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Interlocking directorship networks: what is relevant for the evolution and change of the networks?

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Abstract- In addition to the instruments based on pyramiding, voting pacts, cross shareholding, it is possible to underline the deviation of the principle of one share-one vote also using interlocking directorship networks where corporate links take place. In this paper it is argued the relevance of different ways of connections among corporations. Particularly, by making use of the graph theory, it is possible to take into account the strategic allocation in a group of allied firms. Through this approach the attention moves from the "number" of graph edges to the "importance" of each individual edge. Our claim is that the different "importance" of links is captured by the concentration index that measures the asymmetric distribution of corporate links. Such an information allows us to understand the progressive elimination of edges not only with regard to the implications on the distance among firms, but also by pointing out the real solidity of the network itself. Empirical application at the sample of all listed Italian companies between 1983 and 1998, in order to consider the evolution of the interlocking directorates, is also provided.

JEL classification- C49, G32, G34

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1.**Introduction**

The corporate governance stability problem is analyzed by economic theory considering mainly the benefits linked to the dispersion of investors in terms of diversification of risk. Strictly speaking, this advantage is connected to the cost of shareholders "free-riding", which is the consequent lack of control on behalf of the corporate ownership. Inevitably, a trade-off takes place. One has to consider the fundamental question of aligning the managers interests with those of the corporate owners, motivating company directors to act in such ways which contribute to corporate wealth. Most economists reckon that the low stability of governance and the good operation of the market for corporate control can strengthen the link between personal and corporate financial health.

These findings form the main point on which is based the comparison between the main corporate governance systems of the Anglo-American and Japanese companies.

However, instruments that aim to the stability (cross shareholding, pyramiding, voting pacts, interlocking directorship) can apply to contexts, both in Italy and in a larger scale in most of the other EU countries, where management independence cannot be accepted as a valid assumption (Barca et al. 1998).

More precisely, the Italian companies "frozen control" system is different from the Japanese one, because of the presence of a strong ownership that weakens in many ways the management role. This fact is also linked with a substantial dispersion of shares due to the need of financing the firm development.

The combination of these two factors generates a difference between the shareholders cash flow rights and control rights and a substantial deviation from the principle of one share-one vote (Becht-Roell 1998).

The main consequence is an ownership-control separation that is achieved in different ways with respect to the "strong managers-weak owners" contrast. Therefore, the traditional Berle and Means separation can be paralleled to the alternative separation that originates inside the ownership. The latter involves different classes of investors and a strong monitoring of management on behalf of the block-holder of the firm.

The above opens the door to the consideration whether a strong preference for control rights of some shareholders increases indefinitely or converges, on the contrary, towards a final point. In this paper we analyze interlocking directorship as a legal device aiming to support control positions without concentration of cash flow rights.

More precisely, we have the intention to verify if the diminishing of the voting pacts in Italy[1] is connected with an increase of informal shareholders agreements that also aim to the concentration

[1] Between 1994 and 1998 the blocked capital as % of stock exchange capitalization shrinks from 2,0 to 0,9.

of voting rights. To study these informal relations we take into consideration interlocking directorship networks where corporate links take place. In other words, we are interested in the relation that takes place between two companies when the same executive is a member of the board of directors in more than one company. A person with two or more positions is a "multiple director" and generates complex chain of connections among firms. The above networks can operate in order to prevent the pressure from investors and support the private interests of the restricted control group in a single firm.

In this way it is possible to re-establish the original and formal agreements among individual shareholders when the law aims to prevent formal pacts (as in Italy since 1994 when voting pacts of listed company must be made public).

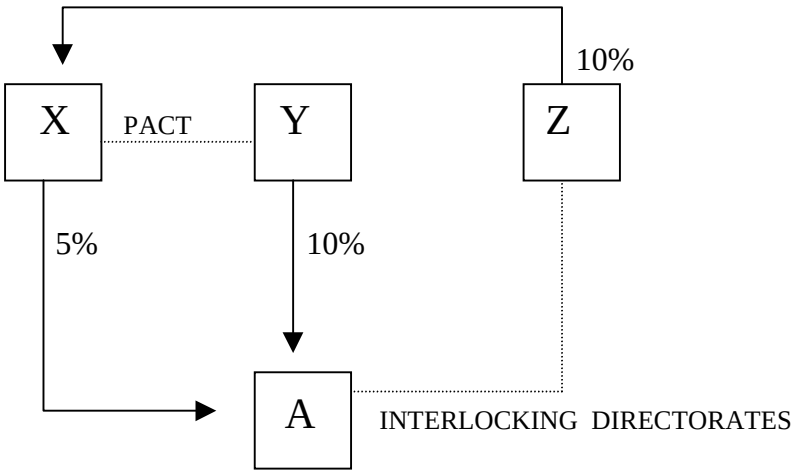
In this paper the interlocking directorship phenomenon is studied as a legal instrument in order to make the control position in a firm steadier. The purpose of our study is consistent with the analysis of Bianco-Pagnoni (1997), Ferri-Trento (1997) and, in a more general context, with those of the ECGN (1997-1998) and Barca et al. (1997).

We don't take into account the related questions of the concentration of economic power, and the diminishing of economic competition, as well as the anti-trust concerns, or issues related to industrial organization.

The paper is organized as follows. In section two we present a general description and a basic interpretation of the interlocking directorates. Section three considers the analytic framework to study the links among firms obtained through the executive multiple positions. More precisely the analysis of the links is studied through a twofold approach: quantitative and qualitative approaches. The latter is examined thoroughly in section four through a mathematical model. Section five takes into account the evolution of the networks in Italy between 1991-93 and 1995-98. Finally, section six concludes.

2. Informal agreements through interlocking directorates

The following example explains corporate networks carried out by executive multiple positions. Consider firm A controlled by firm Y (which has a stock equal to 10% of A) through a voting pact with firm X. In addition firm A shares at least one executive director with firm Z without ownership connections. Finally firm Z has some equities of X. The above process is represented in the following figure (fig.1).



(fig.1)

If the firm named X and the firm named Y choose, considering opportunity reasons, to withdraw their voting pact, it is possible to keep the link between firm X and firm Y, thanks to the role held by the firm named Z. If this process takes place, firm Y controls firm A with a voting right higher than 10%. This example makes clear why it is relevant to take into consideration corporate links, and which assumption we adopt on the meaning of "interlock". Particularly, the perspective related to the "loci of control" is emphasized.

The above example also underlines the fact that the unit of analysis is not the single firm nor the network itself, and does not even concern the executives with multiple positions. In fact, the finding unit is just the link among the different firms. These links can support a considerable stability in the corporate governance. Moreover, the links are possible independently from the holding stock in one or more than one company.

At first glance this reading of interlocking directorates makes possible an extension of the management theory of the firms which underlines the roles played by those instruments that aim to strengthen the block-holder stability. Strictly speaking, the basic topic of this extension considers the presence of a block-holder who has a strong control position without the same strength of his financial exposure.

In the case considered, as in the case where corporate links are due to ownership connections (Berglof-Perotti 1994), the phenomenon of "interlocks" is based on elements stronger than trust. In fact, a deviating behavior implies not only a future non-collaboration, but an immediate substantial weakening of the block-holder power in making relevant decisions inside the firm.

2.1 Administrative body of control in the Italian system

In the Italian system the board of directors has a unitary structure and it forms, if it is made of more than one person, a collegial body. In order to become a member of the board one doesn't need to be a shareholder of the company. The board of directors can delegate matters to one or more managing directors or to a collegial body (executive committee).

The decisions of the board should operate in the interest of the corporate health and the alignment of interests is linked to the rule of the "shareholders representation", that is the appointment of the directors is made by the shareholders assembly[2]. In the companies where there is a control coalition group each member of the group appoints one or more directors in the board and the quitting of only one director must involve a new meeting of the shareholders assembly to vote a new board.

Usually the duty of loyalty with regard to the company is based on a role of "agent" of the board (the board has to do its level best aiming the interest of the company). This feature join the trustee feature that binds each director close to the company, which is the fundamental element for a possible compensation act in view of damages caused by the duty of loyalty violation[3].

It's important to point out that the loyalty relation doesn't come to an end when the directors finish their office, but the enforcement is kept also after by the law. In fact, the law bans them from making use of inside information for the purpose of suiting private interests and from spreading out such information as well[4].

The non-respect of the duty of loyalty implies that the defaulting directors are supposed to pay compensation for damages. The commitment for trial is decided by the shareholders assembly which has to produce evidence for the prosecution.

Up to July 1998 an individual shareholder, and some groups of minority shareholders, could not prosecute directors for damages caused to a company. The corporate governance reform in 1998 established, for listed companies, a minimum threshold of 5% of a company's capital (a lower percentage is also accepted if it is specified in the corporate statute) to commit directors for trial.

An interesting point concerning the Italian companies' board regards a very strong correlation between the members of the board and the ownership of the company itself. In other words, the directors would actually represent the company's block-holders. This feature weakens the

[2] The lenght of the task can't be longer than three years but it is possible to be reelected.
[3] See Weigman, Digesto item "società per azioni", and Di Sabato (1995).
[4] See Weigman, Digesto item "società per azioni".

monitoring role of the board on management decisions and prevents possible commitment of the directors.

In addition, the supporting block-holders private interests is also possible when the board has to settle, in collegial way and with collegial responsibilities in force of the Italian civil code, the company's strategic decision. As a matter of fact, the above considered collegial principle doesn't exclude the task due from each director to monitoring the corporate going concern making inquiries and examining thoroughly important documents of the company. This implies that each director can ask the board to take measures in front of lack of information.

Particularly, a strong inspection task is due from the auditors of the company ("collegio sindacale"). They have a continuous inspection duty in checking all auditing minutes. The "collegio sindacale" is an inside administrative board elected by the shareholders assembly. The auditors (three or five members and two substitute members) must have considerable professional qualifications (they have to be registered in the auditors' roll) and are theoretically independent from directors. The whole "collegio sindacale" and each disagreeing auditor can veto the board of directors' decisions. It is most unfortunate that auditors and directors (whose conduct is the main object of checking by the auditors) are chosen by the same voters (the shareholders' assembly).

In this regard, the 1998 corporate governance reform establishes that at least one of three (or two of five) members of the "collegio sindacale" should be chosen by minority shareholders.

The above underlines the fact that the contrast between the block-holders and the minority shareholders of a company can be more or less adjusted only if the monitoring role of both administrative bodies is effective. In this regard the interlocking directorates phenomenon is relevant as it allows collusion in the board of directors or between directors and auditors in a company.

More precisely, as shown in figure 1, the understanding of corporate links caused by "multiple directors", which can be viewed as informal agreements among people with minority shareholdings in a company, is the heart of the whole matter.

3. An analysis of corporate links

In this section we take into consideration an analytic framework in order to study links among firms due to "multiple directors". These links are independent from ownership concerns, as pointed out before, they are not generated by industrial relations and they want to protect the block-holders

of the involved companies. This implies that the decision process inside a single company could not be addressed to the corporate "first best" or, briefly said, under-performance results are possible.

Particularly, we consider a formal definition of link as follows.

Let **I** be the set of all the companies involved, I = { 1,2…….M}, and D the set of all directors that have an appointment in at least one of the above firms D = { 1,2…….S}. It is also # D > # I, as # A denotes the number of elements in A.

A link between firm i and firm j is achieved, $\forall$ **i, j** $\in$ **I,** in case that the same director **h** $\in$ **D** appears in the board of both company.

The directors set D appears to be subdivided in the two separate subsets $\mathbf{D_1}$ (multiple directors) and $\mathbf{D_2}$ (normal directors). At the same time the firms set I is parted in the two subsets, separate as well, $\mathbf{I_1}$ (connected firms) and $\mathbf{I_2}$ (independent firms). The subset D originates a third set L termed the links set. From the above structure, the element of L can be defined by subsets of two firms: **{i, j}, i** $\in$ $\mathbf{I_1}$**, j** $\in$ $\mathbf{I_1}$**.**

Therefore, we consider the director belonging to $\mathbf{D_1}$ with the highest number of appointments in different boards and the firm belonging to $\mathbf{I_1}$ with the highest number of links actually achieved. It is obvious that both these values (number of appointments and number of links) are independent, as each firm has many directors in its board and each of them can originate a link.

Once taken into account the frequencies of the appointments and of the links, it becomes possible to investigate the networks. More precisely, the networks' investigation implies a twofold analysis aiming to check both quantitative and qualitative aspects of multiple directors' phenomenon.

Unfortunately, recent studies[5] have shown mainly the quantitative concern of this event and lack of attention has been addressed to the different ways in which connections among firms can be achieved. In other words, we want to underline the importance of different shapes of networks and the relevance of the tightening of the system as well.

The above analytic framework allows us to consider a matrix $\mathbf{A_{M,S}}$. Its generic element is:

$$a_{i,\,h} = \begin{cases} 1 & \text{if } h \in D \text{ is in the firm } i \in I \\ 0 & \text{otherwise} \end{cases}$$

[5] See for the Italian system Bianco-Pagnoni (1997) and Ferri-Trento (1997).

Multiplying the matrix $\mathbf{A_{M,S}}$ by the transpose matrix $\mathbf{A'_{M,S}}$ we obtain the matrix $\mathbf{F_{M,M}}$ whose generic element is $\mathbf{f_{i,j}}$.

In other terms:

$$\mathbf{A}_{M,S}\ \mathbf{A'}_{M,S} = \mathbf{F}_{M,M}$$

$$f_{ij} = \sum_{h=1}^{S} a_{ih} a_{hj}$$

where

$$a_{i,h}\ a_{h,j} = \begin{cases} 1 \text{ if the firms i and j have the same director h} \\ 0 \text{ otherwise} \end{cases}$$

The matrix F is a real, square and symmetric matrix where $\mathbf{f_{i,j}}$ denotes the number of directors who have an office in both firm i and j at the same time. Particularly, the elements of the matrix's main diagonal $\mathbf{f_{i,i}}$ denote the number of directors in D that are appointed in firm i. In case that $\mathbf{f_{i,j}}$ =2 the link between firm i and j is generated by two different directors.

Therefore, matrix F considers the links among companies taking into account the whole group of directors and allows us to count the number of linked firms, the number of links belonging to each company, the total number of links among the M firms, and the number of links that is achieved through more than one director. In addition, through matrix F we can consider the "density" of the interlocking phenomenon which is given by the ratio of the actual links to the maximum total possible links among M firms (the latter is equal to M (M-1)/2). It could be also desirable to count a collusive index (see section 5).

4. A mathematical model of links

This section concerns the importance of the qualitative aspects of firms' connections. We will focus on the application of a model giving information of the tightening of a network.

As a matter of fact, the quantitative approach considered in section 3 is a partial analysis. It takes into consideration that in a group of firms some are dependent on the supporting of “friend firms”. Unfortunately, this approach doesn’t provide any information about the strategic allocation in a group of allied firms. Strictly speaking, it would be desirable to understand if the alliances are achieved in a circular pattern, or in a pattern in which few “central firms” (at least only one “central firm”) appears.

In other words, as we can obtain different classes of connecting firms matrixes, with the same “density” value, it would not be sufficient to consider descriptive statistics giving quantitative information of the phenomenon. In fact, it is also important to deepen different ways of connections. More precisely, the number of the actual total links in a network can be viewed as one side of a coin.

The following example explains these considerations.

Let’s assume that there are six firms which, using overlapping board membership, make among them a total number of links equal to six (that imply a “density” equal to 6/15). Our question is: which is the form of matrix $\mathbf{F_{M,M}}$? Consider for example the following cases.

$$F = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 1 \\ 0 & 1 & 1 & 0 & 0 & 1 \\ 0 & 1 & 1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 \end{bmatrix} \qquad F = \begin{bmatrix} 1 & 1 & 0 & 0 & 0 & 1 \\ 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 \\ 1 & 0 & 0 & 0 & 1 & 1 \end{bmatrix}$$

(a) (b)

From the above example it is evident that if one has to analyze networks, the intensity of connection matters. It is to say that it is possible to have many different cohesion patterns with the same number of total links. In fact, case (a) shows the “centrality” of firm 6 in the network, and case (b) is about the event that each firm makes two different connections. Therefore, the strategic allocation in a group of allied firms is now considered.

The differences among firms belonging to a network in respect of their “centrality” in the network can be studied using graph theory.

A graph can be denoted by a pair (I, E) where I is the set of the points and $E \subset I^2$ is the set of the edges of the graph. The set E originates a binary, symmetric and anti-reflexive relation among the firms (Berge 1979).

More precisely the set E satisfies the following conditions:

1) $\forall$ i, j $\in$ I se (i, j) $\in$ E $\Rightarrow$ (j, i) $\in$ E

(symmetry)

2) (i, i) $\notin$ E

(anti-reflexivity)

The set E is denoted by a matrix C (real, symmetric and binary) with dimension equal to the elements belonging to the set I. Its generic element is:

$$c_{i,j} = \begin{cases} 0 & \text{if } (i, j) \notin E \\ 1 & \text{if } (i, j) \in E \end{cases}$$

The total connection of a graph is given by the number $\frac{1}{2}\sum_{i=1}^{M}\sum_{j=1}^{M} c_{ij}$ and its maximum value is equal to M(M-1)/2.

In the graph (I, E) a path with length equal to L is given by a succession of points i $\in$ I (i_1, i_2, …i_j…i_{L-1}) with each pairs (i_j, i_{j-1}) $\in$ E. We examine the number of paths with a prefixed length equal to L between two different points in the graph, e.g.: i and j. This number will be given by $c_{ij}^{(L)}$. This is the (i, j)th element of the matrix C^L where the latter is obtained multiplying by itself L times the matrix C.

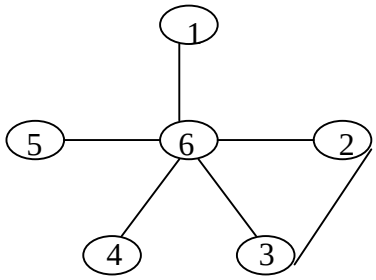
In addition, we consider the minimum path distance between two points. This minimum distance is given by dist (i, j) = min {k: $c_{ij}^{(k)} > 0$} and determines among all paths, with an origin and an end in two prefixed points in a graph, the one with the lowest number of edges.

In the case examined a path portrays a companies chain, each of them shares one or more directors with the company that follows. This issue is very important to analyze the intensity of the network. In fact, two different points in the graph can be connected through several paths and the minimum path distance forms a key concept where we focus our attention.

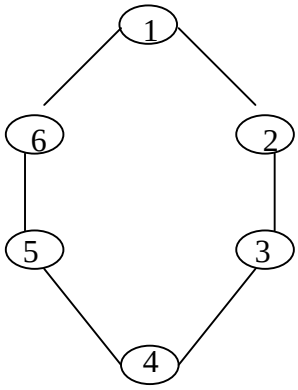
Because we can observe different cases between the two extremes of that with no connection among firms (with a minimum path distance equal to ∞) and of that with a maximum “centrality” of a single firm connected with all the others firms by only one edge (with a minimum path distance

equal to 1 for each point in the graph), it seems appropriate to have an index of centralization that keeps account of the heterogeneity of the concerned firms.

In the above example we associate to the matrixes (a) and (b) the following graphs:



(a)



(b)

The higher connection in the graph (a) is shown by a distance between each firm equal to 2 paths. This is lower than the same distance in the graph (b) (equal to 3 paths).

Moreover, in the graph (a) the firm we named 6 appears to have a key role in the network. Both of these situations represent extreme cases with a prefixed positive density of the matrix F^6.

The above issue leads to the first conclusion with regard to the partial information role of the "density" in the analysis of interlocking directorates networks and with regard to the importance of the strategic allocation of firms.

In fact, from the above graphs originate two different implications. First, the tightening of connection could decrease with the decreasing of the wish of a single firm to have a central position, or in other words, with the increase of the distance in a graph. In addition, this issue is associated with a different possibility that a single firm quits the group. In other words, the tie concerning all firms in the graph (b) is stronger (as each company makes two links instead of one). Therefore, it would become more difficult for each firm considering the detachment and a full independence.

Moreover, if we pay attention to the "corporate links contribution" that each firm supplies to the whole network, - the degree of the individual points δ (i) given by $\sum_{j=1}^{M} c_{ij}$ - we can move a step forward.

Let's consider the event that firm 6, becomes independent from the network. This would imply strong differences if we are moving in graph (a) or in graph (b). In the latter it will be not weaken the solidity of the whole network (though the distance among firms increases). The opposite will be

[6] The case (b) represents one of the possible extreme cases as we consider forward.

achieved if the situation is characterized by the network (a) because the main consequence of firm 6 independence will be associated with an almost total break of all connections. Therefore, also the concept of a different "importance" among firms belonging to a group is associated with the shape of the networks.

It is also evident that as we are studying the interlocking directorship networks with the intention of deepening the control stability of the block-holders in a firm, the factor regarding the solidity of a network seems a crucial factor. Unfortunately, some existing measures directed to assess the tightening of a graph as the diameter, are unable to capture both these factors (tightening and heterogeneous importance of the points in a graph).

In the analysis of the density found for a certain graph, one may ask the question "could this value of density be obtained in a situation very close to the one shaped in graph (a) or (b)?" Or put in more precise terms, "would this value been changed in a substantial way just with the independence of one firm?"

In order to answer this question we examine the concentration index of the links which measures the asymmetric distribution of corporate connections.

The basic idea is the following: let L be the actual number of links among M firms. These links are equitably distributed among the M firms if each firm has the ratio 1/M of the total L. More precisely each company can be considered "wealthy" according to the number of connections with the M-1 group of companies. This wealth can be distributed among the companies in several ways between two opposite cases of a perfect equal distribution and a maximum concentration.

The latter concerns the case in which only one firm has the whole amount of links and the others have only one link. In a more general situation we can say that the wealth of links is concentrated if one firm, e.g. i, owns more than the ratio 1/M of the total L and each of the others M-1 firms owns a lower number of links comparing to those of firm i.

Let I_1, I_2 …..I_M be the M firms in a non decreasing number of links order and let l_i ($l_i \geq 0$) be the amount of links owned by the firm i-th where $l_1 \leq l_2 \leq \ldots\ldots \leq l_M$. The sum $L_i = l_1 + l_2 + \ldots..+l_i$ represents the total amount of links belonging to the less wealthy firms. We can therefore count the values $P_i = I_i / I_M$ and $Q_i = L_i / L_M$.

In the event of perfect equal distribution we have: $l_1 = l_2 = \ldots\ldots = l_M \quad \Rightarrow P_i = Q_i$ ($\forall i = 1,2\ldots.M$) therefore all firms have the ratio 1/M of the total links. In the opposite case, with maximum concentration we obtain: $l_1 = l_2 = \ldots\ldots = l_{M-1} = 1$ and $l_M = L_{M-1} \quad \Rightarrow P_i = i/M$ $Q_i = L_i / L_M$ e $Q_M = 1$. Moreover,

$$P_i - Q_i = \begin{cases} 0 & \text{if } i = M \\ \alpha > 0 & \text{if } i \neq M \end{cases}$$

The general result is that more concentrated are the links, the higher is the difference $P_i – Q_i$ for $i \neq M$. Therefore, the concentration index is given by:

$$g = \frac{\sum_{i=1}^{M-1}(P_i - Q_i)}{\sum_{i=1}^{M-1} P_i} = 1 - \frac{\sum_{i=1}^{M-1} Q_i}{\sum_{i=1}^{M-1} P_i}$$

This index corresponds to the measure of the area formed by the equi-distribution line and the Lorenz curve, transferring, as we know[7], the values P_i and Q_i on the abscissa and ordinate axes respectively. These values show the concentration curve that begins in the origin, end in the point (1,1) and has junctions in the points with co-ordinates:

$$\frac{i}{M}, \frac{\sum_{j=1}^{i} l_j}{\sum_{j=1}^{M} l_j}$$

The above area increases to the concentration value, that is, under the same P_i as smaller is Q_i , and more the concentration curve becomes close to the axes of P.

Coming back to the above example, the concentration index is equal to 0.4 in the graph (a) and equal to 0[8] in the graph (b) showing in the first case a more asymmetric distribution of links among companies.

[7] See Leti (1983)

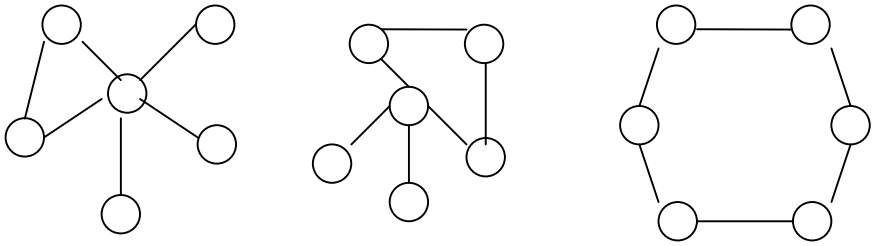
[8] In this approach the concentration index can't be equal to 1 and gets near 1 with the increasing of the number of firms. It is, however, possible divide the value of g by the corresponding value with the maximum concentration. In this way

The information concerning the distribution of links in a network is alternative to the most known overall measures of undirected graphs as the density and the diameter. In fact, a positive value of concentration index allows us to split up the total links in two different classes: “sensitive” and “insensitive” links. This is very useful when we consider how strong is the block-holder position. We can also say that through the measure of the asymmetric distribution of corporate links the attention moves from the “number” of graph edges to the “importance” of each individual edge.

More precisely, we want to focus on the fact that the elimination of particular links implies substantial consequences on the network not only regarding the distance among companies but also in terms of the whole solidity of the network.

To understand the above statement or the reason why the “importance” of the edges is a relevant information, we present the following examples that show graphs with the same “density” or “diameter” but with different values of concentration index.

Example 1: same density but different concentration



(a) (c) (b)

These graphs show a same density but have a different value of the concentration index. Particularly, the graphs of kind (a) are those that have a maximum concentration with a density equal to 6/15; the graphs of kind (b) show a minimum concentration with a density equal to 6/15 and finally the graphs of kind (c) have an intermediate concentration level of links with a density equal to 6/15.

With a set value of density less than 1 the concentration index provides information on the asymmetric distribution of links among a group of corporations. We are referring here to a “set density” because it is obvious that we can have different possible graphs with the same concentration but with different values of density.

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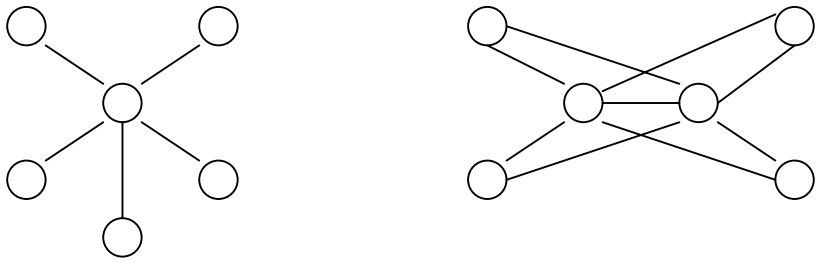
we can obtain an index varying from 0 to 1. In the extreme case in which the number of links is 0 the concentration curve is a straight line laying on the abscissae axes.

Example 2: same diameter (equal to 2) but different concentration and density



(a) (b)

A high concentration is not necessarily associated with a high connection among companies. In fact, the extreme case of a totally connected graph has a concentration index equal to 0.

It is also important to underline that a decreasing of density does not necessarily mean an increase of concentration (see the following example).

Example 3: same density, same diameter but different concentration of links

(a) (b)

This example shows that, although there is an equal connection level in the graphs, because the more distant points are connected through a path with two edges, there is also in the graph (b) an asymmetric distribution of links. The latter implies that in the graph (b) the independence of the company named 1 is linked with the independence of another company too, whereas in the graph (a) the independent process of firm 1 does not mean the same “twofold independence”.

Additionally, if we focus on the link we named “a” this link has a key role in the graph (b) because without it the whole network of the four companies would fail. We can’t come to the same conclusion in the graph (a).

Therefore, we conclude that either in terms of companies’ quitting or in terms of links’ getting looser, the second network is less solid.

From the above examples, we deduce that a decrease in number of links is not a sufficient condition for a variation of the concentration index (not an increasing or a decreasing of the index). In fact, if we consider a set number of points equal to M and a graph totally connected (concentration index equal to 0 and density equal to 1) the progressive elimination of links 1,2….M-1, will imply an increase of the concentration index and a decrease of the density.

We obtain a number of graph equal to k>1 (the value of k depends on the value of M) with the same number of edges. However, the concentration index does not have a monotonous trend related to the elimination of links, but it will come back exactly equal to 0 whenever we eliminate from each point the same number of edges. As a conclusion, the trend of the concentration index will depend on the ways we operate the elimination of the edges. If links are eliminated from each point in a symmetric way we cannot obtain a graph of the kind we exposed in the example 2 (graph a).

An asymmetric distribution of links among M firms means that there are some firms more important than others and whose links are more "sensitive" in comparison with the total actual links in the network (as shown in the example 3). It is therefore possible to split up the total links in the two classes of "sensitive links" and "non sensitive links". The first ones are defined here as the links belonging to those companies that own a number of links much higher compared to the average number of links held by all the other companies. The links' sensitivity increases to the increasing of links' concentration.

To better explain, different patterns of networks are possible not only referring to a different grade of connections among firms, but also considering the different links' "sensitivity". The latter seems to be a key feature in the analysis of the evolution of networks as we show in the next section.

Our approach has the advantage of providing an appropriate measure to establish the evolution of the connections among a group of companies taking into consideration the different possible companies strategies. In fact, the quantitative dimension of the interlocking directorates' connection opens the door to consider how a network is shaped. We claim that it seems reasonable to draw our attention not only to the tightening of the network but above all to the solidity of the network itself. Using the concentration index of links allows us to distinguish situations with the same dimension of the phenomenon. The handling of the solidity issue is one of its key virtues.

5. Empirical application to the Italian companies

In the present section we analyze the interlocking directorates phenomenon with reference to the Italian companies, using the above issues.

The data concern the board of directors and the "collegio sindacale", considering the name of each member and the relative appointment[9]. The total different appointments are named "directory appointment". A "director" who is appointed in more than one company can foster coordination among different companies. He/she can promote a simple switch of information, favoring specific decisions, up to support the control position of the respective block-holders of the companies. The latter implies a lack of market for corporate control. In case that there are only few "directors" appointed in many firms, we conclude that it will be possible a high level of "impermeability" in the whole system.

The data set is created by the total "directory appointments" in listed companies in Italy from 1983 to 1998[10]. We consider 15,219 "directory appointments". The information concerning each "director" is about the type of appointment, entry and exit time. We have examined the data with the intention to study two different periods of time. In fact, as we pointed before, we aim to study the evolution of the interlocking directorship networks because of the obligation to make public the voting pacts among different shareholders of a listed company. Therefore we consider three separate data sets corresponding to the following scheme.

Period 1

It considers the appointments appearing between 1991 and 1993 included. This means to take into account both the "directors" that are replaced in the same period of time and those that are not replaced.

Period 2

It considers the appointments appearing between 1995 and 1998 included. As in period 1 we take into account all the "directors" that are existing in the period.

Period 2a

It considers only the appointments entered after January 1995.

The above scheme does not exclude superimposition among the three data sets and it is also obvious that the third set is a subset of the second one.

The advantage of working with this framework instead of comparing the singles years 1993 and 1995 is due to the following reasons:

1) a period of three years allows us to take into account information on former links as we have considered in section 2.1. More precisely, an actual co-ordination could not be captured by an

[9] The appointments are: chairman of the board of directors, vice-chairman, managing director,director, honorary chairman of the board of directors, chairman of the "collegio sindacale", auditor, substitute auditor.

[10] More precisely up to april 1998. The data are from Consob.

analysis based on the activity of isolated years because it could be undervalued by the "previous" and "subsequent"[11] links.

2) It is also possible that adjusting to a new legal system needs a longer time than a year.

The three data sets have been filtered again in order to eliminate all banks. However, we consider IMI and Mediobanca. This filter allows us to consider only the industrial sector. As a matter of fact, the Italian banking sector has showed recently interest in substantial transformations not completely performed in the periods considered. Therefore, we limit our analysis to the industrial sector.

The above steps imply an analysis of three different matrixes of links concerning 232 companies and 855 " multiple directors" in period 1, 223 companies and 729 "multiple directors" in period 2, and 153 companies and 236 "multiple directors" in period 2a.

The evolution of the interlocks is shown in the tables 1 and 2 that describe, respectively, the phenomena of "multiple appointments" and of links among companies that are originated from the "multiple directors".

The number of "multiple directors" (compared to the all "directors") decreases in the two periods from 25.5% to 22.3% and in addition the data concerning period 2a shows that the new appointments are characterized by a low level of interlocks (13.9%) compared to those of period 2 (22.3%).

This fact makes evident that the sample of period 2a is not a good sample in order to consider the interlocks set between 1995 and 1998, independently from the entry year. In other words, the "directors" entered after 1995 look less interested to make overlapping memberships. We, therefore, conclude that basically the phenomenon of interlocking directorate decreases. It is also interesting to note that this issue appears with a higher number of companies in the sample of period 2. The average number and the concentration index concerning "multiple appointments" are almost stable in the two periods (1.7 and 0.3 respectively). The latter denote that approximately 45% of "multiple directors" own more than two appointments. The concentration of appointments, however, is much lower in period 2a showing a decreasing of the index by 20 points.

[11] The importance of "previous" and "subsequent" links in order to study co-ordination among firms is considered in the

TABLE 1 -Multiple offices-

	Period 1	Period 2	Period 2a
(1) Total directors (#)	3,349	3,267	1,700
(2) Total companies (#)	235	240	220
(3) Total offices (#)	5,586	5,160	2,228
(4) Multiple directors (#)	855	729	236
(5) Multiple directors -% (3)-	15.3	14.1	10.6
(6) Multiple directors -% (1)-	25.5	22.3	13.9
(7) Total offices -% (1)-	1.7	1.6	1.3
(8) Offices concentration index	0.3	0.3	0.1

Source: data from Consob

The network among companies is considered in table 2. The first issue is the number of companies that own links. They are equal to 98% in period 1 and 92% in period 2. There is also a decreasing trend in number of links from period 1 to period 2. In fact the value of density decreases by one point though in period 2 there is a higher number of firms. The directors appointed after 1995 generate a lower number of links (5.6%) in comparison with the number of links originates by all the directors appearing in the same period independently from time of election.

This finding is consistent with that of multiple directors in the same period as the latter can aim to originate only few links. There is a decrease also in the maximum and in the average number of connected companies (equals respectively to 55 and 16.3 in period 1 and 50 and 14.2 in period 2). Moreover, in period 1 we obtain a higher number of links generated by more than one director in comparison with the same in period 2. This could mean that in order to create a stable and strong link one director is insufficient and we can show this case in the graph approach considering different "thickness" of each edge. This feature decreases substantially in period 2a. The links originates by more than one multiple directors are equal to 30% in period 1, to 26% in period 2, and to 5% in period 2a.

We provide also another measure to investigate the network. The following index ("collusion index") considers the collusion power that is achieved by M companies belonging to a group. The index is given by:

$$\gamma = \frac{\sum_{i=1}^{M} \frac{l_i}{L_i}}{M}$$

analysis of Ferri-Trento (1997).

It is developed as a mean of the relative frequencies of links. Let M be the total number of companies each of them has a number of links equal to $l_i > 0 \quad \forall i \in I$, whereas L_i are the possible total links of each firm equal to M-1.

The index can vary from the value of 0, that means that there are no multiple directors, to 1, when it appears the maximum collusion. Table 2 shows that the collusion index decreases in period 2 and more substantially in period 2a (in period 1 the connected companies are in average equal to 7.5%). This confirms the finding concerning density.

It is also possible, referring to the above index, to consider some classes of relative frequencies, concerning connected companies, in order to study the distribution among all the classes. We find asymmetric distribution in both periods that shows a higher percentage of connected firms in period 1. The class with a higher frequency is, in fact, the one which has a number of connected companies between 0.05 and 0.10, whereas either in period 2 or in period 2a a higher frequency appears in the class 0-0.05, where there is maximum 5% of connected companies (the distribution in period 2 moves to the left).

TABLE 2 –Links among firms-

	Period 1	Period 2	Period 2a
Connected firms (#)	232	223	153
Actual total links (#)	1,891	1,591	647
Actual total links (% possible links)	7.1	6.4	5.6
Links by more than one director (#)	558	418	35
Links (max)	55	50	40
Links (mean)	16.3	14.2	7.7
Links (stan. dev.)	10.9	10.5	6.8
Collusion index	7.5	6.4	5.2
Concentration index	0.3	0.4	0.4

Source: data from Consob

We also provide the concentration index of links as analyzed in the previous section. The index shows a variation by 10 points from period 1 to period 2 and shows apart from a possible higher connection among companies in the latter, an increase in the asymmetry of the links' distribution. Moreover, both in period 2 and in period 2a the index is equal to 0.4. This means that the higher asymmetry is generated by the multiple directors appointed after 1995 and does not involve the total multiple directors that appear in the same period.

To come to the point the evolution of the interlocking directorates network in Italy underlines the following stylized facts:

- a decreasing number of links among firms;

- the decreasing number of links is associated with an increase of asymmetry in links distribution.

We interpret the new pattern of alliances in period 2 as follows. In front of less need of connection at a aggregate level, for some firms the alliances become more crucial, whereas others firms appear more independent in the sense that they originate a lower number of links.

6. Conclusive remarks

A decreasing trend in overlapping membership in order to support block-holders is given by a decrease in density as well as by an increase in the asymmetry of links distribution. The latter shows an increase of those links that, more easily, it is possible to eliminate. Moreover, a same increase in concentration of links is shown for the companies that originate overlapping after 1995. In front of a substantial decreasing in the number of companies owning links (69%) the complexity of agreements increases. It seems reasonable to interpret these findings in terms of the trouble concerning the correspondent block-holders in keeping their control position.

Our study focuses on the question concerning a convergence in the voting power concentration. We conclude that this convergence is endogenous. This interpretation is based on the fact that the overlapping membership represents a more feasible instrument than voting pacts, as the first could represent informal agreements among different shareholders in a company. The feature of informality becomes crucial when the pacts must be declared. In this case the interlocking directorates could be used as a legal device in order to support the block-holder position. The above instruments substitution doesn't apply for Italian listed companies. This issue is consistent with a possible renewed awareness about limits attached to a strong control position on the behalf of the ownership of the firm[12] [13].

Our approach brings us to make a forward point. In fact, we reckon that the more asymmetric is links' distribution among M firms, the highest is the probability of eliminating a "sensitive link" whenever the number of links decreases, that is to make substantial changes in the network. This consideration is of course associated with the finding attached to the value of density. If the value of density is low and its trend is decreasing it is reasonable to maintain that an increase in the concentration of links among the M firms will imply negative consequences in the network in terms of solidity.

[12] The analysis concerning also a higher connectivity among firms does not change this issue.
[13] This limit is deducible in a teoretical analysis considering a "private control cost" in terms of "failed development" as it is analyzed in the Ph.D. dissertation on which this paper is based.

In other words, the sample concerning the Italian companies between 1991 and 1998 is analyzed here in order to answer also to the following question: what kind of links has been eliminated in that period of time? Is there a change in the probability that the equilibrium of the whole system will be modified through a further links' elimination? The concentration index applied to the actual links in a network allows us to provide the answer.

On the other hand, other interpretations are also possible. In fact, because we denoted links as mutual links, it is obvious that, if the value of density is low, a higher concentration index of links will imply a higher connectivity of the network. That means that if the link originated by a company with a low links' contribution is broken, the network will not suffer a substantial change in terms of tightening. This factor could strengthen the "impermeability" of the block-holder as well. As a matter of fact, the block-holder will be able to guarantee itself with a tighter network mesh.

The above interpretations bring us to a further analysis.

The first is about a theoretical definition of a value of density such as it is possible to identify an increase in the concentration index with a less solidity of a network. It would be also desirable to consider measures aiming to assess the asymmetry of the links distribution together with the tightening of links.

It would be also relevant to take into account the evolution of links among firms concerning ownership. An interesting direction of thorough examination could consider if interlocking directorship networks show a counter-trend evolution in comparison with that originated by links concerning ownership (of majority or not).

The possibility of "drawing" connections among companies using graphs and measures regarding the asymmetry, besides those regarding the more traditional measure of connectivity, provides interesting points in order to study the stability of the corporate control. The above empirical analysis makes evidence that when we aim to consider how strong is the block-holder position in an industrial system the overlapping membership matters. However, the analysis based only on quantitative dynamics could hide meaningful and substantial connections.

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