



# How a cartel operates: evidence from Graphite Electrode cartel from a social network perspective.

Ponce, Carlos <sup>1</sup>

*Universidad Alberto Hurtado - Ilades, Chile*

Roldán, Flavia <sup>2, 3</sup>

*Universidad ORT Uruguay*

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## Abstract

This article analyses the organization of communication in the Graphite Electrode cartel. By using European Commission data, we reconstruct the network of communication among cartel's participants. From this information, we can state that the Graphite Electrode conspiracy is organized in a decentralized way, where the hierarchical rank of participants was key in the organization of meetings. The low level of density index in the overall network may indicate that cartel's designers took care about security target by reducing the level of communication. The analysis of different centrality measures may suggest that cartel's instigators exerted a role of coordinators, but in a position such that they remained hidden from antitrust scrutiny. That is, operativeness could have been limited by the security target.

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<sup>1</sup>E-mail: [cponce@uahurtado.cl](mailto:cponce@uahurtado.cl)

<sup>2</sup>E-mail: [roldan@ort.edu.uy](mailto:roldan@ort.edu.uy)

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## 1. Introduction

The success of a cartel depends on the conspirator's ability to design appropriate decision making structures. As Levenstein and Suslow (2006) said "Successful cartels develop mechanisms for sharing information, making decisions, and manipulating incentives through self-imposed carrots and sticks". Moreover, successful cartels design organizational structures such that they be able to challenge any external threat.

This article describes the internal organization of communication among the Graphite Electrode (GE) cartel's members. Our aim is to understand the organizational economics of an enterprise that must operate and maintain its activities but in secret. To this end, we use tools from social network analysis.

Collusive cartels require extremely careful organization to succeed, and the organization is beyond fixing price. The organization of its internal communication is a device with two aims, namely an operativeness aim and a concealment aim against any external menace. Thus, the internal organization of communication involve to define the contacts, the frequency of contacts, who would be in contact with whom, and for what. All these things imply to define tasks and to define the allocation of authority of decision making among participants. Some relevant issues that collusive cartel designers should solve are: who and how decides on prices and on market allocations, who and how implements such allocations, and who and how monitors those agreements. In the *who* and *how* cartel designers have into account market conditions, and the pursuit both operativity in functioning and protective against any external disruption.

While every cartel has its owns characteristics and circumstances, the graphite electrodes cartel is an example among successful profitable cartels, of course while lasted. The U.S. Department of Justice's investigation when described the offence clearly stated that cartel members participated in discussions concerning: (1) the present and future prices, (2) the elimination of price discounts, (3) the allocation of volume among conspirators, (4) the division of the world market among themselves and designation the price leader in each region, (5) the reduction or elimination exports to members' home markets, (6) the restriction on capacity, (7) the restriction of non-conspirator companies' access to certain graphite electrode manufacturing technology, (8) the exchange sales and customer information in order to monitor and enforce the cartel agreement.

Meetings among cartel participants of GE cartel were the artefacts of communication to carry out tasks such as *design* of agreements, their *implementation*, and their *monitoring*. From the European Commission trial records, we have got participation or affiliation data. That is, our data consist on the description of agents who attend (or agents who are affiliated to) meetings with different aims. In this regard, we study the Graphite Electrode cartel as an affiliation network. Usually in affiliation analysing,

it is assumed that attending to same meetings is either an indicator of an underlying relationship between agents (or meetings) or potential opportunity for develop one. By means of this relationship, information and knowledge can be shared among agents (or among meetings) and coordination of activities would emerge.

In the economic literature, cartels are studied as a monolithic entity. However, the design of the necessary structure to deal with the tasks required by a collusive project is crucial for its success. We might conclude that the Graphite Electrode conspiracy was organized in a decentralized way, where the hierarchical range of participants was key in the organization of meetings. The overall level of communication is measured by the density of the collusive network. We find that density index is relatively low, and this would suggest that cartel's designers take care about the security target by restricting the level of communication. From the analysis of different centrality measures, it is possible to state that cartel's instigators exerted a role of coordinators, but in a position such that they tried to remain hidden from antitrust scrutiny.

The economic and sociological literature have studied collusion from their distinct perspectives. Both have contributed to unravel price-fixing conspiracies, and help us to frame our description of the Graphite Electrode Cartel. From the economic literature, several papers from industrial organization study problems that relate to our work. In this strand, Genesove and Mullin (2001) analyze the private discussion within Sugar cartel to study the inner working of it. From this narrative evidence, they highlight the role of communication as a device for coordination. Harrington (2006) describes from European Commission decisions collusive outcomes in terms of setting prices, market allocation, monitoring agreements, punishment methods, and some operational procedures related the frequency of meetings, and some issues related to organizational structure of cartels.

Additionally, Clark and Houde (2013) by using weekly station-level price data they conduct an empirical analysis about a cartel in the Quebec's retail gasoline market. They describe the internal functioning of the cartel and the difficulties of successful colluding given the presence of asymmetric colluding firms, and highlight the strategies used to deal with that. They find that asymmetric pricing cycles, and a transfer mechanism to low-cost stations were the artifacts used to sustain a successful collusion. In this line, Wang (2008) studies how communication is used by a retail gasoline cartel in Australia to coordinate price increases. By using a data set from the trial record, Wang quantifies the pricing dynamics and the communication patterns. He shows that the collusive communication and pricing behaviour is captured by the price cycle equilibrium of the Maskin and Tirole (1988) model. Moreover, Asker (2010) studies the internal organization of a bidding cartel by analysing the conduct of a ring in the market for collectable stamps in North America that lasted for over 15 years. From a different

perspective and by using social network tools, we also study the internal functioning of the cartel by analysing the path and the organization of communication among cartel's members.

From sociological literature, several articles from organization crime theory contribute to our understanding of this type of white-collar crime. In this strand, Baker and Faulkner (1993), Faulkner et al (2003) have largely study this kind of crime. Baker and Faulkner (1993), study the network of communication in conspiracies in switchgear, transformers, and turbines. They find that network structure depends on information-processing requirements imposed by product and market characteristics. They test the causal relationship between personal centrality in the network with verdict, sentence, and fine. Furthermore, Faulkner et al (2003) find that cartel continuity and the corporate authority of cartel are strong predictors of effectiveness in the conspiracy.

In the same line of the literature, Morselli et al (2007) analyse the trade-off between efficiency and security in criminal networks by comparing terrorist with criminal enterprise networks. They find that criminal enterprise networks, given their monetary ends, they are organized in a way such as efficiency is prioritized over security aim.

This article is structured as follows. In the next section we discuss about the organization of a collusive project. Section 3 presents basic concepts on affiliation networks, and Section 4 describes some salient characteristics of graphite electrode market. From a network perspective, in section 5 we study the internal organization of communication, and we analyse the organization of meetings and the level of coordinaton of activities. We conclude with some remarks in section 6.

## 2. The organization of a collusive project

A price-fixing conspiracy is an undertaking whose performance relies on three pillars: the *environment* in which operates (market conditions, product characteristics, legal framework, antitrust law and so forth), the *strategy* adopted to achieve its goals, and the *organization* that have to put in action such *strategy* in such *environment*.

Broadly speaking, a strategy defines a set of activities and, in order to execute them, an organization must be put in place. The main ingredients that an organization involves are both people who belong to the organization, with their background, knowledge and skills, and the relationships and communication among its members.

In terms of our problem, a price-fixing conspirators need a device that allows them to coordinate and communicate with each other to carry out tasks in order to accomplish their goals. Such device should be designed to deal with the environment that challenges the organization in two crucial issues. Namely, on the one hand, market conditions and product characteristics impose restrictions on the way to organize people and activities.

On the other hand, the necessity of secret imposed by the illegal nature of its activities restricts the path and the frequency of communication.

In the cartel's life, a set of events or tasks goes emerging, and its members are appointed to deal with them. This requires communication among cartel's members either for accomplish the tasks or for coordinate all activities. Be appointed to deal with a task or be appointed to facilitate coordination, however, is costly in terms of the necessary concealment that the illegal nature of these activities requires.

Therefore, there exists a trade-off between the operativeness and concealment in the organizational design for cartel activities. This trade-off depends on criminal's objective as a whole. Morselli et al. (2007) claim that the trade-off depends on how long horizon of the criminal's objective is. If the objective is ideological, actions can be prolonged in the time. By contrary, if the objective is pecuniary, participants expect to get their pay-off as soon as possible, and therefore actions must be carried out in a shorter time frame. So that, in this latter case, communication should be designed to achieve greater operational capacity, and assure as much secrecy as possible. In the first situation, however, communication should be organized for greater secrecy and assure as much operativeness as possible. Specifically, from literature of crime, when the trade-off between operation and concealment is solved in terms of secrecy, the communication is organized in a sparse and a decentralized way.<sup>4</sup> On the other hand, when considering the operational aim, the device should allow that information be exchanged in a fluid way. At this point, the question is how fluent the communication should be, and who should be in contact with whom, and for what.

**Operational aim** Operational aim of the organizational structure calls for fluid communication among its members. Following Levenstein and Suslow (2006), we can distinguish some functions attributed to communication among cartel members. First, communication reduce strategic uncertainty. Second, communication allows for building trust, and trust is a key factor for stabilizes collusion. Third, communication is useful for monitoring each to another. That is, the more information cartel members have, the more profitable collusion will be since it will be rarely disrupted by price war.<sup>5</sup> Additionally, more communication may positively impact on cartel effectiveness since cartel members could be aware about cartel's activities as a whole, and thereby it reduces the possibility of miscoordination among them.

In sum, in order to successfully accomplish tasks, communication and coordination are crucial. And, more coordination and communication increase the probability of

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<sup>4</sup>See Baker and Faulker (1993).

<sup>5</sup>Nonetheless Compte (1998) suggests the opposite. More information among cartel's members, it will be harder to sustain collusive outcome since information can also facilitate cheating.

success.

**Secrecy aim** As Morselli et al. (2007) claim, the interplay between time and actions is shorter in a criminal enterprise than in a terrorist network. Concealment aim calls for low level of contacts, and the relationships among conspirators are marked by high level of distance between participants. This configuration offers security but the communication among its members is low. Nonetheless, a centralized structure might be preferred since it reduces the number of agents with relevant information about activities of the illegal cartel.

### 3. A social network approach to price-fixing cartel

We assume a cartel is organized along a set of meetings (or tasks) that allow to elaborate and institutionalize cartel rules of exchange, of collective understanding regarding with who transact with whom and in which conditions. In this regard, we define a social organization structure by the triple

$$S = \{M, N, g\}$$

where

- $M$  is a set of meetings held by cartel members  $M = \{m_1, m_2, \dots\}$
- $N$  is a set of agents (or actors) who participate in cartel activities and they are indexed by  $i = 1, 2, \dots, N$ . They are executives of different ranks in the hierarchy from firms participating in the collusion.
- $g$  is a network of relationships between these two sets, i.e.  $M$  and  $N$ .

Strictly speaking,  $g$  is an affiliation network in the sense that agents participate in (or are affiliated to) cartel meetings. The design of the affiliation network  $g$  implies to set the meetings, and define who goes to which meeting.<sup>6</sup>

It is important to note that agents are linked among them only by mean of meetings; and meetings are linked among them only by mean of agents. In other words, tasks (meetings) allow communication among agents; and agents act as coordinators among tasks (meetings). Moreover, it is worth to note that to assign agents to tasks (meetings), i.e. the horizontal allocation of authority implies to define not only who are in communication with whom, but also the frequency of contacts, the frequency of attendance to certain kind of meetings, the co-attendance of agents to meetings, and

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<sup>6</sup>To attend to meetings is only by invitation, so that an actor can refuse to participate in it.

the design of meetings in regarding the rank of agents who attend to them, among other elements.

### 3.A. Affiliation networks: some concepts and notation

In social network analysis, the term “affiliation” refers to membership or participation data. That is, data consists of a set of binary relationship between members of two distinctive sets. In terms of our case, one of these sets is the set of agents ( $N$ ), and the other one is the set of meetings ( $M$ ).<sup>7</sup> In our case, the set of actors corresponds to a set of collusive employees, and the set of events corresponds to a set of tasks or meetings. In the social network analysis, a common assumption is that co-memberships in events (tasks or meetings) is an indicator of an underlying relationship; and meetings (tasks) that share members is an indicators of a liaison or coordination of meetings (tasks) through agents. Let  $G$  denote an affiliation matrix where the rows correspond to actors, and the columns are meetings (events) they attend. Thus,  $G = [g_{ik}]$  describes the “affiliation” of agents to meetings, where  $g_{ik} = \{0, 1\}$ , and  $g_{ik} = 1$  indicates that agent  $i$  attends (is “affiliated” with) to the meeting  $k$ ; and zero otherwise. We denote by  $X^N$  the matrix that indicates the number of memberships shared by each pair of agents, where  $X^N = GG'$ . Furthermore, let  $X^M = G'G$  denotes the overlap of meetings, i.e.  $X^M$  gives the number of agents shared by each pair of meetings.

**Example** Consider a set of employees  $N = \{1, 2, 3\}$  and a set of meetings (tasks)  $M = \{A, B, C\}$ . Given these two sets, a possible affiliation network  $G$  is as follows:

$$G = \begin{array}{c|ccc} & A & B & C \\ \hline 1 & 1 & 0 & 1 \\ 2 & 1 & 1 & 1 \\ 3 & 1 & 1 & 0 \end{array}$$

That is, agents 1, 2 and 3 attend to meeting  $A$ ; agents 2 and 3 attend to meeting  $B$ ; and agents 1 and 2 attend to meeting  $C$ . Given the affiliation matrix  $G$ , then  $X^N = GG'$ , where

$$X^N = \begin{array}{c|ccc} N & 1 & 2 & 3 \\ \hline 1 & 2 & 2 & 1 \\ 2 & 2 & 3 & 2 \\ 3 & 1 & 2 & 2 \end{array}$$

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<sup>7</sup>The set  $N$  and the set  $M$  are two different entities called modes. For that, an affiliation network is a two-mode network.



In the main diagonal we have the number of meetings that each agent attends,<sup>8</sup> and off-diagonal we have the number of times that an agent  $i$  meets with an agent  $j$ . For example  $x_{13}^N = 1$  means that agent 1 and agent 3 meet each other one time (in meeting A).

It is important to note  $\sum_j x_{ij}^N$  tells us the total level of activity of actor  $i$ . That is, it is the number of contacts that an agent has with other actors, counting other agents each time they are encountered.

Moreover,  $X^M = G'G$ , where

$$X^M = \begin{array}{c|ccc} & M & A & B & C \\ \hline A & & 3 & 2 & 2 \\ B & & 2 & 2 & 1 \\ C & & 2 & 1 & 2 \end{array}$$

In the main diagonal we have the number of attendees to each meeting, i.e.  $x_{33}^M = 2$  means that meeting C has 2 attendees.<sup>9</sup> Moreover, the numbers off-diagonal are the number of agents that meeting  $i$  shares with meeting  $j$ . For example  $x_{13}^M = 2$  means that meeting A and meeting C share 2 agents (in our example, agent 1 and 2) .

Again, it is worth noting that in this case  $\sum_j x_{ij}^M$  tells us the level of activity that the attendees to meeting A have had.

#### 4. Graphite Electrode Cartel

In this section, we will briefly describe the Graphite Electrode Cartel. The cartel investigation began after a customer complaint, and its activities took place around the world (U.S, Europe, Australia and Asia) between about 1992 to 1998. As a result of collusive agreements the prices rose around 45% in average around the world. In this part, we describe the market for the Graphite Electrode, and some characteristics of the production process. Thereby, we pretend to gain understanding about the communication process that was needed to hold the collusive agreement in this market.

**Product description** Graphite electrodes (GE) are large carbon columns used by electric arc furnaces (EAF) or “minimills” in the making of steel. These mini-mills use graphite electrodes to generate the heat necessary to melt scrap metal and convert it back into a marketable steel product. Electrodes can be up to 700 mm in diameter and 2,800 in length and weigh up to 2,200 kg. They form part of the roof structure of the furnace. After the furnace is filled with selected scrap, the electrodes are lowered

<sup>8</sup>This number corresponds to degree centrality of the actor.

<sup>9</sup>This number corresponds to the degree centrality of the meeting.



until the tips almost touch the scrap. Electricity is passed into the electrodes, and by this means to the scrap. As conductors of electricity, graphite electrodes generate the necessary heat (up to 3,000°C) to melt scrap steel. It is necessary nine electrodes, joined in columns of three, which are consumed in approximately every eight hours.

GEs are made from synthetic graphite, for which the primary raw materials are petroleum coke, coal tar and petroleum pitch. The manufacturing process has several steps and it takes approximately two months to be completed.

There are no product substitutes for graphite electrodes, other than traditional methods of making steel (oxygen or open hearth process). However, it is important to note that GEs make up only 6-7 percent of the cost of production in minimills. So that, if the price of GEs were to rise, minimills would be able to absorb such price increase before being obligated to shut down.

**Supply side** The major producers of GE are multinational firms. The market is characterized by an oligopolistic structure with high entry barriers.

Regarding the cost structure, almost fifty percent of GE costs are raw materials costs, about twenty percent is due to labor cost. Furthermore, the GE's production process is highly electricity intensive so that this portion of cost varies according the location of the factory.

In the legal complaint, steel producers claimed that it takes approximately four years to build a new plant with a capacity of 20,000 tones. They observed that no significant new player has entered in the industry since 1950.

Total world production of GE in 1998, around conspiracy dates, was around 1 million tones.

In this article, we are concentrated in the European market where 280,000 tones of GE were produced. In the world market, the largest produced of GE is UCAR, the second largest one is SGL Carbon, both producing in Europe and North America. The third producer is Showa Denko and its production is concentrated in Japan and United States. However, firms have a direct sales force that handle domestic and worldwide sales, as well as independent sales agents.

Other firms that supply the European market are VAW, Conradty, C/G, some Japanese producers (about 3-4% of the European market by conspiracy dates) and Indian, Chinese and Russian producers supply the rest of the demand in this market.

**Demand side** The demand for GE is linked to the production of steel in electric arc furnaces. The customers are steel producer (85% of demand).

World electric arc steel production grew 38% between 1987-1997 and by 1997, forecasts predicted that capacity of EFA would increase. On the other hand, in spite of

transportation cost and tariff barriers might well lead to higher costs, they were not sufficiently high to prevent the producers to trade on a worldwide basis.

A challenging matter in a conspiracy arise when the product offers many variants in order to match to diversity of consumer preferences. It was a important issue in the graphite electrodes cartel since the product could change by means of the length, diameter or weight.

**The conspiracy** The conspiracy took place between 1992 and 1998 approximately. The firms involved in the collusive agreements were SGL Carbon AG (SGL), UCAR International Inc (UCAR), VAW Aluminum AG (VAW), Showa Denko K.K.(SDK), Tokai Carbon Co. Ltd.(Tokai), Nippon Carbon Co. Ltd (Nipon), SEC Corporation (SEC), and The Carbide Grapite Group Inc. (C/G).

Cartel members carried out practices contrary to competition law. These practises consisted on: 1) fix the prices of the product; 2) agree on and implement a mechanism for implementing price increases; 3) allocate markets and market share quotas; 4) agree not to increase production capacity; and 5) agree not to transfer technology outside cartel members.

The machinery to define, to implement and to monitor their agreements was organized by meetings of several different levels: periodic “Top Guy” meetings, regular “Working Level” meetings, national and regional meetings, and bilateral contacts between firms. In this article, we concentrate on Top Guy, and Working Level meetings and some bilateral contacts in the European market.

## 5. Internal functioning of the Graphite Electrode cartel

### 5.A. Data and research design

The principal data source is the information publicly accessible by the European Commission.<sup>10</sup> It includes 244 paragraphs with information about cartel operation and description. We use that to create a matrix of communication. We would emphasize that given the confidentiality of this data, it was very difficult to reconstruct the exact network of communication. Nonetheless, in the Appendix we clarify the exact piece of information in which we base to construct each tie.

The final network is composed by 21 individuals and 33 meetings. We do not include national or binational meetings.

After matrix was created, all participant are distinguish by rank, and meetings are distinguished by their subject. That is, actors are labeled by the name of firm from which they belong, and by the hierarchical rank that they hold there. We consider

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<sup>10</sup>[http://ec.europa.eu/competition/elojade/isef/case\\_details.cfm?proc\\_code=1\\_36490](http://ec.europa.eu/competition/elojade/isef/case_details.cfm?proc_code=1_36490)

three levels of hierarchical ranks. CEOs are considered to be of rank 1, where 1 is the highest rank. General managers were labeled as rank 2. Sales managers were coded as rank 3.

Regarding meetings, we consider four types of meetings. Meetings of type *S* are meetings whose aim were to maintain the discipline among members. Among such kind of meeting, we also include the seminal meeting where main participants agreed the overall scheme by which the world market would be cartellised. The second type of meeting are implementation ones (*I*); that is meetings where different tasks regarding price set and market allocation are defined. Meetings of type *M* are monitorig ones; that is meetings where members share information about prices, allocation quotas and so on. Finally, we consider bilateral meetings, labeled by *B*, which are meetings held by two agents of two different conspirators. In this case, we distinguish bilateral meetings whose goal is to discipline members (*SB*), bilateral meetings for implementation purpose (*IB*), and bilateral meetings for monitoring purpose (*MB*).

In order to identified each meeting, they have been labelled chronologically (1,2,3,...), and each kind of the meetings is graphically identified by the shape of the node.

UCINET software (Borgatti et al., 2002) was used for running the analysis.

Basic statistic of cartel's organization are summarizing in the following table.

Type of meeting	# of meetings	# of attendances	Average of rank
S	5	27	1
I	4	25	2,25
I/M	1	2	3
M	14	115	2,74
<i>Subtotal</i>	24	169	
<i>Bilateral meetings</i>			
SB	1	2	1
IB	3	6	1,67
IB/MB	2	4	1
MB	3	6	1,33
<i>Subtotal Bilateral</i>	9	18	
<b>Total</b>	<b>33</b>	<b>187</b>	

Table 1: Descriptive statistics

### 5.B. The internal organizational of the Graphite Electrode cartel. A social network perspective.

In this part, our main purpose is to get a first understanding about the assignment of tasks (or meetings) to individual agents, i.e., the allocation of horizontal authority among agents. Moreover, we study the pattern and the level of communication among agents, and the coordination among tasks. That is, from a network perspective, our aim is to understand the pattern of ties both between and within each set of nodes, i.e. the set of actors, and the set of meetings.

**Assignment of tasks to agents. Allocation of authority.** In order to obtain a first qualitative understanding about collusive network structure and the allocation of authority, we present the figure 2. In this representation, we plot in the same graph both meetings and agents. Agents are represented by red circles, and meetings by squares of different colors depending on the type of meeting. A line between a red circle (an agent) and a square (a meeting) represents a tie between these two nodes (meeting and agent). That is, a line between an actor and a meeting means that this actor has attended to that meeting. In this layout, the distances between two nodes are meaningful in the sense that two nodes are close to the extent that the distance between them is short. That is, in the following graph two agents are near each other if they attended the same meetings (i.e. both actors are assigned to the same tasks), and two meetings are near each other if they are attended by the same agents (i.e., two tasks are near if they are assigned to same actors).

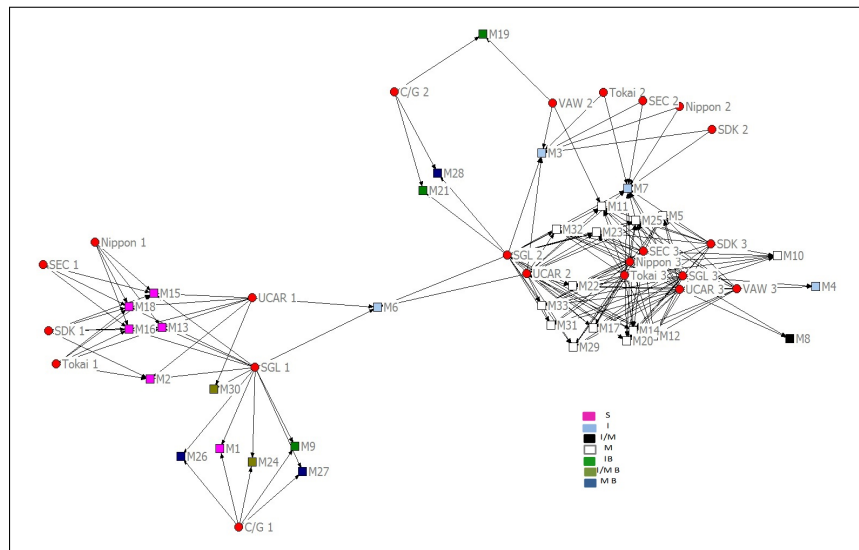


Figure 1: Agents and Meetings

This representation makes clear that the rank of actors is key in the configuration of meetings. At a first glance, we are able to distinguish that:

- Agents UCAR1 and SGL1 are connected with other rank 1's actors by meetings M2, M13, M15, M16, M18; all of them are meetings of type *S* (pink squares).

- Agents UCAR2 and SGL2 are connected with agents of rank 2 and 3 by implementation and monitoring meetings (white and light blue squares).
- Meetings of type *M* (monitoring meetings), like M5, M12, M14, M23, M25, M29, M31, M32, M33 were mainly attended by members of rank 3 (sales managers).
- Meetings of type *I* (implementation meetings), like M3, M4, M7, M8 were mainly attended by members of rank 2 and rank 3 (general and sales managers).
- Meeting M6, an implementation one, is the connection between rank 1's employees and the other group of agents.
- The firm C/G participated in the cartel in a marginal role, i.e., only C/G1 and C/G2 attended to meetings, they were bilateral contacts with UCAR and SGL's agents.
- Actors VAW1 and C/G3 are included because of we consider that some tasks could not have been done without them, however it is hard to know to which meeting they have attended, if any.

In sum, we observe a pattern of attendance; namely, agents of rank 1 have attended to meetings of type S; implementation meetings were mainly attended by members of rank 2; and sales managers have participated in monitoring tasks. This observation is also confirmed by analysing the average rank of agents who attended to each type of meeting (see Table 2).

Type of meeting	Average of rank
S	1
I	2,25
M	2,74

Table 2: Rank by meeting

From the European Commission data, we might hazard to assume that “attend to” a meeting was, in a lot of cases, an approximation to “to have” power over decisions. In this sense, we could say that the horizontal allocation of authority in the Graphite Electrode cartel has followed a sort of knowledge-based hierarchy. The allocation of authority based on knowledge recognizes that to relax time constraint in an organization less knowledgeable workers should deal with routine activities, and more expert agents should specialize on giving directions on the harder tasks. Top ranking members formed an structure that defined the main rules for the cartel and imposed discipline among its members. Thus, top managers had the role to introduce policies and practices in the cartel as well as they cared about the discipline among members. On the other hand, the agreements were negotiated by middle managers from the participating firms; and sales managers or pricing specialists were the main responsible for more routine monitor activities. We interpret that the top managers have the knowledge or resources necessary to discipline participants because, given their respective

position in their firms, they were able to transform their firm power into cartel power. That is, for accomplish their task in the cartel, top manager used the intra-organizational lines of authority of their firms, and they are the unique members in possession of such resource. In turn, sale managers, who had in charge of more routine activities, are the agents endowed with the specific knowledge about pricing and market specificities.

As a final observation, we highlight that agents from firms UCAR and SGL have acted as a kind of bridge among conspirators. Likewise, middle managers from UCAR and SGL have a lot of contacts both with members of their rank and with members of other ranks by mean of implementation and monitoring meetings.

**Observation 1** The Graphite Electrode cartel has followed a sort of knowlegde-based hierarchy where less knowledgeable agents dealt with routine activities, and more expert actors specialized on giving directions and solving harder tasks.

Now, we try to get a deeper understanding about how cartel organization deal with the coordination among tasks, and the communication among agents.

### 5.C. Operativeness: communication and coordination of cartel's activities

The above visual representation allows us to make a first approximation about cartel's organization. Now, we study the operativeness of the cartel, that is, the pattern of communication among agents, and the coordination among activities. We present the network of relationship among meetings and actors, and measure such operativeness by using indexes developed by social network analysts. In this part, we concentrate on indicators that characterize the network of communication as a whole.

**The overall level of communication.** To measure the overall level of communication we calculate the density of relationships. The density is an index that measures the degree of connection in a population. The density is calculated as the number of actual ties divided by number of all possible ties, i.e,  $n \times m$ , where  $n$  is the number of rows (agents) and  $m$  is the number of columns (meetings) in our matrix of relationships. As agents attend to more meetings, the density index increases. Thus, as density index is larger, more information can flow between agents through meetings. Nonetheless, at the same time, as agents attend to more meetings, it becomes easier to discover these illegal activities as agents become more visible.

The density score for the Graphite's cartel is 0,236 which means that of all possible ties among agents and meetings ( $n \times m = 24 \times 33$ ), 23,6% are actually present.

Covert networks are said to be sparse or to have low density.<sup>11</sup> Morselli et al (2007) suggest that density is related to the type of covert activity, where terrorist networks are

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<sup>11</sup>Demiroz et al compute a density of 9.8% for a terrorist network; Calderoni (2012) gets a density around 12% in the Ndrangheta and cocaine drug network.

denser than criminal ones. Furthermore, Hefstein and Wright (2011) argue that pre-existing relationship among members or specific attributes could explain variation in the density score among networks. Baker and Faulkner (1993) found that the density of three communication networks in the heavy electrical equipment industry were around 23.3%, 32.4%, and 35.5%.

So that, in spite of there have no common cut point as to define what it is high or low density, we can say that the graphite network is not so dense as it would be if all possible ties were formed, but it is at least so dense than other cartel cases.<sup>12</sup>

**Observation 2** Following the density score, the overall level of communication in Graphite Electrode cartel was at least as other cartel's cases, and maybe not so high as the maximum level of communication.

Now we explore deeper in the coordination of activities and the communication among agents.

**Coordination among activities.** In order to study the coordination among activities (i.e., the relationship among meetings), we concentrate about the pattern of ties that arises out of the co-attended matrix  $X^M$ .<sup>13</sup> By using the Graphite Electrode data we obtain a matrix  $X^M$  in which entries show how many agents attended both meeting in common. In the main diagonal of  $X^M$ , an entry  $a_{ii}$  accounts for the number of agents that participated in meeting  $i$  and, off-diagonal, an entry  $a_{ij}$  tells us the number of employees that meeting  $i$  shares with meeting  $j$  (see Example in Section 3). Thus,  $a_{ii}$  would measure the level of communication that a task has registered, and  $a_{ij}$  would measure the level of coordination that meetings  $i$  and  $j$  had have, in the sense that the number of agents in common ( $a_{ij}$ ) would allow that information flows from meeting  $i$  to meeting  $j$ .

The panel a) of the following graph represents the matrix  $X^M$ , and it shows the similarities among meetings, i.e. each meeting is a node that appear close to each other to the extent that these meetings share many agents.<sup>14</sup> In the graph, line thickness corresponds to tie strength, i.e. number of actors shared between meetings involved in the extremes of a line.

The diagram shows the bridging role of meeting M6, an implementation one. This meeting is co-attended by employees that also participated in seminal and monitoring meetings. Meetings in a role such as M6 could be regarded as key in the extent to which information is able to flow from one kind of meeting to the another. In a sense, it could said the same for the meetings M3 and M7.

Additionally, let us observe that monitoring (white squares) and type S meetings (pink squares) are homogeneous in the sense they are co-attended by approximately the same agents within each type of events (they are close to each other within their types). If the co-attended

<sup>12</sup>Baker and Faulkner (1993).

<sup>13</sup>See Section 3.

<sup>14</sup>It is important to note that two meetings could be similar (i.e., co-attended) just because they are well attended. Therefore, we use the Bonacich's (1972) normalization that measures co-attended relative to the size of the meetings.



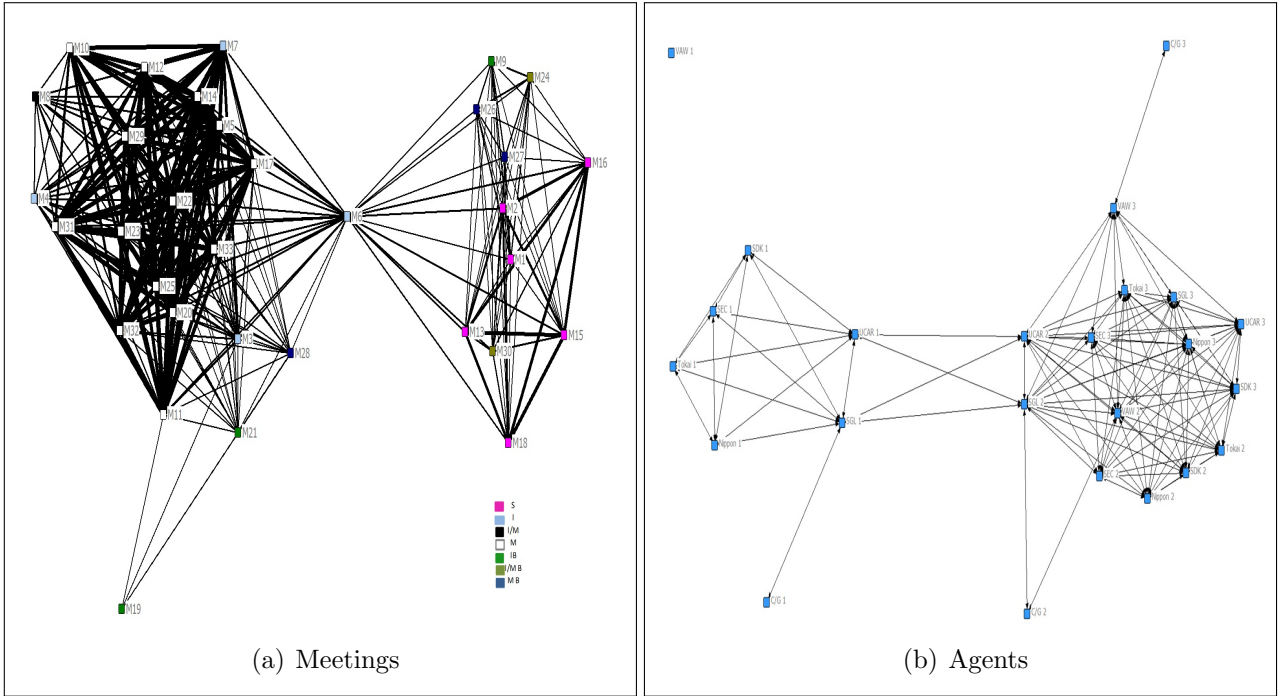


Figure 2: Co-affiliation relationships

to meetings allows the information flows among them, we may say that cartel tasks were highly coordinated.

*Density among meetings.* Members of a cartel need to meet to reach agreements, and to put these agreements in actions. The co-attendance to meetings might impact on the success of agreements that they have reached. Joint attendance might have positive impact on the organization of communication as it would allow a better coordination among tasks by mean of communication of agents that co-attend to meetings.

We study the general level of coordination among tasks by analysing the density index of  $X^M$ . Density between meetings measures the degree of co-attendance and connection among them. This index is measured as the number of pairs in common in terms of all possible ties. The value of the density among meetings is the average number of agents who belong to each pair of meetings. The density index for Graphite’s cartel is 2.04, i.e., in average, a pair of meetings have had 2.04 agents in common.

Furthermore, we can partition the set of meetings into the five type of meetings, and we analyze the density within and between groups as a more precise measure of coordination between tasks.

In the main diagonal, we have the number of agents in common by a pair of meetings of the same type. For example, type *S* meetings shared, in average, 3.60 actors. In the case of implementation meetings, this index is of 1.6 actors in common by each pair of meetings; in turn meetings of type *M* had in average 7.52 agents in common.

Furthermore, off-diagonal values measure the number of agents that different kinds of

	S	I	M	IB	MB
S	3.60	0.37	0.00	0.83	0.78
I	0.37	1.60	3.07	0.32	0.33
M	0.00	3.07	7.52	0.20	0.31
IB	0.83	0.32	0.20	0.5	0.87
MB	0.78	0.33	0.31	0.87	0.67

Table 3: Density among Meetings by type

meetings share between them. These values allow us to study the coordination between tasks because agents, that meetings have in common, facilitate coordination given the information that they allow to flow between meetings co-attended. There are a high level of coordination among implementation and monitoring tasks since meeting *I* and meetings *M* have in average 3.07 agents in common. Moreover, actors who have attended to *S* meetings also attended to other kind of meetings, but in this case they were some implementation or bilateral encounters. Actors who have attended to *S* meetings never attended to *M* ones, and vice versa.

Finally, although tasks *S* and *M* apparently was not coordinated, implementation meetings may have acted as the liaison between them.

**Observation 3** Monitoring meetings had have a high level of coordination within their respective type. Additionally, implementation meetings may have acted as the liaison between tasks *S* and *M*.

**Agents.** We analyse the communication among agents by studying the pattern of ties that gives rise matrix  $X^N$ . The main diagonal of  $X^N$ , the element  $a_{ii}$  counts for the number of meetings that agent *i* has participated. Furthermore, the element  $a_{ij}$  reveals the number of times that agents *i* and *j* have met. The panel b) of figure 2 is similar to panel a), however in this case it plots ties from matrix  $X^N$ . This visualization allows to see similarities among agents in the sense that each agent is a node that appear close to each other to the extent that these agents have attended to same meetings.<sup>15</sup> As before, line thickness corresponds to tie strength, i.e., number of meetings shared by agents in the extremes of the line.<sup>16</sup>

Let observe the pattern of communication among cartel's members. From the picture, we can follow that agents of rank 1 are in communication among them since these agents are close to each other in the sense that they attended to the same meetings. The same observation is valid for agent of rank 2 and 3.

From the above graph, we are able to understand the marginal role of agents from C/G and from VAW, and the crucial role of agents of rank 2 from UCAR and SGL. The last two ones are the agents that connect all other agents of rank 2 and 3 among them. Moreover,

<sup>15</sup>The Bonacich's (1972) normalization in this case measures co-membership relative to the number of meetings attended by agents.

<sup>16</sup>It is the co-membership of a pair of agents.

agents UCAR2 and SGL2 are the link between agents of rank 1 and all other agents. This evidence would seem to show that these agents were the main coordinator among remain of agents.

*Density among agents.* To analyse the level of communication among agents, we compute the density index from matrix  $X^N$ . The value of the density among actors is, in average, 2.55; i.e., in average a pair of actors met together 2,55 times.

We are able to compute the same measure by taking into account the rank of actors. The following table depicts the relationship among the rank of agents.

	1	2	3
1	3.24	0.071	0.00
2	0.071	1.96	3.70
3	0.00	3.70	12.14

Table 4: Density among agents by rank

Agents of rank 3 are the more active ones, and they met each to others, in average, in 12,14 meetings. Agents of rank 1 have also a fair frequency of contact; in average, agents of rank 1 met 3,24 times.

It is important to note that, in spite of rank 2’s agents had have less contact among them, they were an open group in the regard that they met with other groups of agents, specially with agents of rank 3.

**Observation 4** Sale managers were the more active agents, i.e. agents with high level of communicaton. In turn, middle managers were an open group in the sense they were in communication with agents of rank 1 and 3.

#### 5.D. Operativeness versus Security. An assessment through centrality measures

The precedent analysis characterize the general pattern of communication and coordination among cartel’s tasks. Now, we concentrate at agent level, and we study who were the more active agents, who were the agents with greater level of communication, and who were the agents that facilitate the coordination of activities. To do that, we provide a family of measures of centrality based on agent position on the Graphite Electrode’s social network. The Appendix contains the scores for each node for each centrality measure.

If we assume that more communication and coordination is always better, then a lower level of communication or coordination than a reference one could be indicating a sacrifice in the operativeness of the cartel. A number of reasons may be behind this hypothetical fact. We assume that one of them might be a security reason. That is, communication is good but it might increase the visibility of agents faced to antitrust scrutiny. Therefore, some sacrifice

in the level of communication would decrease the level of exposition of agents to antitrust authority.

*Degree centralities.* The degree centrality of an agent is the number of events to which an agent has attended.<sup>17</sup> This measure gives an idea about how active is an actor.

In the Graphite cartel, agents that have more degree centrality are SGL2, SGL3 and UCAR3 in this decreasing order for the score.

This centrality measure points out the more active nodes. An agent with high degree centrality is an active node with a potential greater access of information since he/she attends to a high number of meetings. As the level of activity increases, however, agents will be in a more visible position faced with antitrust scrutiny.

*Betweenness centrality.* Betweenness centrality focuses on the extent to which actors sit on paths between other pairs of actors. That is, betweenness centrality measures the ability of a node to control flow of information. In other words, betweenness centrality captures which nodes act in a role of coordinators and gatekeepers of information.

In the Graphite cartel, actors with highest betweenness centrality are SGL1 and SGL2.

*Eigenvector centrality.* We concentrate now on the centrality of actors by considering that an actor is central on the extend that they have ties to other actors that are themselves central.

In the affiliation context, the centrality of an actor is proportional to the centralities of meetings to which the actor has attended.<sup>18</sup> This measure explicitly incorporates the duality between actor and meeting centralities.

Actors SGL3 and UCAR3 have had the highest index score; SGL2 and UCAR2 are also quite central according eigenvector centrality.

**Operativeness and Security. Discussion.** The following figures depict the relationship between hierarchical rank and degree, betweenness, and eigenvector centrality. To allow us to make easy comparison across measures, we have rescaled all centrality scores so that each one ranges between 0 to 1 by dividing by their corresponding maximum values.

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<sup>17</sup>This measure is normalize by the maximum value possible in a graph of that size which allows comparability.

<sup>18</sup>Additionally, the centrality of a meeting is proportional to centrality of members affiliated to it.

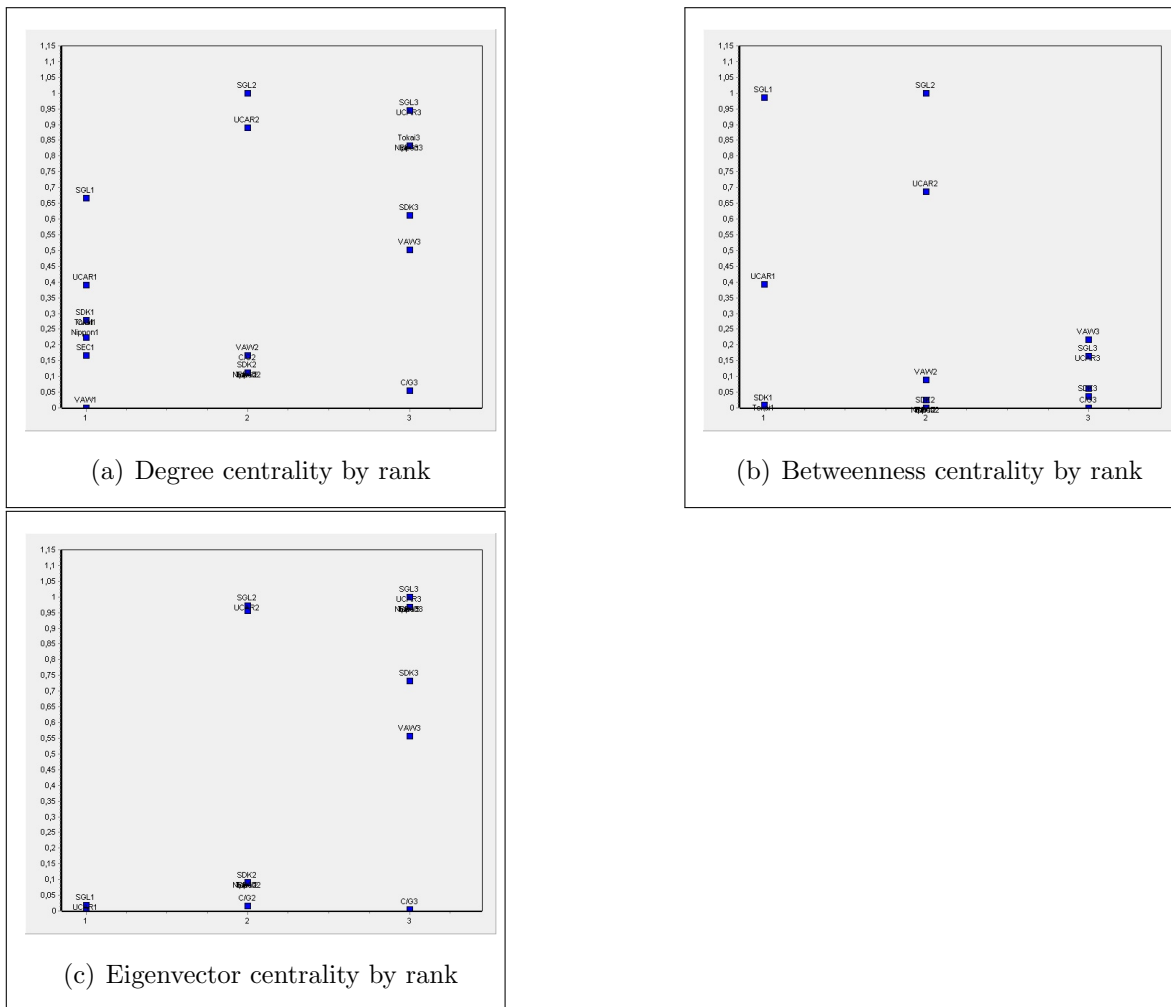


Figure 3: Centrality measures by rank

Panel a) shows that agents of rank 3 display higher degree centrality than other ranks. Additionally, it is clear that, relative to their own ranks, agents from UCAR and SGL are the more active ones.

Betweenness centrality provides a good notion about who has a better control over all activities, since it measures the extend to which a node is on the shortest paths between other pairs of nodes. This position allows a node to have a strategic brokering power. Figure in panel b) shows that agents of rank 1 and 2 from UCAR and SGL have greater betweenness centrality scores than the other agents. Thus, these actors appear to have a brokerage roles for control and for the exchange of information.

In some sense, more active nodes are in a more vulnerable position than less active ones given his/her level of exposition and visibility faced with external agents. A more strategic position is one such that allows undertake the tasks assigned and, at the same time, it provides protection in case of an investigation. Eigenvector centrality captures this notion since the level of activity is greater not only if an actor attends to more meeting but also if he/she attends to more central meetings where the flow of information might be greater. Panel c)

shows that agents of rank 3 have a higher eigenvector centrality since they were more active in more central meetings.<sup>19</sup>

*Covert coordinators. Operativeness versus Security.* If operativeness goal claims for more communication, and security goal calls for less communication, then the result of the trade-off between operativity and security could be followed by Figure 6.

The next picture shows that even if SGL1 and UCAR1 have a level of activity near or greater than the mean, they did not attend to central (or crowded) meetings. The last observation can be followed by their respective low eigenvector centrality scores. Nonetheless, they have acted in a strategic position as brokers as it is revealed by their betweenness centrality scores. Therefore SGL1 and UCAR1, as leaders of the cartel, have acted as coordinators but in a covert position according the comparison between their respective betweenness and eigenvector scores.

On the other hand, agents such as SGL2 and UCAR2 have had a lot of activity, which can be followed by their degree and eigenvector scores, but they also have acted in a broker position (high betweenness centrality).

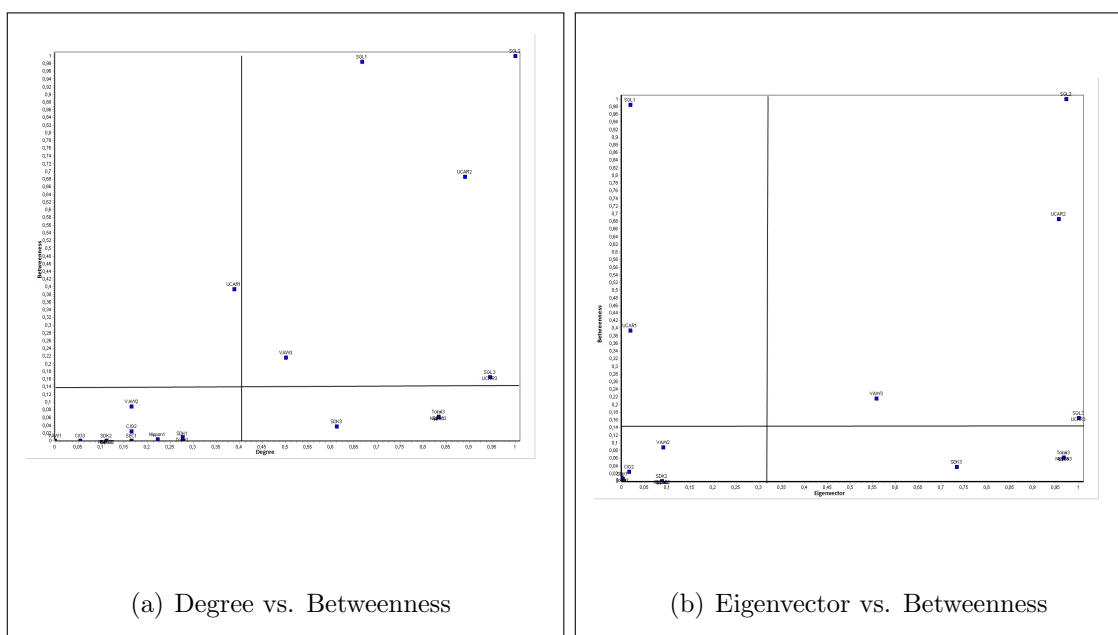


Figure 4: Efficiency vs. Security

**Observation 5** Cartel’s leaders, SGL1 and UCAR1 have acted as coordinators (high betweenness centrality) but in a covert position (low eigenvector centrality).

<sup>19</sup>The degree centrality of a meeting is measured by the number of agents that attend to it.

## 6. Concluding Remarks

In this article, we reconstruct and analyse the Graphite Electrode cartel from a perspective that combines some elements from economic theory and tools from social network analysis. By doing that, we try to open the “black box” of a conspiracy, recognizing that a cartel is not a monolithic entity. We study the internal organization of communication among participants of the conspiracy. From the analysis, we find that the Graphite Electrode conspiracy was organized in a decentralized way, where the hierarchical range of participants was key in the organization of meetings.

Moreover, the overall level of communication measured by the density index is low, and it would seem to show that cartel’s designers took care about security aspects of the organization by reducing the level of communication among cartel’s members. We also find that monitoring tasks were highly coordinated, and implementation meetings may have acted as the liaison between the other kinds of tasks.

From the analysis of different centrality measures, we can say that cartel’s instigators exerted a role of coordinators, but in a position such that they tried to remain hidden from antitrust scrutiny. That is, coordination as a proxies of operativeness could has been limited by the security target.

Our analysis is a first step in the understanding how a cartel operates from a social network perspective, and it is the first part of a bigger project where we pretend to model, from an economic theoretical perspective, the internal organizational of covert activities, either criminal or just secret activities by using tools from social network theory.

## 7. Appendix

**Appendix 1.** Data from European Commission

**Appendix 2.** Affiliation data

**Appendix 3.** Centrality measures



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