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A social network analysis of interlocking directorates in French firms

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Abstract

This article investigates the network of boardroom contacts among the boards of French companies. Using approaches and measures developed by social network analysis we compare directorship networks in France for 1996 and 2005. The network considers all directors serving on board of SBF250 companies. The boardroom network in 1996 is more densely than that of 2005. Moreover we find that big companies (measured by their market capitalization) are the central actor in these networks.

Using social network analysis, this research examines whether interlocking directorates exists among the CAC 40 and SBF 250 French firms. Further, it compares directorship networks in France for 1996 and 2005. Moreover, it looks at whether a firm's measure of centrality is associated with its size. In other words, big companies (measured by their market capitalization) are the central actor in these networks. The results suggest that the location of big French listed firms in these networks is more important than simply the number of ties. The findings point to the role of links between listed companies.

Keywords: Corporate Governance, Interlocking Directorates, Social Network Analysis, Graph Theory.
JEL classification: C0, L1, G3

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Introduction

The board of directors is central to corporate governance, it is the prime decision making body. An important feature of such boards is that they are often connected to each other by a shared director. Such network connectivity has important economic consequences. Research studies of company managers and directors look at multiple directorship holders just as ’interlockers’; people who create linkages between corporations.

Network study of interlocking directorates begin from the following information base: lists of the directors and managers of major corporations. Researchers select a population of large companies and then make a census of all persons on the boards of these companies. That they analyze this information in different ways creates an impression of distinct research traditions.

Networks studies of interlocking directorates ignore most of the personal information. They shift the material to find those directors who have two or more positions. Then they reconstitute this basic information as a set of linkages, a network, between the companies of the original selection set.

Belonging to the same board of directors provides the opportunity for people to meet and interact, and thus constitutes a link between individuals. Overlap in group membership allows for the flow of information between groups, and perhaps coordination of the group’s actions. According to Sonquist and Koenig (1975), the interlock among corporate boards through sharing members might facilitate coordination among companies. This paper presents the results of the study of French corporate interconnections.

In this research, we are interested in whether among the SBF 250 and CAC 40 companies an example of interlocking directorates exists and how this network changes from 1996 to 2005. The overall objective of this work is to represent the results of a broad descriptive analysis of the data on board interrelationships for a group of 250 corporations in France and to detect some of their implications.

The specific objectives of the present study are:

- Describe patterns of relationships among French boards in 1996 and 2005;

- Explore ways of identifying ’nodes of power’, these being the most influential directors in French corporate network. The network represents the connections among companies. Directors are the actors who, via co-membership on boards, interact and communicate with one another. In the case of a corporate board network, the nodes are individual boards and the lines (also called links) that link and connect them together are directors with multiple board memberships.

Moreover, we look at how the position in the network is related to firm’s size measured by the weight of the firm in the financial indexes (SBF 250 and CAC 40).

Previous research on interlocking directorates has studied the impact of intercorporate ties on firm’s performance and in general on financial variables. To our knowledge, there is no study which uses social network analysis and graph theory to explore interlocking directorates in French firms. Furthermore, this research does not only look at the relationships among French companies, it also examines the links between the financial institutions and firms in other sectors. A further contribution of this research is the analysis of correlation between the firm's size and its position in the whole network. The results suggest that the location of a big company in these networks is more important than simply the number of ties.

This paper is organized as follows. In section 2, we study networks of interlocking directors. In section 3, we present a social network analysis and give topological measures on networks. Section 4 presents our sample and our data. Section 5 provides results and analysis of our study. And section 6 concludes the paper.

Networks of Interlocking Directorates

The interlock literature

Scott, (1985), Glasberg (1987) and Mizruchi (1996) review the interlocking data literature and show why the study of interlocks is important. These theorists classify perspectives on interlocks into four sets: management control, class hegemony, resource dependency, and financial control.

According to Mace (1971), management control theory argues that a board of directors is appointed by management to act only as "passive rubber-stamps". This theory views management as isolated and autonomous from external pressures.

Therefore, interlocks are considered accidental and are less significant. But Mintz and Schwartz (1985) argue that a well integrated system of interlocking directorates disagree with the fundamental logic behind the management control theory.

Class hegemony theory (Sonquist and Koenig (1975)) asserts that interlocks highlight upper-class contribution in business. Interlocks are integrative ties whose main function is to support class cohesion. Belonging to the same social clubs and schools also supports this perspective.

If elite individuals are always appointed to the board of directors, they will frequently control corporate power.

Researchers like Pfeffer and Salancik (1978) judged resource dependency as the greatest justification for interlocking among boards. This theory argues that interlocks are established to reduce uncertainty. Many researchers (Burt (1980), Burt (1983), Boyd (1990) and Lang and Lockhart (1990)) justified that a firm creates a connection through an interlock to guarantee access to external resource. Consequently, uncertainty is reduced. Therefore, interlocks are viewed as a transfer device. It has been complicated to validate resource dependency because this view proposes that reducing uncertainty will raise profits. The firm's mutual profits will be higher if an interlock offers additional information to a company.

On the one hand, Pennings (1980) and Burt (1983) have found positive relation between interlocking and firm profitability. On the other hand, Fligstein and Brantley (1992) demonstrate a negative association between wealth and connections among boards.

These contradictory findings can be clarifying by the nature of interlocking ties.

Based on interviews with bankers, Mizruchi (1996) and Richardson (1987) suggest that generally bankers sit on a board of a distressed firm, in other words firms in financial difficulty. From the side of the distressed firm, it seeks additional interactions to obtain funds.

Financial institutions are a central actor in the interlocking network. Resource dependency theory states that interlocks diminish improbability while financial control theory asserts that access to funds increase the greatest concern.

Mintz and Schwartz, (1985) consider that financial control theory as a stem of the resource dependence model. The grouping of these two theories would imply that interlocks take place more often between industrial companies and financial firms in particular banks. This provides industrial firms the ability of obtaining funds when required.

To conclude, interlocks are a mean for firms to exchange knowledge and strategy (Useem

(1984), Lorsch and MacIver (1989), Haunschild and Beckman (1998), Carpenter and Westphal (2001))

The major hypothesis of interlocking directorates that this social embeddedness supposes that the individuals holding many directorships will have better access to information, resources, etc... and will be remarkably thought after for their knowledge and experiences by firms in less favorable situations.

Graphs of Boards and Directors

At this level of the study, an important question rise: How should one draw a graph to represent the data about boards of directors?

Indeed, there are two units of analysis either boards or directors. One could treat the "boards" as the basic unit of the analysis and form a graph whose vertices represent boards and whose edges represent shared directors (board graph). Alternatively, one could make a graph whose vertices represent directors and whose edges represent shared board memberships (director graph). There is no obvious way to choose between the two graphs. The ambiguity about representation arises naturally from the structure of the data: there really are two sorts of social entities here, the directors and the boards, and the network's edges represent membership of the former in the latter.

Belonging to the same board of directors provides the opportunity for people to meet and interact, and thus constitutes a link between individuals. Overlap in group membership allows for the flow of information between groups, and perhaps coordination of the group's actions. According to Sonquist and Koenig [1975], the interlock among corporate boards through sharing members might facilitate coordination among companies.

To understand what an interlocking directorate is, one must first understand something about the management of major corporations. Major corporations operate under the control of steep managerial hierarchies, with ultimate power vested, in principle, in the board of directors. (In

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actuality, corporate governance has become corrupted, with CEOs typically appointing the boards instead of the reverse.) Boards are comprised of anywhere from 10 to 25 members.

Boards hire and fire the highest level managers, control all significant policy changes, and steer the corporation through any crises that may arise, including such things as mergers. They also speak on behalf of the corporation to other corporations, and, on occasion, to the public as well.

CEOs will often serve on the boards of other corporations, in part as a matter of prestige, as this illustrates that their advice is valued outside of their home corporation, but also as a means of obtaining valuable, and perhaps sensitive and privileged, business intelligence, and as a means of extending their own social networks. Outside directors of this kind, usually members of the upper class, sometimes own substantial shares of the companies on whose boards they serve. Their social backgrounds, together with their vested interest in corporate wealth and power often result in a highly conservative and elitist outlook.

Social Network Analysis

Basic Terminology

A network or a graph is a set of items termed vertices (or nodes) with connections between them called edges. Networks can be used to represent a multitude of phenomena (from family ties through marriage in 15th century Florence to needle sharing among drug addicts, to networks of friendship and advice among managers). We restrict our attention to networks derived from the world of corporate boards of directors and adopt the following conventions. Let denote by N the number of nodes in a graph and by E the number of edges. We can represent nodes as points and relationships as segments connecting pairs of points. This representation is called a graph.

There are different kinds of graphs. There are directed and undirected graphs. In directed graphs (also known as digraphs), the ties have direction and we refer the lines as arcs. In undirected graphs, the ties have no direction. For example, there is a relationship between A and B, this is the same thing saying there is a relationship between B and A.

Graphs may be valued or non-valued. A valued graph has numbers attached to the edges, which may be used to indicate the strength, capacity, frequency, duration and other quantitative measurement of the link.

In our case, we consider a valued and undirected graph.

One of the most important uses of network analyses is identification of most central units in a network. Measures of centrality can be defined in two different ways:

- For each firm respectively: unit of centrality

- For the whole network: network centralization

Centrality Measures

A traditional issue in social sciences is the centrality of a node in a network of social actors. In fact some actors (or nodes) are not only more connected than others, but their position in the network allows them for playing the role of mediating information from one part of the network to one another. Other nodes have to rely on these "central" nodes to communicate between each other (Padgett and Ansell [1993]). In other words, in social network analysis, centrality measures are used to characterize the importance and the role of particular actors in the larger network by analyzing their position within the network. Degree, closeness and betweeness are common measures of importance in Social Network Analysis.

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Centrality measures are used for undirected graph. Selected unit is central, if:

- It has high degree;

- It is accessible (close to) other units;

- It lies on several geodesics (shortest paths) between other units.

A key idea in the structural approach to social science is that the way an actor is embedded in a network offers opportunities and imposes constraints on the actor. Occupying a favored position means that the actor will have better access to information, resources, social support etc. and will be exceedingly thought after for such opportunities by actors in less favorable positions.

In particular, power and influence in informal networks stem from occupying positions that are central to the network. The measure of centrality has been the subject of several studies in Social Network Analysis.

Degree Centrality

Actors (here firms) who have more ties to other to other actors may be advantaged positions. Since we are interested to undirected data, centrality degree is computed by ignoring the direction of ties. Degree Centrality is defined as the number of nodes that a given node is connected to.

$$C_D(k)_{norm} = \frac{\sum_{j=1}^{n} a(i,k)}{(n-1)}$$

Where n is the total number of nodes in a network and $a(i,k)$ is a binary variable indicating whether a link exists between nodes i and k.

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The greater a person's degree, the more potential influence they have on the network, and vice-versa.

Freeman's approach

Freeman (1979) developed basic measures of the centrality of actors on their degree, and the overall centralization of graphs.

In our graph, degree is the number of corporations that a given firm is in relation with.

$$d_i = \sum_j a_{ij}$$

Where d_i is the degree centrality of actor j, and a_{ij} is the number of links that actor$j$ has with all the other actors $(i = 1 \ldots (n-1))$.

In Freeman's approach, actors who have more connections are more likely to be powerful because they can directly affect more other actors. But having the same degree does not necessarily make actors equally important.

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Bonacich's approach

Bonacich argued that actor's centrality is a function of how many connections one has, and how many the connections the actors in the neighborhood had.

An actor is likely to be more influential if one is connected to central others, because one quickly reaches a lot of other actors with one's information. But if the actors that an actor is connected to are, themselves, well connected, they are not highly dependent on him, they have many contacts, just as he does. Bonacich argued that being connected to others makes an actor central, but not powerful. And being connected to others that are not well connected makes an actor powerful, because these other actors are dependent on him, whereas well connected actors are not.

The centrality of an actor i (denotedc_i) is denoted by:

$$c_i = \sum_j A_{ij}(\alpha + \beta c_j)$$

Where:

A is an adjacency matrix,

α is a value used to normalize the measure. The Normalization parameter is automatically selected so that the sum of squares of the vertex centralities is the size of the network.

β is an attenuation factor which gives the amount of dependence of each vertex's centrality on the centralities of the vertices it is adjacent to. The parameter β is arbitrary selected, negative values should be selected if an individual's power is increased by being connected to vertices with low power and positive values selected if an individual's power is increased by being connected to vertices with high power.

Therefore, the centrality of each vertex is therefore determined by the centrality of the vertices it is connected to.

Closeness Centrality

Closeness centrality is defined as the total graph theoretic distance to all other nodes in the network. Closeness centrality thus characterizes the reach of the ego to all other nodes of the network. A node with a low central closeness score (⇒ highly central), it tends to receive anything flowing through the network very quickly.

$$C_c(k)_{norm} = \frac{\sum_{i=1}^{n} l(i,k) - C_{c_{min}}}{C_{c_{max}} - C_{c_{min}}} \text{ with } i \neq k$$

Where $l(i,k)$ is the length of the shortest path connecting nodes i and k. $C_{c_{max}}$ and $C_{c_{min}}$ are the minimum and maximum lengths of the shortest paths respectively.

Betweeness Centrality

Other measures of power and influence are therefore related to the advantage gained through weak ties and/or brokering positions. Betweeness centrality measures the extent to which other parties have to go through a given actor to conduct their dealings. Consequently, betweeness is defined as the proportion of paths -among the geodesics between all pairs of nodes- that pass through a given actor.

$$C_B(k)_{norm} = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} g_{ij}(k)}{(n-1)} \text{ with } i \neq k$$

Where $g_{ij}(k)$ indicates whether the shortest path between two other nodes i and j passes through node k.

The values of these three normalized centrality measure from 0 to 1.

Network Measures

Density

The density of a network is a measure of the connectedness in the network, and takes on a value between 0 and 1. Link density measures how complete a group is in terms of the relations among its

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members. It is defined as the proportion of the maximum possible number of links that actually exist among all group members.

$$Density = \frac{2\sum_{i=1}^{n}\sum_{j=1}^{n} a(i,j)}{(n-1)}$$

Where n is the size of the group and $a(i,j)$ is a binary variable indicating whether a link exists between nodes i and j. Members in a dense group have relations to a large number of other group members. When density is close to one, the network is considered dense; otherwise it is sparse. Communication and collaboration are easier for members in a dense group and this imply more efficient planning and execution of corporate strategies. However, a dense group may also be vulnerable because one member may release critical information about other group members.

When the density achieves 1, a group becomes a clique where each member connects with every other member.

Clustering Coefficient

Watts and Strogatz [1998] introduced the clustering coefficient graph measure to determine whether or not a graph is a small-world network. The clustering coefficient quantifies how well connected are the neighbors of a vertex in a graph. In real networks it decreases with the vertex degree, which has been taken as a signature of the network hierarchical structure.

First, let us define a graph in terms of a set of k nodes $N = n_1, n_2, n_3, \dots, n_k$ and a set of edges E where e_{ij} denotes an edge between nodes n_i and n_j. We define the neighborhood N for a vertex $n_i$as its immediately connected neighbors as follows:

$$\widetilde{N}_i = \{n_j\}/e_{ij} \in E$$

The degree $d(n_i)$ of a node n_i is the number of nodes in its neighborhood$\widetilde{N}_i$. The clustering coefficient C_i for a node n_i is the proportion of links between the vertices within it neighborhood divided by the number of links that could possibly exist between them.

- For a directed graph, e_{ij} is distinct frome_{ji}, and therefore for each neighborhood $\widetilde{N}_i$ there are $d(n_i)(d(n_i)-1)$ links that could exist among the nodes within the neighborhood. Thus, the clustering coefficient is given as:

$$C_i = \frac{|\{e_{jk}\}|}{d(n_i)(d(n_i)-1)} \text{ such that } n_j, n_k \in \widetilde{N}_i \text{ and } e_{jk} \in E$$

- An undirected graph (which is our case) has the property that e_{ij} and e_{ji} are considered identical. Therefore, if a node n_i has $d(n_i)$ neighbors, $\frac{d(n_i)(d(n_i)-1)}{2}$ edges could exist among the nodes within the neighborhood. Thus, the clustering coefficient for undirected graphs can be defined as:

$$C_i = \frac{2\left|\{e_{jk}\}\right|}{d(n_i)(d(n_i)-1)} \text{ such that } n_j, n_k \in \widetilde{N}_i \text{ and } e_{jk} \in E$$

Sample and Data Collection

To investigate the social network of corporate boards, we use data from France. The French data are supplied by *Dafsaliens*. The two data sets for this study comprise lists of directors for the CAC 40 and SBF 250 companies in France in 1996 and 2005. The main characteristics of the full population of companies and the population of directors are given in Table 1. These data show two changes occurring between 1996 and 2005. The first is the size of the board. In 1996, the average board size is 7 members per board, while in 2005; it is near to 12 members per board. This may be the consequence of the setting of the Dualist system of governance (*Directoire et Conseil de Surveillance*) which implies a large size of boards (it may attempts 22 members).

The second trend in the data is the decreased incidence of multiple directorship holding. The number of seats per director decreased from 1, 2 to 8. There was not, however, a commensurate increase in the number of board seats available. Hence the net effect of this movement is that there were fewer directors overall on the boards of the CAC 40 in 1996 than there are in 2005.

Table 1: Top 250 French companies and directors, 1996 and 2005

	SBF 250		CAC 40	
	1996	2005	1996	2005
No. of Companies	189	249	39	40
No. of Positions (board seats)	1764	2407	530	631
Average Board Size	9.23	9.66	13.59	15.77
No. of Directors	2337	2875	692	773
No. of Positions (seats) per director	1.33	1.19	1.30	1.22

In the table above, we note that average board size is increased across time. This may be due to the dualistic governance (Directoire and Conseil de Surveillance) adopted by many companies in the sample, after 1996. Moreover, the number of positions per person decreases for both SBF 250 and CAC 40 companies. According to Stokman and Wasser (1985), the French corporate governance is caracterized by a high density of interconnections (18% of the French firms are linked to others, while only 15% and 12% respectively for Anglo-Saxon and Germanic corporations). In 1998, an AFG-ASFFI report on corporate governance recommends to reduce the number of positions per person to three rather than eight.

Multiple directorships create "links and interlocks". Table 2 below shows the number of directors who hold more than one position.

Table 2: Number of directors/positions for Top 250 French Companies

	SBF 250		CAC 40	
	1996	2005	1996	2005
1	1431	2107	442	535
2	177	191	48	60

3	70	68	21	28
4	31	29	11	6
5	20	9	5	2
6	9	1	1	0
7	4	1	1	0
≥ 8	4	1	1	0

In table 2, we note that for SBF 250 companies, only the number of directors holding two positions increases. While for CAC 40 companies, the number of directors holding three positions increases too.

Some of the interlocks indicated in table 2 involve more than two shared directors. In these cases, the sum of links involved in the interlock relationships is greater than two times the number of interlocks.

Networks are defined by their actors and the connections among them, and then it is useful to begin our description of networks by examining these simple properties. First, focusing on the network as a whole, one might be interested in:

- The number of actors,

- The number of connections that are possible, and

- The number of connections that are actually present.

Since the size of a network is indexed simply by counting the number of nodes (actors), in our study, the network's size is equal the number of firms involved in the network, for each year (in 2005, the network size is 249, and in 1996, it is equal to 189). For undirected data, or symmetric ties, the number would be $\frac{(k*(k-1))}{2}$ [†].

Therefore, for a network of 249 actors (or 189), there are 30 876 (17 766) logically possible relationships.

The number of actors places an upper limit on the number of connections that each individual (in our case company) can have$(k-1)$, thus 248 (or 188) connections.

We employ network analysis, centrality of position and centralization to describe the structural properties among French firms' network. The two concepts (evenly measures) most used in network analysis are network density and centrality[‡]. Node dynamics resulting from changes can be captured by a set of centrality measures from social network analysis. Centrality is often used to indicate the importance of a member within a group or a network. Various centrality measures have been proposed and they have different interpretations and implications. Freeman (1979) defines the three most popular centrality measures: degree, betweeness and closeness.

The diagrams below present the four boardroom networks in our study.

[†] Since the relationship AB would be the same as BA.
[‡] Wasserman and Faust (1994).

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INSERT FIGURE 1

INSERT FIGURE 2

INSERT FIGURE 3

INSERT FIGURE 4

A boardroom network can change in its nodes, links, groups, and even the overall structure.

Analysis and Results

The social network analysis was carried out using the social network software, UCINET (Borgatti, Everett and Freeman, 1999). Network descriptive measures and individual firm centrality were calculated using UCINET VI version, which uses the calculations described above.

Description of Networks

In conducting any form of social network analysis, it is important to understand the characteristics of the network involved.

It is also important to not only understand what is going on in a network, but how one network differs from another. The network characteristics discussed here include density, components, isolates, clustering coefficient, and network centralization. Density is a measure of the overall amount of ties that are present.

Density in a valued graph is the average value attached to each path across all possible paths. This measure can be interpreted as the average number of board members shared by each possible pair of companies.

Components represent subsets of the graph in which there are no connections to nodes in a different subset. For the networks presented here this demonstrates groups of companies that are connected either directly or indirectly to each other but not connected to companies outside the group. This measure indicates the extent to which a network is connected.

The number of isolates indicates the number of nodes in the network that are not connected to any other node.

The overall graph clustering coefficient is simply the average of the densities of the neighborhoods of all the actors. The weighted version gives weight to the neighborhood densities proportional to their size, that is, actors with lager neighborhoods get more weight in computing the average density.

Network centralization is an index that indicates the extent to which a single actor or set of actors is highly central with the remaining actors considerably less central. It is measured by calculating the variation of the centrality of all actors (Wasserman and Faust, 1994). The index will always be

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between 0 and 1, 0 when all actors have equal centrality and 1 if one actor receives all the ties in the network.

The network measures for the four networks are shown in table 4. The number of isolated firms in the network is low. Of the 250 firms, only 55 are isolated for the SBF 250 network in 2005.

Table 3: Descriptive Statistics for Networks

	SBF 250		CAC 40	
	1996	2005	1996	2005
Components	18	7	6	3
Isolates	38	55	5	0
Density	1.4575	1.1777	1.5137	0.2051
Degree Centralization	0.3720	0.1499	0.4936	0.3833
Betweeness Centrality	0.0429	0.0417	0.0944	0.0963
Clustering Coefficient	0.444	0.127	1.034	0.319

From these measures it is possible to see several differences between the four networks. A comparison of the descriptive statistics shows that CAC 40 companies are much more interlocked than SBF 250 companies. The boardroom network among the top 40 French companies in 1996 is more dense (1.5137) than that in 2005, although there is 5 non connected firms. In 2005, the whole density of the network among the top 40 companies is 0.2051 and all companies are connected.

All descriptive statistics for networks are decreased across time.

Nodes Measures

Degree centrality of a given company is the number of links to other companies via shared directors. For example, a company with six board members each having one directorship will have a degree centrality of 0. A company with six board members, three of which hold directorships at other companies will have a degree centrality of 3. A company with a high score is considered central and consequently expected to play a marginal role in the network.

Table 4: Ten Most Connected Companies by Degree Centrality (Freeman's Approach), 1996 and 2005

Company Name	Degree Centrality 2005	Company Name	Degree Centrality 2005
BNP Paribas	43	Cie Bancaire	64
Publicis Group	34	Paribas	57
Casino Guichard	30	LVMH	56
Lagardère	29	Société Générale	52
Accor	29	Lyonnaise des Eaux	46
Rubis	28	Schneider	46
CNP Assurances	27	Sefimeg	43
France Télécom	24	Axa	40
PPR	23	Lagardère	39
Bouygues	23	Saint Gobain	37

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In 2005, BNP Paribas has the large number of direct connections to other companies via the members of its board of directors. BNP Paribas, with the highest degree centrality, could be the leader or "hub" in the network.

Moreover, we note that values of Freeman's Centrality Degree are higher in 1996 than in 2005. According to Freeman's approach, BNP Paribas (in 2005) and Cie Bancaire (in 1996) are the central actor.

The Freeman graph centralization measures express the degree of inequality or variance in our network as a percentage of that of a perfect star network of the same size. In 2005, the network centralization is equal to 14.99% while in 2005, and to 37.20%. However, Freeman's degree centrality is not reliable indicator of leadership. We therefore use Bonacich's approach to measure centrality.

As we mentioned above, Bonacich's Approach takes into account the connections of the actors in the neighborhood. This is possible through a parameter β which provides the degree of independence of each node's centrality on the centralities of the nodes it is adjacent to. β may be negative (which means that a firm's power is an increased when connected to nodes with low power) or positive (otherwise).

With negative attenuation parameter, we have a quite different definition of power: having weak neighbors, rather than strong ones.

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Table 5: Ten Most Connected Companies by Degree Centrality (Bonacich's Approach), 1996 and 2005 $(\beta = -0.5)$

Company Name	Degree Centrality 2005	Company Name	Degree Centrality 2005
BNP Paribas	3.741	Cie Bancaire	9.455
Publicis Group	-1.939	Paribas	3.038
Casino Guichard	-0.683	LVMH	-1.347
Lagardère	6.374	Société Générale	6.253
Accor	1.220	Lyonnaise des Eaux	-1.970
Rubis	0.530	Schneider	-11.447
CNP Assurances	-4.543	Sefimeg	-1.569
France Télécom	4.807	Axa	30.876
PPR	3.230	Lagardère	2.770
Bouygues	-2.631	Saint Gobain	2.698

In 1996, AXA is the powerful actor with a degree of 30.876, while the Cie bancaire the well connected actor has a coefficient power of 9.455. Schneider and Lyonnaise des Eaux are distinguished because their ties are mostly ties to actors with high degree, making these actors "weak" by having powerful neighbors. AXA and Cie Bancaire have more ties to neighbors who have few ties, making them strong by having weak neighbors.

In 2005, Lagardère and France télécom are the powerful actor.

When the attenuation factor β is positive (between 0 and 1), being connected to neighbors with more connections makes one powerful. This is a straight-forward extension of the degree centrality idea.

Table 6: Ten Most Connected Companies by Degree Centrality (Bonacich's Approach), 1996 and 2005 $(\beta = +0.5)$

Company Name	Degree Centrality 2005	Company Name	Degree Centrality 2005
BNP Paribas	-4.451	Cie Bancaire	4.077
Publicis Group	1.319	Paribas	-3.788
Casino Guichard	-64.933	LVMH	-4.271
Lagardère	51.625	Société Générale	3.760
Accor	-45.843	Lyonnaise des Eaux	-8.074
Rubis	34.973	Schneider	-12.174
CNP Assurances	21.286	Sefimeg	1.806
France Télécom	-32.527	Axa	2.254
PPR	-114.257	Lagardère	10.346
Bouygues	34.224	Saint Gobain	1.555

In 2005, Bonacich power measure $(Mean = 1.022)$ is higher than in 1996$(Mean = -2.287)$. Rubis and Lagardère appear to have high centrality by this measure because these actors are connected to all of the other high degree nodes. In 1996, Lagardère has the high coefficient(10.346).

The notion of power arises from connection to weak others, as opposed to strong others is an interesting point: the positions of actors in network structures endow them with different potentials.

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Betweeness centrality can also be used to form a measure of overall network centrality. Betweeness measures the extent to which a particular node ties "between" the various other nodes in the network: a node with few ties may play an important role and so being central in the network. It measures the number of geodesics[§] and consequently the extent to which a company, landing on the shortest path between two other companies, has a potential for control.

Table 7: Ten Most Connected Companies by nBetweeness Centrality, 1996 and 2005

Company Name	nBetweeness Centrality 2005	Company Name	nBetweeness Centrality 2005
BNP Paribas	4.606	Société Générale	4.770
Accor	4.469	Sefimeg	4.582
Publicis group	3.889	Paribas	4.453
Rubis	3.669	Saint Gobain	4.419
Schneider	3.150	Suez Compagnie	3.853
M6	3.129	Danone	3.806
Air Liquide	3.109	Bolloré	3.253
AGF	2.569	Cie Bancaire	2.725
Air France	2.569	Peugeot	2.598
Lagardère	2.336	Aventis	2.552

The nbetweeness coefficient decreases across time. An individual with high nbetweeness may act as a gatekeeper or broker in a network for smooth communication or flow of information. In 1996, Société générale has a normalized betweeness measure of 4.770; while in 2005, its nbetweeness coefficient is equal to 0.806.

Moreover, in 1996, there is a lot of variation in actor's betweeness (from zero to 4.770 for 1996), and there is an important variation (standard deviation = 0.916 relative to a mean nbetweeness of 0,502). Despite this, the overall network centralization is relatively low (4.29%). For 2005, actor betweeness vary from zero to 4.606, and there is an important variation (standard deviation = 0.809 relative to a mean nbetweeness of 0.458). The overall network centralization is high (4.17%).

The degree centrality takes into account only the number of direct ties that a node has but the closeness centrality also considers indirect ties (which are not directly connected to that node). Closeness measures the centrality of a point by summing the geodesic distances from that point to all other points in the network.

[§] A geodesic is the shortest path between any particular pair of nodes in a network.

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Table 8: Ten Most Connected Companies by nCloseness Centrality, 1996 and 2005

Company Name	nCloseness Centrality 2005	Company Name	nCloseness Centrality 2005
BNP Paribas	1.542	Suez Compagnie	2.141
Rubis	1.540	Société Générale	2.141
Accor	1.539	Sefimeg	2.139
Lagardère	1.539	LVMH	2.139
M6	1.539	Lagardère	2.139
Publicis Group	1.539	Cie Bancaire	2.138
Air France	1.538	Paribas	2.137
Neopost	1.538	Saint Gobain	2.137
NRJ Group	1.538	Schneider	2.137
Casino	1.538	Aventis	2.136

Values of nCloseness centrality vary from 0.532 to 2.141 in 1996, with a mean value of 2.053. Standard Deviation is very low (0.311). In 2005, these values decreases, nCloseness mean value is equal to 1.480, with a variation of 0.223. A maximum value of 1.542 can be reached.

Some actors have lots of connections, other have fewer. Differences among individuals in how connected they are can be extremely more consequential for understanding their attributes and their behavior. Highly connected individuals may be more influential, and may be more influenced by others.

Group Level Measures

One common way of measuring the extent to which a graph displays clustering is to examine the local neighborhood of an actor (that is all the actors who are directly connected to ego), and to calculate the density in this neighborhood (leaving out ego). The degree of clustering is an average of all the neighborhoods.

In 1996, the overall density of the entire graph in this population is 1.4575, and the overall graph clustering coefficient is 0.444. So, the density of local neighborhoods is much higher than the density of the whole graph. The weighted overall graph clustering coefficient is equal to 0.335 (smaller than 0.444).

The clustering coefficient is high and equal to 0.444 in the board network. It is worth noticing here the two-sided effect of the interlock on the clustering coefficient. In the absence of interlock, directors would be connected to all the other directors of their board and to no other directors outside their board. Therefore the clustering would be 1 for the director network and 0 for the board network. If now a director of board i serves also on board$j$, then his clustering coefficient will be much less then 1 because his neighbors in board i and j are not nearest neighbors among each other. Thus the interlock decreases the clustering coefficient of the director network and increases the clustering of the board network.

These values decreased across time. In 2005, the overall clustering coefficient is equal to 0.127, and the weighted overall clustering coefficient is equal to 0.141. Since interlocks decreases the clustering coefficient, we can conclude that the number of ties increases during these last ten years (in 1996, there is 33 387 ties, and in 2005, there is 34 895 ties). This may be due to the difference

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between the number of firms considered in 1996 and 2005. In 1996, we have 189 firms because of the lack of information on *Dafsaliens* Database (mergers, acquisitions...).

There are 261 cliques for the boardroom network in 1996. A clique is a maximally complete sub-graph. In 2005, there are only 162 cliques.

We conclude that decisions made concerning corporate governance in order to limit the practice of interlocking directorates have reduced the number of multiple directorships and then, obtain a less dense network.

Comparison with Hong Kong, Great Britain and United States

We computed key network statistics, and compared them with those from Stockman et al (1985) research on the top 250 listed firms in Great Britain and the United States and those from Au et al (2000) work on top 200 listed companies in Hong Kong (Table 1).

Within an interlocks network, only persons with two or more board positions, multiple directors, generate interlocks. Multiple directors in France are a minority group (12.5%), just like in Hong Kong (17%), Great Britain (11%), and the United States (18%). The mean number of position per director in France (1.19), i.e. the accumulation ratio[**] is also similar to Hong Kong (1.29), Great Britain (1.15), and the United States (1.28).

Among the multiple directors, the number of directors seats they hold reveals that France has a large proportion of multiple directors who belong to just two boards (64%), larger than in Hong Kong (61%), equal to the percentage found in the United States (64%), and lower than the percentage found in Great Britain (69%).

Table 9: Patterns of interlocking directorates in France: A comparison with Hong Kong, Great Britain, and the United States[††]

	France	Hong Kong	Great Britain	United States
Variables	SBF 250	Top 200	Top 250	Top 250
Total number of directors	2,875	1,628	2,682	3,108
Total number of director seats	2,407	2,105	3,091	3,976
Total number of multiple directors	300	276	282	564
Proportion of multiple directors	12.5%	17%	11%	18%
Accumulation Ratio	1.19	1.29	1.15	1.28

[**] The accumulation ratio is equal to the number of director seats by the total number of directors.

[††] The data on France are based on our own calculation. The data on Hong Kong come from Au, Peng and Wang (2000). The data on Great Britain and the United States are from Stockman, Ziegler, and Scott (1985).

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Centrality and Market Capitalization

The location of a firm in a network directly impacts access to information. Centrality in a network can be seen as the importance of a firm in that network. It would be expected that the extent to which large firm (with high market capitalization would influence the centrality degree of that firm, because of the possible relationships that can be realized through interlocked directorates. A multitude of studies assert that "big" companies and financial institution tend to be the central actors in a network. In this subsection, we will examine this relationship by looking at the correlation between network centrality measures and the weight of each company in the index. Correlation will be calculated for both CAC 40 network in 2005 (information are available only for 2005) and SBF 250 companies.

Results from the CAC 40 network are shown in table 9. Degree centrality and normalized betweeness both are significantly correlated with respectively weight in index and weight in business at 5% level.

Table 10: Correlations of CAC 40 firms' measures and weight in index and business, 2005

	Weight in Index	Weight in Business
Degree Centrality	0.365*	0.354*
nBetweeness	0.369*	0.229*

*Correlation is significant at the 0.01 level.

This suggests that while interlocked directorates may exist among top 40 French companies, it may be the relationships with larger well-established companies that make a difference. These results also suggest that the number of ties is less important than the strategic value of ties.

Discussion

The most basic goal of this study was to examine a particular dimension of the structural social capital of a firm, namely the links between its boards and boards of other firms. Individual links are important. They create the embeddedness of key members of the firm in the social environment. This view of corporate, structural social capital also takes us into the study of interlocking directorates, a field with long history and intense theoretical contestation (Fennema and Schijf, 1978; Mizruchi, 1996).

We have used formal analysis of social network theories to analyze structural characteristics of intercorporate networks in France. The intercorporate network represents the relations between corporations made by their shared directors.

Using CAC 40 and SBF 250 index, we were able to determine all interlock ties among firms. The findings for SBF 250 index indicate that, though interlocked to some extent, network density of 1.4575 in 1996 is relatively high. In order to study the evolution of intercorporate network over ten years, interlocks ties among SBF 250 companies in 2005 were also obtained. The findings of this analysis show that the network is quite less dense 1.1777 than one made in 1996.

When comparing these two networks, it is important to keep in mind that the characteristics of the firms that make up the network are different, and that differences in network may be attributable to these differences.

The higher number of board members for SBF 250 firms, in 2005, may influence the number of ties with other firms simply because there are more possible ties to be had, given the higher number of members. Moreover, the number of firms included in the study in 1996 differs from that in 2005 (due to the lack of information).

Comparing at the same date, the SBF 250 network and CAC 40 network, an important remark appears. Although the 40 firms in CAC 40 are included in SBF 250, we find that density in CAC 40 network is quite higher than in SBF 250 network in 1996, and very low in 2005. From looking at the differences that exist between these two networks (CAC 40 and SBF 250), what transcends as an interesting issue is whether CAC 40 firms are most important to study.

Another objective of this research was to examine whether a firm's weight in index, which is equal to the market capitalization of the firm by the total market capitalization in the index or in the sector, reflects its measure of centrality and its position in the network.

We find that both degree centrality and normalized betweeness centrality within the network of CAC 40 companies was significantly correlated with a firm's weight on the financial market. These correlations are positive, which means that larger or big French corporations are the central actor of the Boardroom networks among French companies.

These results agree with theoretical and empirical findings on interlocking directorates. In fact, many researchers and authorities tend to adopt laws and recommendations to reduce the use of the interlocking directorates. As mentioned by Brandeis (1914): "The practice of interlocking directorates is the root of many evils. It offends laws human and divine. Applied to rival corporations, it tends to the suppression of competition and to violation of the Sherman Law. Applied to corporations which deal with each other, it tends to disloyalty and to violation of the fundamental law that no man can serve two masters. In either event it leads to inefficiency; for it removes incentive and destroys soundness of judgment. It is undemocratic, for it rejects the platform: "A fair field and no favors"- substituting the pull of privilege for the push of manhood".

Recently, in 1998, in a report of the AFG-ASFFI on corporate governance reduce the number of directorships to three rather than eight. As consequence, we find that network measures decreases across time.

Multitude of studies asserts that big companies tend to be more interlocked than other because they can benefit from their reputation, knowledge and strategic choices. In our study, we find that, market value of the firm and centrality, are positively correlated.

Conclusion

This article examines the boardroom network connecting company directorates in France in 1996 and 2005. The Companies Act of 1966 provided a very succinct definition of the board of directors:

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"Corporations are governed by a board of directors... The board of directors has the broadest powers to act in all circumstances in the name of the company..." [‡‡]

The first Viénot Report specified the board of directors ' mission as follows: "The board defines the company's strategy, appoints the corporate officers responsible for managing the company and implementing this strategy, oversees management and ensures the quality of information provided to shareholders and to financial markets through the financial statements or at the time of very important operations".

This definition confirms both the prominent role of the board and the collegial nature of its decisions, one of the consequences being that directors are collectively responsible for decisions that have been made. Patterns of relationships among boards and directors may engender potential for conflict of interest, or that may lead to poor quality decision-making.

The network analysis gave us abundance information on the network of interlocking directorates. The positions of banks in the network and the relations between bank and industry are significant. The finance capital theory expects that banks are involved in strong and multiple interlocks (e.g. the centrality degree for BNP is equal to 43 in 2005).

The major findings are:

1. Thirty percent of the most connected firms are financial institutions. In fact, Financial Interlocks occurs for several reasons. First, companies that are in financial difficulty tend to form a close association with one or more financial houses. Second, banks fid it advantageous to be connected with large firms through electing company officers to the bank's board of directors; this may attract large deposits as well as secure a reliable customer for bank loans. Third, these financial interlocks also arise from the trust operations of banks (Dooley, 1969).

2. In 1996, the number of directorships in France is quite the same with the US companies[§§], while the mean board size in US (13.2) is quite higher than in France ($\simeq$9.5).

3. In comparison with the US, the UK, and Germany, France has a quite same coefficient clustering (0.319 for CAC 40 companies).

4. Big companies are the central actor in the network. There is a positive correlation between the number of ties that a firm has, and its market capitalization.

These results provide us an idea about the French interlocking network, but leave many of the most interesting questions beyond reach. For example, our data is snapshots of the French corporate networks: it would be very interesting to collect similar data over a period of years in order to look at the dynamics of connections within the corporate world. Another questions that should be considered, is to study the effects of these networks measures on firm performance.

[‡‡] Association Française des Entreprises Privées et Association des Grandes Entreprises Françaises [2002]
[§§] See Malcolm (2002)

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Figures

Figure1 : CAC 40 network in 1996

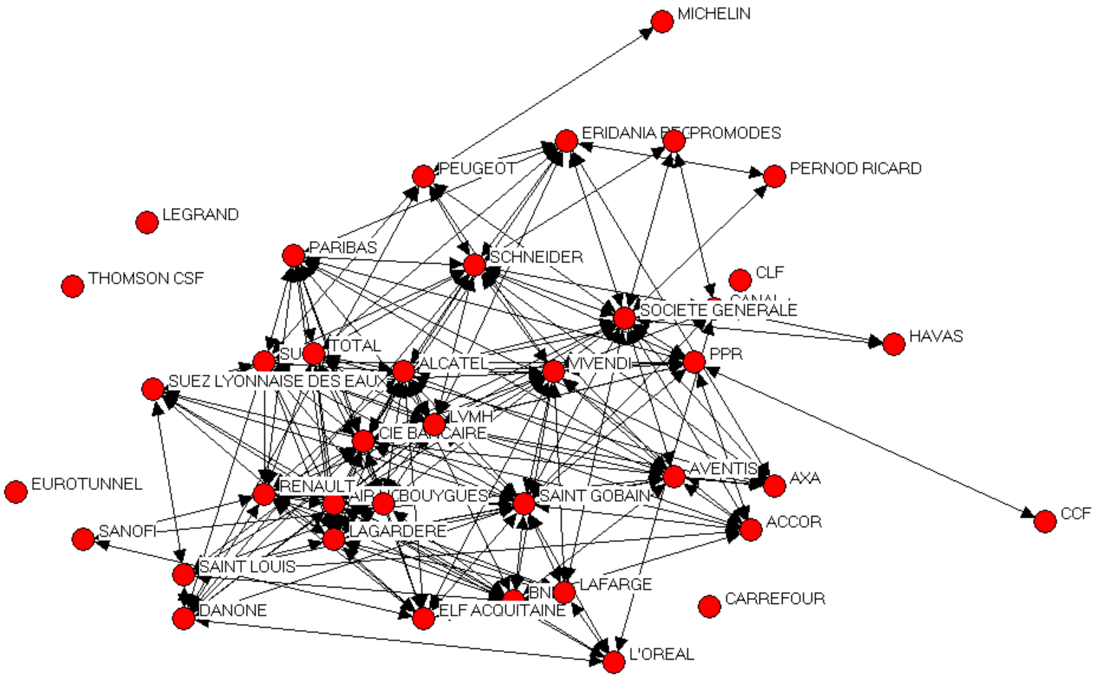

Figure 2: CAC 40 network in 2005

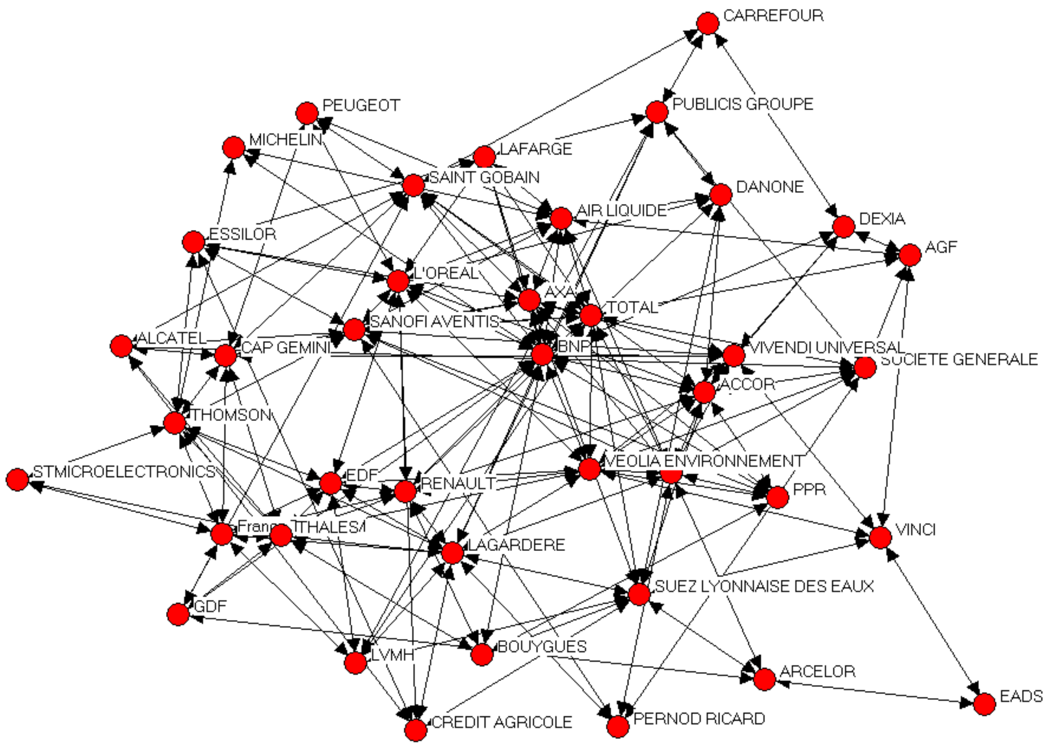

Figure 3: SBF 250 network in 1996

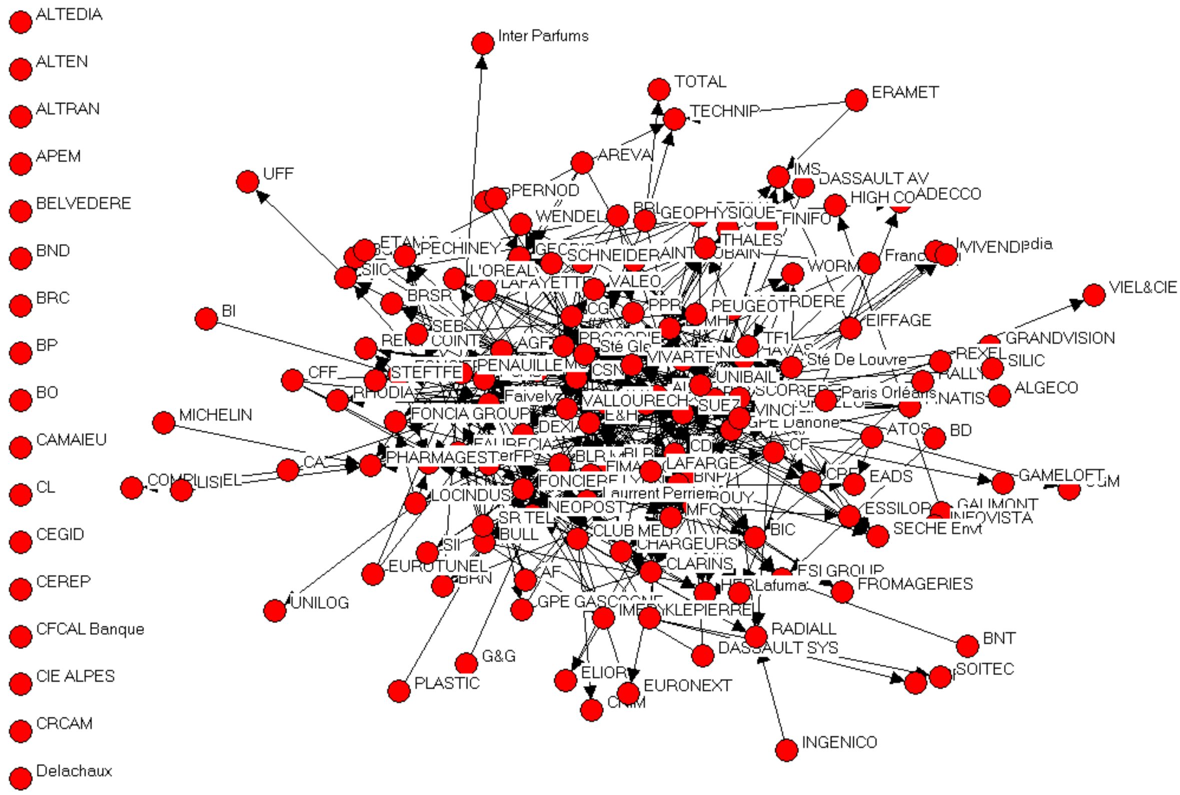

Figure 4: SBF 250 network in 2005