) banks. On the other side of the spectrum we find the IT industry, which for the entire sample period employs significantly more outside board members than the average.

5. Networks and firm profitability

5.1. Firm growth and connectivity

Over the ten years that our sample covers some firms have, as discussed earlier, ceased to exist. Many others have seen profound changes in their business models or have for other reasons gained or lost in influence and size. As a starting point we will therefore follow the 1,798 firms that have survived and for which consistent data is available on their performance. We have calculated the percentage growth in total assets over the course of the 10 years and have grouped the firms into the top 25%, middle 50 % and bottom 25 % according to this criterion.

In figure 5 we show how these different groups develop. We observe that the firms from the weakest performing group do not only loose in terms of total assets but that these firms also loose connections in the board network and the ownership network (top left and bottom right panel). The top 25% on the other side have a high connectivity in both networks which is further growing, partially by hiring more outside board members and other board members with multiple mandates.⁸

Arguably, some of these developments are natural consequences of the growth and shrinkage of firms (for more details see also figure D.13 in the appendix, which shows the relationship of connectivity with other firm characteristics). The fact however that the worst performing 25% of firms had a connectivity above average in the board network and the ownership network

⁸Twelve firms which showed abnormal changes in total assets, mainly due to mergers and acquisitions, have been removed from this analysis.

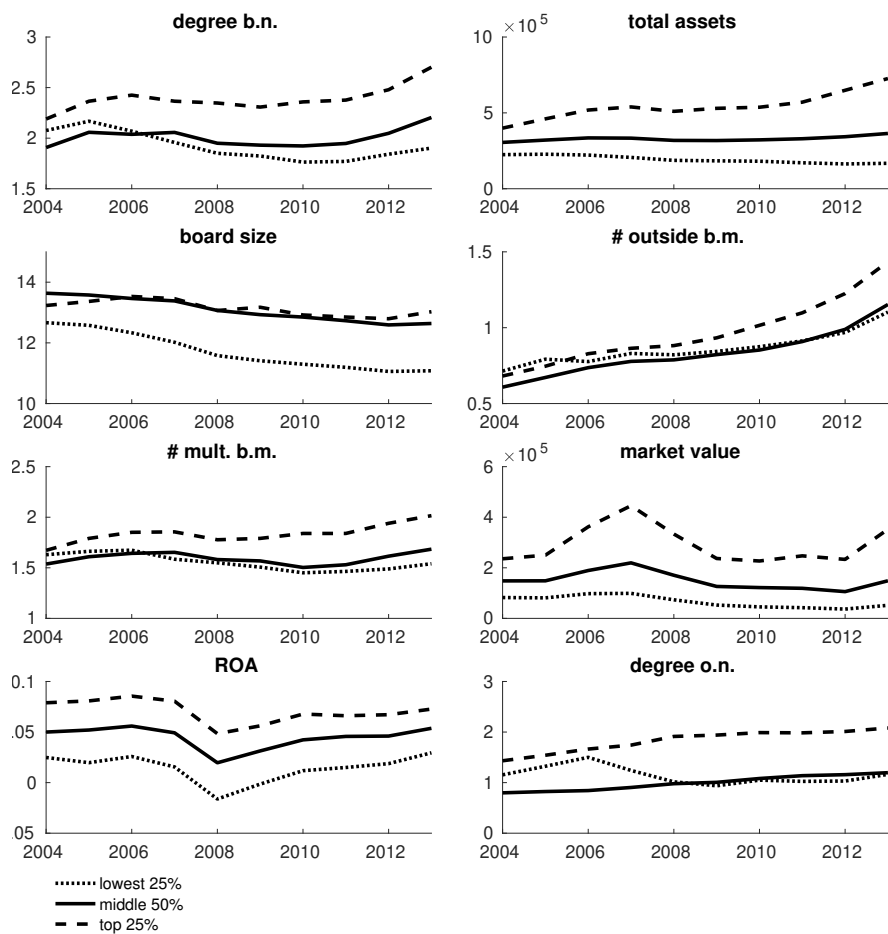


Figure 5: Firm growth over time

The figure shows how the top 25% of firms with the highest total asset growth have developed compared to the lowest 25% and the rest. The figures show that firms that shrink (lowest growth) also lose connections in the board network and ownership network. Firms that grow gain interorganizational ties and gain more outside board members.

in 2004, which then successively dropped, suggests that some conditional feedback might exist from connectivity to profitability and growth. It looks like those firms who performed worst lost more ties during the financial crisis than everybody else. This suggests that not the amount of ties but their quality is related to growth and profitability.

5.2. Determinants of profitability

The structure of the top layer management of a corporation and how it is connected with the management of other corporations has implications for the long run success of a company. Executives or other board members who can bring in experience from outside the company can be very valuable to navigate economic downturns or restructuring processes. On the other hand, board members who serve as a mere transmission channel for the needs of affiliated companies can slow down the effective management of a company. Similar effects occur in the case of ownership or equity ties between corporations. Connected firms can profit from these connections if they supports a chain of value generating activities that would be hard to achieve without them. When ties exist for the mere sake of diversification of business activities the effects are often ambiguous. In the case of Japan corporate ties however have a special history. Firm conglomerates, often referred to as *keiretsu*, used to have a huge influence on the economic system until the middle of the 20th century. Traces of it are still visible today, even if many argue that the economic downturn of the 1990s dissolved most of them.

Studies on the long-run success of these conglomerates find that these structures go at hand with within-group interventions and risk sharing. A process that in total has been found to significantly lower the return on assets of conglomerate members. We will follow up on this issue and analyze if there are effects from firm connectivity on profitability by using variables from the board and ownership network together with some control variables. Similar to the work by Lincoln and Gerlach (2004) we measure profitability by the

return on assets (ROA) and we use the total assets and the ratio of loans to total assets as controls.⁹ Data on this key financials are not consistently available for all the firms in our sample. This limits the subsample for this part of the analysis to around 2,000 in each year.¹⁰

Since the number of potential variables that describe network relationships, centrality, local connectivity or clustering is almost endless, we choose to break this analysis into two steps. First we employ a simple machine learning algorithm that we feed with data of many potential variables. From this process we learn which variables seem to have an impact on the ROA. It also helps to identify variables that might interact. In both these cases, the results from the machine learning algorithm can then be used to construct dummy variables which significance can later be analyzed within a regression analysis.

We found that a regression tree model delivers satisfactory results for our aim. The output of this model consists in a regression tree, a hierarchical structure where at each branch the data set is split into two parts depending on the value or state of the most important variable. An example of such a tree is shown in figure D.12 in the appendix. We have run the tree model separately for all the ten years of our data set and we have evaluated which variables, thresholds of variables, and combinations of variables repeatedly appear in the regression trees for all the ten years. We have supported this by calculating the importance scores for all the variables for all ten years. These results are shown in figure 6.

We have tested the following variables: log total assets, loans to total assets, number of outside directors, log eigencentrality in board network, sector dummies, log eigencentrality in ownership network, log eigencentral-

⁹We found that the ROA is the variable that works best for a large sample comprised of firms from different sectors, including variables like sales into our model would necessitate either a much more complex model or a drastically reduced sample size.

¹⁰We omit firms from the analysis which report a ROA that is outside the range $-20\% < ROA < 25\%$ since such results are typically not the result of continuing business activity.

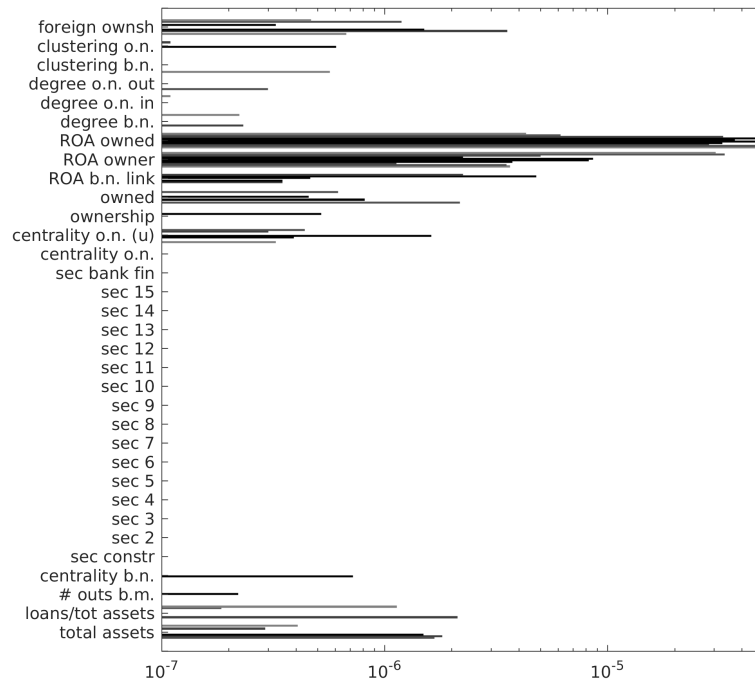


Figure 6: Importance of variables in regression tree

The figure shows the importance scores of all our variables for all 10 years in a combined bar plot and on a log scale. Variables that are not used at any node in the regression tree will have a score of zero, while the score of other variables depends on the relative improvement to describe the data when the variable is used as either a primary or surrogate splitter.

ity in undirected ownership network, total ownership of other companies, fraction of company owner by other companies, average ROA of company linked to in board network, ROA of largest owner (min 3.8% ownership), average ROA of companies owned (min 2% ownership), degree in board network, in- and out-degree in ownership network, local clustering in board and ownership network, and foreign share ownership.

From this analysis we learn that the ROA of owned firms as well as the ROA of the main owner have most influence on the firms' ROAs. The regression trees show us in fact even more, namely that these two variables often appear as two successive branches in the tree with predicted ROAs significantly different from the mean when both, the ROA of the owner as well as the average ROA of owned firms are greater than 3.5 percent. Also other variables from the ownership network have some importance, namely total ownership and the total share owned by other firms as well as centrality (which are of course related). The degree itself is almost never important in any network. What is further interesting is that also the ROA of a firm which is linked by a shared board member is sometimes a significant influence.

In a second step we can now test the significance of the influence of links in the ownership and board network by estimating the determinants of ROA. Since only some of the firms have a connection in the board and ownership network we cannot use the ROA of connected firms as a variable directly. Also, in the case of the ownership network, both directions of ownership seem to be important. Hence, we set up two dummy variables. The board link dummy is 1 if the mean of the ROA of connected firms is larger than the mean of all firms plus 0.2 times the standard deviation. The dummy for the ownership network is 1 if both, the average ROA of owners and of owned firms is larger than the mean ROA minus 0.3 times the standard deviation (resulting in a still slightly positive ROA). Hence, it signals that a firm is not sandwiched in between badly performing owner and similarly bad performing partly owned firms. We further test for the influence of the position of a

firm in the ownership network by adding the variable *total ownership* which describes the cumulative percentage shares held by other companies in the ownership network, and *degree/total assets* the number of companies of which a firm holds shares of divided by total assets. These specifications are chosen to make sure that these two variables do not correlate with *total assets* but give a measure of ownership relative to the size of a firm.

We now estimate three versions of this model.¹¹ The first version uses only the just mentioned variables without any further differentiation for sectors or years. Since the threshold for our ownership and board link ROA variables depend on the yearly averages of the ROA, a pooling for all 10 years should in principle be possible. The results for this model are shown in the left column of table 7. Since the financial crisis of 2008 has probably led to more than just minor fluctuations it makes of course sense to employ individual constants for each year. As we can see, this does not change the estimation results much, yet it improves the explained variance quite a bit. Finally we can add variables to classify the most populated Topix sectors. This should help to explain differences in ROA which are caused by differences in the asset base due to industry specific needs. We use 12 dummy variables for the sectors, yet in the table we only show the most important ones. We note that the financial sector is a merged category that contains banks, insurances, and firms offering other financial services.

Interestingly our analysis shows that ownership relations generally lead to slightly (yet significantly) lower ROAs. There are however two exceptions from this. Positive effects can be found when both the owner and the (partly) owned firms are profitable (signaled by the variable ROA owner net). Significantly positive effects can also be found from links in the board network (ROA board net), if connected firms have above average profitability.¹²

¹¹We note that the distributional properties of the data require a robust regression. This means that all our assessments of significance are based on t-distributed errors.

¹²As a robustness check we have performed the same regression on a yearly basis and

model	simple pooled	year dummy	year and sector
R^2	0.0464	0.0794	0.1107
N	20,942	20,942	20,942
const	0.05467 (10.56)		
const 1–10		•	•
total assets	0.00077 (1.58)	0.00058 (1.22)	0.00150 (2.97)
loans/tot assets	-0.08289 (-10.89)	-0.07927 (-10.58)	-0.08662 (-11.04)
tot owned	-0.00166 (-7.41)	-0.00168 (-7.63)	-0.00132 (-5.92)
degree/tot assets	-0.05415 (-2.00)	-0.04806 (-1.80)	-0.06166 (-2.31)
ROA owner net	0.01647 (4.32)	0.01696 (4.52)	0.01502 (4.06)
ROA board net	0.00820 (4.14)	0.00816 (4.19)	0.00695 (3.61)
sec constr			-0.01773 (-4.93)
sec chem			-0.00047 (-0.88)
sec machinery			0.00317 (0.34)
sec elec appl			-0.00674 (-2.20)
sec bank finance			-0.02019 (-3.23)
sec IT comm			0.01848 (5.49)
sec pharma			0.02718 (4.55)
sec 7–16			•

Table 7: Determinants of ROA

The table shows the estimation results for three different models of influences on the return on assets. The simplest model in the left column only considers the main variables. The model in the middle column considers a dummy variable for each year. The model in the right columns considers a year dummy and 16 dummies for sectors, of which the results for the seven most important ones are given. t -statistics based on t -distributed errors are given in parenthesis.

At last, the results on the effects of ownership deserve a closer look. We want to investigate if instead of referencing to connected firms' ROA structural features could be responsible for our results.

First of all, one could argue that in some cases we might see effects from minority shareholder relationships. Some authors claim that minority shareholders can be disadvantaged against controlling shareholder who enjoys private access. This can impact firm valuation and profitability (see, e.g. Guedes and Loureiro, 2006; Claessens et al., 2002).

Second, our general result on negative effects from ownership relations is in fact in line with many studies on diversification. Although diversification as an instrument of risk management is often successful, many studies show that corporations which invest into companies that operate outside of their own area of expertise are likely to negatively influence their own profitability (see, e.g. Berger and Ofek, 1995; Schommer et al., 2019; Kawakami, 2017).

In order to judge if any of these effects are related to our findings we will look at subsamples of companies from the five most populated sectors, namely construction, chemicals, machinery, electrical appliances and IT and communications. We will compare firms with regard to the above mentioned effects based on their ROA, which we normalize by the yearly group averages.

The results are presented in figure 7. We show box plots for three different comparisons for firms from five different sectors. The top panel shows the differences in the normalized ROA for our good ownership dummy variable as defined in our regression analysis and serves as a reference point. The averages of the bar plots labeled as 'no' and 'yes' are almost always signif-

found similar results, although the *ROA* variables were not significant in all years. We have also left out the control variables total assets and loans/TA, this changes the results for the sector dummies but leaves other results qualitatively unchanged. Including further network measures does not improve the model and can lead to problems in the estimation since these variables tend to be related to the existing measures of degree. We note that foreign share ownership is correlated with total assets and also partly explained by the sector dummies and can thus not be included into this estimation.

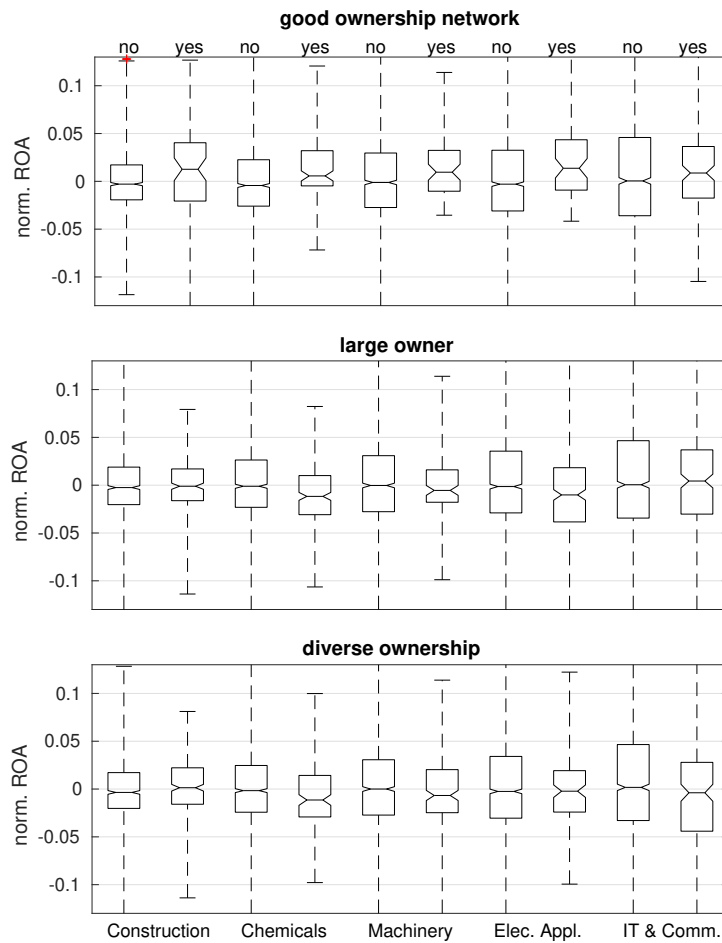


Figure 7: Influences of ownership structures

The figure shows the differences in normalized ROA for firms from five large sectors and for three comparisons. The top panel compares firms with a 'bad' versus a 'good' ownership network. The middle panel compares firms with and without a large owner with at least 20 percent shareholdership. The bottom panel compares firms that have diversified through ownership of a company in another sector versus firms which do not diversity.

icantly different, thus confirming that the results of our regression analysis can in principal be confirmed without further control variables.

We can now look at differences in between the same firms that might be caused by minority shareholdings. The middle panel show a comparison where the firms are now grouped by the criterion whether they have an owner that controls at least 20 percent of the company. The results for this comparison are ambiguous. Firms from the sectors chemicals and electrical appliances do in fact have a significantly lower normalized ROA when they have a large owner, for firms from other sectors this effect cannot be confirmed.

Finally we group the firms by asking whether they own at least one percent of some other firm that is active in a sector different from their own. This aims at checking effects from diversification. At a first glance the results, presented on the bottom panel, appear unsystematic. For some sectors the difference is positive, for others negative. However, a pattern can be found once we go back to the sector-based dummy variables from our regression analysis in table 7. In those sectors where the average ROA is above or similar to the economy average (chemicals, machinery, IT) the average normalized ROA is lower for corporations which diversify to other sectors. For the two sectors where the average ROA is below economy average (construction, electrical appliances) diversifying into other sectors yields a slightly higher normalized ROA. These results are admittedly not in all cases significant, yet they show an interesting tendency. The benefits of diversification might depend on what the heritage of a corporation is and whether they can in the long run divert funding into activities in more lucrative fields.

Coming back to the question if our previous regression results are related to minority shareholding or diversification effects, we can conclude that these effects are in fact not closely related. Network effects on profitability exist in both, the ownership network and through corporate board interlocks.

6. Conclusions

In this study we have shown that the Japanese board network is still revealing traces of conglomerates of companies. It would not be adequate to compare these structures to the *keiretsu* structures of the past, but these clusters are more pronounced compared to studies of the respective US, German or Italian networks.

The board-to-board linkages show a high level of persistence. When board members leave boards that they have connected they are very often replaced with other executives of high connectivity. This explains most of the persistence of the firm network structure and firm centrality, even though we observe that the year-to-year firm survival rate is much higher than the survival rate of individual directors.

Throughout the sample period we observe an increase in the number of outside directors. While the maximum number of mandates of a board member decreases, this development goes at hand with a slight increase in the average number of mandates (and the share of board members with multiple mandates). The trend towards outside directors is more pronounced for companies with a high ratio of foreign share ownership. This might speak in favor of a mild influence of governance practices from overseas. The sector-based differences also point into the direction that traditional and more locally operating industries fall behind this trend, while the more open IT industry is at the forefront of this development.

For the economic effect of interorganizational networks we find mixed results. Firms that are organized in conglomerate-like structures tendentially have lower ROAs. This effect can be reversed if ties to above average profitable firms exist in either the board or ownership network.

Further research is needed on these effects of interorganizational ties. This however necessitates more fine-grain information on financial ties, including information on the main bank and borrowing relationships. More research is also needed on the dynamics of the corporate board composition, especially

the hiring of female board members.

Acknowledgments

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Appendix A. Board and ownership network

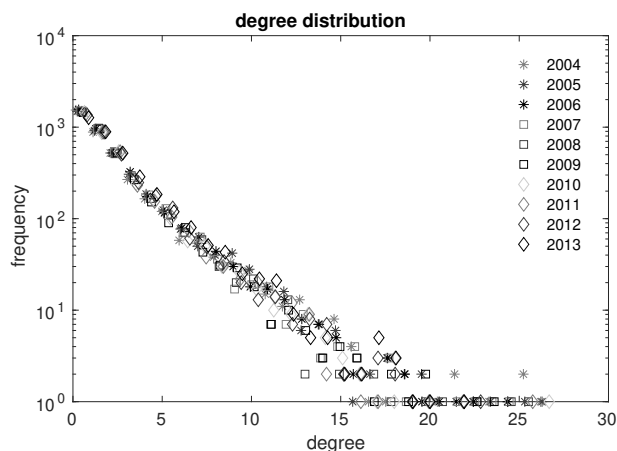


Figure A.8: Board network degree distributions

The figure shows that the degree distributions (plotted on semi-log scale) show similarity to a power-law.

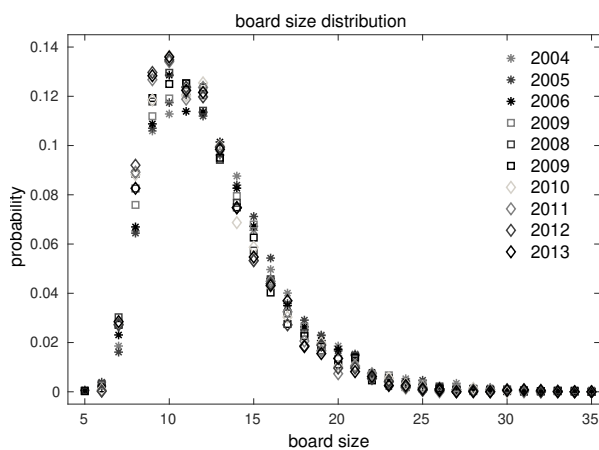


Figure A.9: Distributions of board size

The distribution of the board size shows only little variation over time. Since the board size is mostly determined by company size it shows a tail which for $x > 15$ shows similarity to a power-law.

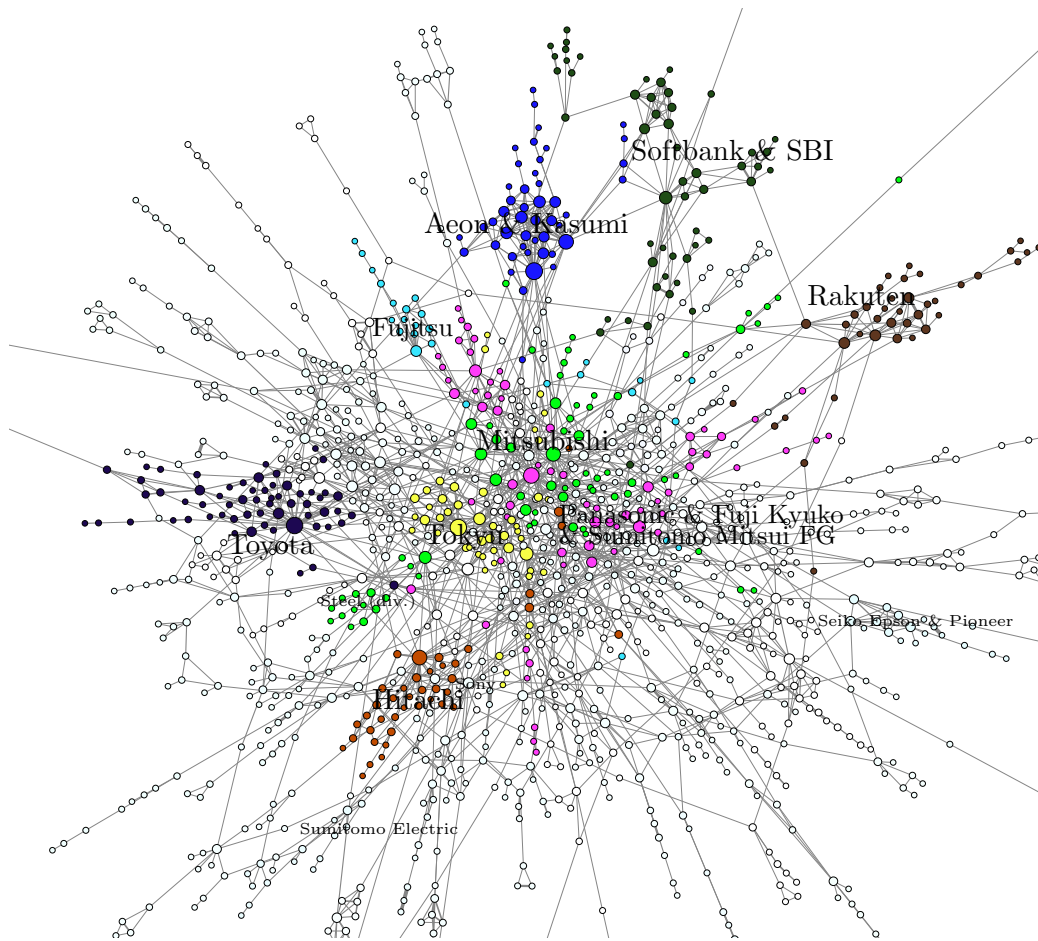


Figure A.10: Detailed board network in 2013

The largest communities are color coded and labeled according to the most connected companies. In general the firm network has very few closed communities, even in the periphery we do have firms that provide shortcuts between them.

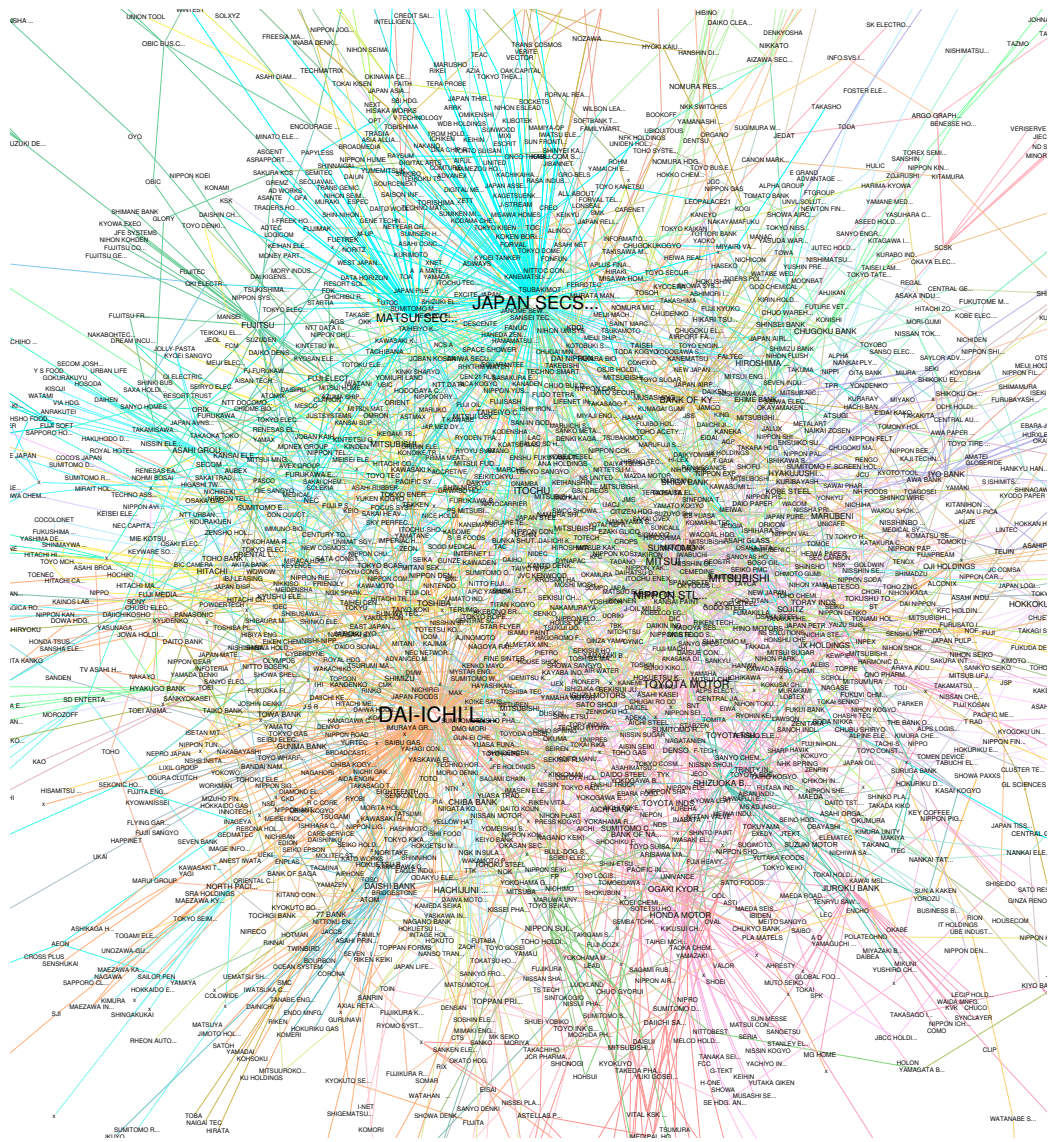


Figure A.11: Ownership network in 2013

This visualization shows the ownership network. The label size is proportional to the number of links. Color coding has been used to highlight the (overlapping and weak) community structures.

Appendix B. Firms and board members

	$t+1$	$t+2$	$t+3$	$t+4$	$t+5$	$t+6$	$t+7$	$t+8$	$t+9$
2004	0.8438	0.6855	0.5588	0.4508	0.3840	0.3175	0.2659	0.2263	0.1989
2005	0.8209	0.6685	0.5402	0.4542	0.3774	0.3155	0.2697	0.2345	
2006	0.8230	0.6665	0.5615	0.4601	0.3854	0.3282	0.2858		
2007	0.8161	0.6862	0.5665	0.4669	0.3976	0.3448			
2008	0.8462	0.6987	0.5779	0.4866	0.4230				
2009	0.8325	0.6886	0.5807	0.4997					
2010	0.8361	0.7065	0.6109						
2011	0.8532	0.7395							
2012	0.8714								

Table B.8: Board member survival

The table shows the survival probability of board members from one year to every other year based on the information in the Toyo Keizai database and our identification method described in section 2.1.

	$t+1$	$t+2$	$t+3$	$t+4$	$t+5$	$t+6$	$t+7$	$t+8$	$t+9$
2004	0.9750	0.9517	0.9180	0.8792	0.8482	0.8219	0.8004	0.7847	0.7730
2005	0.9771	0.9423	0.9000	0.8683	0.8410	0.8194	0.8030	0.7906	
2006	0.9650	0.9226	0.8907	0.8620	0.8385	0.8212	0.8088		
2007	0.9563	0.9233	0.8943	0.8691	0.8508	0.8377			
2008	0.9660	0.9360	0.9092	0.8898	0.8760				
2009	0.9692	0.9417	0.9218	0.9067					
2010	0.9716	0.9513	0.9355						
2011	0.9791	0.9630							
2012	0.9839								

Table B.9: Firm survival

The table shows the probability of survival for the firms from one to every other year, based on the existence of the stock identifier.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	
corr. market value	2004	1.0000	0.9780	0.9543	0.9356	0.9249	0.9226	0.9191	0.9082	0.9031	0.9053
	2005	0.9780	1.0000	0.9776	0.9598	0.9457	0.9395	0.9344	0.9257	0.9204	0.9209
	2006	0.9543	0.9776	1.0000	0.9825	0.9641	0.9534	0.9497	0.9416	0.9330	0.9330
	2007	0.9356	0.9598	0.9825	1.0000	0.9832	0.9694	0.9641	0.9560	0.9448	0.9425
	2008	0.9249	0.9457	0.9641	0.9832	1.0000	0.9847	0.9781	0.9698	0.9585	0.9514
	2009	0.9226	0.9395	0.9534	0.9694	0.9847	1.0000	0.9871	0.9757	0.9674	0.9578
	2010	0.9191	0.9344	0.9497	0.9641	0.9781	0.9871	1.0000	0.9882	0.9784	0.9669
	2011	0.9082	0.9257	0.9416	0.9560	0.9698	0.9757	0.9882	1.0000	0.9874	0.9737
	2012	0.9031	0.9204	0.9330	0.9448	0.9585	0.9674	0.9784	0.9874	1.0000	0.9841
	2013	0.9053	0.9209	0.9330	0.9425	0.9514	0.9578	0.9669	0.9737	0.9841	1.0000
corr. eigencentality	2004	1.0000	0.8721	0.5857	0.4403	0.4765	0.3823	0.5311	0.3671	0.3566	0.4801
	2005	0.8721	1.0000	0.6864	0.4955	0.5252	0.4511	0.5732	0.4486	0.3948	0.5223
	2006	0.5857	0.6864	1.0000	0.6408	0.5813	0.5708	0.5118	0.4845	0.3832	0.5264
	2007	0.4403	0.4955	0.6408	1.0000	0.7597	0.6577	0.4433	0.4359	0.4421	0.4100
	2008	0.4765	0.5252	0.5813	0.7597	1.0000	0.5915	0.4154	0.4428	0.4785	0.3768
	2009	0.3823	0.4511	0.5708	0.6577	0.5915	1.0000	0.5971	0.6248	0.4751	0.5474
	2010	0.5311	0.5732	0.5118	0.4433	0.4154	0.5971	1.0000	0.6067	0.4520	0.7441
	2011	0.3671	0.4486	0.4845	0.4359	0.4428	0.6248	0.6067	1.0000	0.4620	0.5323
	2012	0.3566	0.3948	0.3832	0.4421	0.4785	0.4751	0.4520	0.4620	1.0000	0.4361
	2013	0.4801	0.5223	0.5264	0.4100	0.3768	0.5474	0.7441	0.5323	0.4361	1.0000

Table B.10: Rank cross-correlations of firm's market value and eigenvector centrality
The upper half of the table shows the rank cross-correlation of all the 2081 firms for which data on the market value is available. The bottom part shows the rank cross-correlation of the eigenvector centrality for the 482 firms which have a positive centrality from 2004–2013.

Appendix C. Comparison of estimation techniques for tie structure

ERGM models have become increasingly popular over the recent years. While logistic models were very common at some point two main reasons lead to the development of ERGM: difficulties of ML logit models with large networks as well as possible mis-specifications for networks with interdependent effects (see, e.g., Wasserman and Pattinson, 1996). In many cases the estimation of node or link-covariates however can without problems be done with standard ML, which has the advantage that a likelihood can be calculated analytically (a fact that is maybe sometimes forgotten). It is even possible to improve on the standard logit model by employing a likelihood with penalization, which takes into account that especially in sparse networks links are actually rather rare events, see also Firth (1993) and King and Zeng (2002). This is important in cases when a variable describes a small group of data points very well, which can lead to near perfect separation in the model. The result would be inaccurately estimated errors.

As an illustration we therefore present two additional versions of logistic regressions results in the tables below (compare table 3). Although the differences between all three models are in our case negligible, we observe that the penalized ML tendentially leads to more conservative errors. For example, in 2006, when *fin lk* is less significant, this leads to a p-value of 0.00591 in the penalized ML model, but to 0.00539 in the standard ML logit as well as in the MCMC-ERGM.

year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
MC F ²	0.0725	0.0622	0.0627	0.0661	0.0719	0.0692	0.0664	0.0652	0.0594	0.0597
N	990,528	1,233,235	1,195,831	1,116,765	961,191	955,653	941,878	951,510	1,109,305	1,319,500
ones	2,598	2,931	2,800	2,633	2,387	2,343	2,309	2,303	2,490	2,779
LR	2,614	2,569	2,477	2,453	2,401	2,273	2,148	2,110	2,099	2,376
const	-6.2578 (-246.18)	-6.3386 (-267.55)	-6.3291 (-263.01)	-6.3311 (-255.32)	-6.2965 (-240.17)	-6.3126 (-237.96)	-6.2750 (-239.68)	-6.3066 (-238.17)	-6.3491 (-255.17)	-6.4176 (-272.41)
b size	0.3000 (23.59)	0.3831 (28.27)	0.3723 (28.14)	0.3773 (27.37)	0.3894 (27.20)	0.3970 (25.48)	0.4183 (25.50)	0.4422 (26.00)	0.4229 (26.52)	0.4640 (30.38)
same sec	0.2347 (3.97)	1.3711 (27.55)	1.2373 (23.60)	1.2080 (21.77)	1.2549 (21.59)	1.1996 (19.98)	1.0773 (17.40)	1.1457 (18.82)	1.0572 (17.57)	1.0341 (18.09)
fin link	1.5102 (29.07)	0.2260 (4.05)	0.1580 (2.78)	0.2530 (4.39)	0.2798 (4.62)	0.3848 (6.55)	0.2411 (3.88)	0.3183 (5.29)	0.2767 (4.65)	0.2785 (4.92)
ownersh.	0.2304 (25.60)	0.1979 (26.30)	0.2046 (26.11)	0.1944 (26.81)	0.1994 (25.01)	0.1815 (25.99)	0.1811 (27.03)	0.1680 (27.90)	0.1538 (30.28)	0.1476 (32.72)

Table C.11: Determinants of board network ties: Logistic regression. t-values in parentheses.

year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
N	990,528	1,233,235	1,195,831	1,116,765	961,191	955,653	941,878	951,510	1,109,305	1,319,500
ones	2,598	2,931	2,800	2,633	2,387	2,343	2,309	2,303	2,490	2,779
LR	2,618	2,574	2,482	2,458	2,405	2,273	2,148	2,115	2,105	2,382
const	-6.2574 (0.0254)	-6.3382 (0.0237)	-6.3288 (0.0241)	-6.3307 (0.0248)	-6.2961 (0.0262)	-6.3121 (0.0265)	-6.2745 (0.0262)	-6.3061 (0.0265)	-6.3487 (0.0249)	-6.4173 (0.0236)
b size	0.3003 (0.0127)	0.3834 (0.0135)	0.3726 (0.0132)	0.3776 (0.0138)	0.3898 (0.0143)	0.3973 (0.0156)	0.4187 (0.0164)	0.4425 (0.0170)	0.4232 (0.0159)	.4644 (0.0153)
same sec	0.2358 (0.0591)	0.2269 (0.0558)	0.1590 (0.0568)	0.2540 (0.0576)	0.2808 (0.0605)	0.3858 (0.0587)	0.2422 (0.0620)	0.3194 (0.0602)	0.2778 (0.0595)	0.2795 (0.0566)
fin link	1.5108 (0.0519)	1.3717 (0.0497)	1.2380 (0.0524)	1.2089 (0.0554)	1.2559 (0.0581)	1.2007 (0.600)	1.0786 (0.0619)	1.1470 (0.0608)	1.0584 (0.0601)	1.0352 (0.0571)
ownersh.	0.2300 (0.0090)	0.1976 (0.0075)	0.2042 (0.0078)	0.1941 (0.0072)	0.1990 (0.0080)	0.1811 (0.0070)	0.1807 (0.0067)	0.1677 (0.0060)	0.1535 (0.0051)	0.1474 (0.0045)

Table C.12: Determinants of board network ties: Logistic regression, penalized Likelihood. Standard errors in parentheses.

Appendix D. Firm profitability analysis

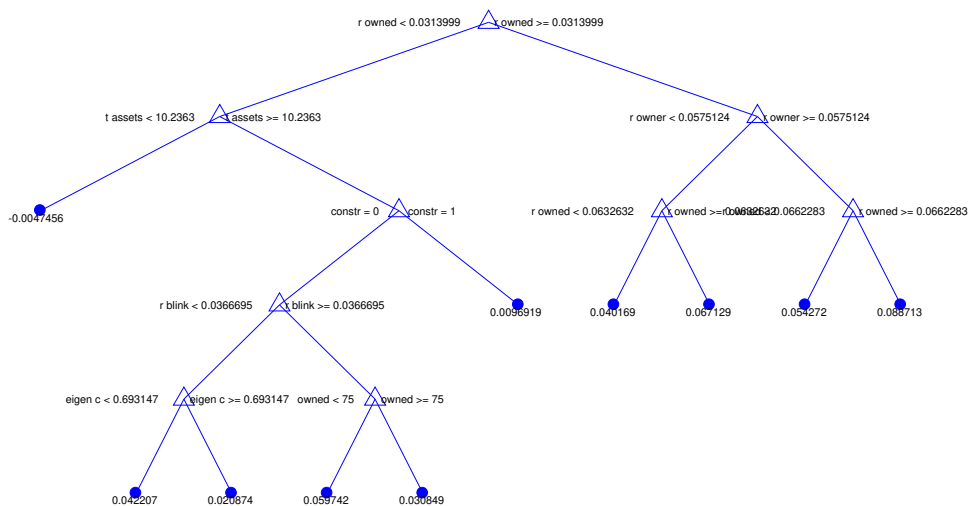


Figure D.12: Regression tree for 2010

This example shows prototypically the results of the regression tree analysis. Branches are labeled with the split variable and the split point value. End leaves show the expected resulting ROA for firms that fall into the category that is defined by the splits in the tree structure.

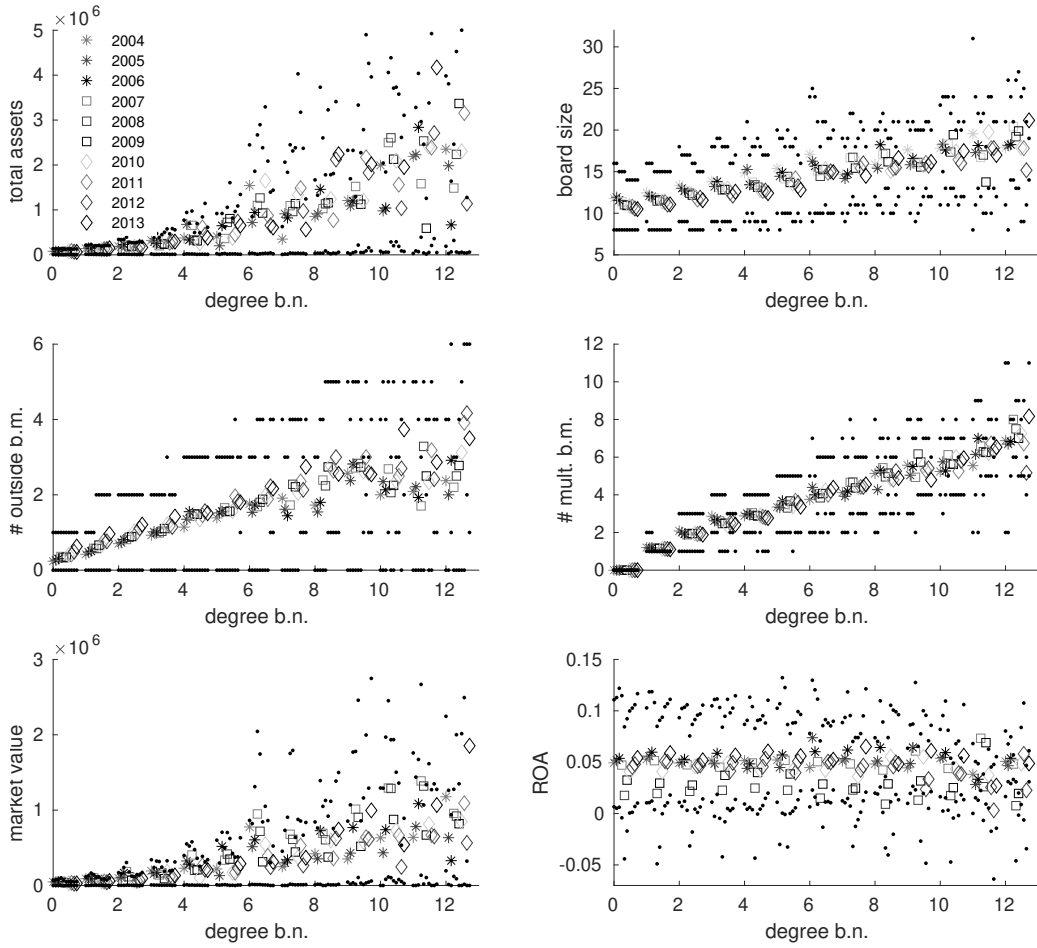


Figure D.13: Board connectivity and firm characteristics

The figure shows how different characteristics scale with the number of links in the board network. The averages for different years are printed with an offset. Black dots show the 75% interval for each year.