

CENTRALITY AND INVESTMENT STRATEGIES AT THE BEGINNING OF THE INDUSTRIALIZATION IN MID-19TH CENTURY CATALONIA ¹

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Abstract

We apply social networks analysis to the study of an important database on investment and companies' share in Catalonia (Spain) of the 19th century. In contrast with most of the existing related literature, usually addressing power relationships across administration boards, we focus on the structure of interactions among individual investors and firms. Centrality analysis uncovers interesting roles played by certain economic sectors (e.g. textile and financial). Furthermore, the diverse composition (in terms of economic activity) of communities in the network (subgroups more densely connected internally than with the rest of the network) reveals a high investment diversification, which nicely agrees with a known characteristic of traditional Catalan business strategies.

Keywords

Social networks analysis, investment strategies, Barcelona, 19th century, centrality, structural communities.

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1 INTRODUCTION

Traditionally, research on business strategies has treated companies as autonomous entities, focusing on the development of competitive advantages based on the optimization of external resources and internal capacities. As from the mid 1980s, however, this tendency was complemented by growing attention to the interactions among organizations. On the one hand, strategies employed when establishing alliances are studied. On the other, the way in which the behaviour of companies is conditioned by this previously-established set of interactions and relations (Gulati, 1998). A consequence of this tendency is the forceful appearance of the analysis of social networks applied to the study of interactions and relations among companies (Grandori, 1995). This type of work is based on the study of the structural properties of networks in which the companies are represented as nodes (vertices) and the ties correspond to different types of connections between them. Some typical examples of the relations considered in this type of work are the supply, contracting, collaboration and interchange of information or the coincidence of common members in the respective administration boards (*interlocking directorates*).² In fact, the study of the firm network derived from links between his management boards, and the power relationships that it entails, has appeared in the literature on social networks analysis for several decades.³

Following this trend, we go further and, in a historic backdrop that is characterized by the take-off for industrialization in Catalonia, we have not considered the study of the management boards (that is out of our extent) and we have focused on the analysis of the relationships between investors. To do this, we have developed a line of research concentrating on the application of social network analysis to the study of an important database on investment and companies shares in Catalonia in the 19th century. This database will be described in detail later, but we have to say that this database picks up of more than 4,000 companies which had been constituted between 1815 and 1866, excluding individual companies. The *Base de dades Empreses i Empresaris a la Catalunya del s. XIX, Departamento de Historia e Instituciones económicas de la Universidad de Barcelona (en adelante BDEC-DHiE_UB)* contributes with information on both the companies and their owners. The main objective of our research is to deepen our understanding of business behaviour during the mid-19th century, a period of enormous importance for the history of Catalonia and of Spain, coinciding with the early stage of the region's industrial transformation. The methodology used combines qualitative procedures (systematic analysis of historic sources in our particular case) with quantitative analysis techniques and the modelling of social networks.

Generally, when talking about social networks we understand that it is defined as a structure made up of social actors (organizations or individuals), connected by one or several types of links (Wasserman and Faust, 1994). This structure serves as a support for multiple social processes. From an economic point of view, the most noteworthy functions of social networks is the channelling of information flows that circulate in different organizations, enabling the coordination as it facilitates the reduction of information costs (Granovetter, 1985). It is reasonable to assume that the social networks among investors in the 19th century performed this function, bearing in mind that we are referring to a historical moment in which the foundations for the modernization of the economy were being established.⁴ Starting from this idea, in previous works (Badia-Miró, Blasco, Lozano & Soler, 2007; Blasco, Lozano & Badia-Miró, 2007) we have built and analyzed social networks as the nodes to correspond to individual investors; a link between two nodes represents one or more joint investments (in the same company). The above-mentioned exercise allows us, among other results, to highlight who were the people who occupied strategic positions on the investors' network (especially concentrating and distributing information) (Barabasi, 2002; Watts, 2003), those mediating between different

² (Stark & Vedres, 2006).

³ (Allen, 1974; Burt, 1978; Koenig & Gogel, 1981; Casson, 1997).

⁴ In this sense we can understand (Lamoreaux, 1994) analysis of "insider lending".

investment groups (Gould & Fernandez, 1989), and the Catalan marriages (Galí, 2002; Fernández & Puig, 2007).

The current work adopts a completely different orientation. We are not interested in the role played by the social networks in supporting the coordination of the investment activity. Our interest is the structural approximation as a tool in analysing a huge amount of detail on economic behaviour (in this case, investment strategies). The later analysis of resulting structures gives us information on individual investments (investor 1 participates in firms A and B), on collective behaviours (firms A and B are participating as investors who specialized in sector α and also for investors concentrating on sector β , constituting a meeting point of sector investors' groups that are economically different). This permits us to ask ourselves about the investment strategies at a historical moment and to understand their subsequent determination in the construction of the business framework in a territory, Catalonia, which is characterized as being key to Spanish industrialization. In this way, we search for answers to some of the questions formulated in recent years regarding the strategies followed by investors, the role of certain economic sectors in the formation and development of the companies (and within them, the specific role played by some of them), the legal structure taken by companies with greater weight within the network, and the importance that the external source of capital might have had. In that sense, our hypothesis is that those strategic firms behind economic development played a central role as nodes of a network where other small pre-existing sub-networks converge jointly with other isolated investors. This, in addition, will be reinforced by the fact that a huge part of those initiatives were boosted by some of the investors whose prestige would help to strengthen the central role of the abovementioned firms. However, all of that took place before the railway fever, which started in 1855, and before the laws that eliminated restrictions on the creation of firms that were enacted during the so-called Progressive Biennium between 1855 and 1856 (Herranz, 2008; Sudrià & Pascual, 1999).

The aim of this article is to contribute empirical evidence about the existence of an organized business network as a result of the industrialization process in mid-19th century Catalonia, given the conditions of both economic development as well as the development of the information and communication media of the time. The article has been structured in the following way: the first section offer a brief revision over the historical framework where we have developed our work; the following part briefly describes how we elaborated the database which should permit us to demonstrate the existence of such a network; this is followed by the presentation of the methodology used to present empirical evidence; we continue with an exhibition of the main results obtained, combining the analysis of the network as a whole with the analysis of the subgroups which appeared from the analysis of the communities applied to the main network. The article closes with a section dedicated to conclusions.

2 CATALONIA AS A CASE STUDY

The Spanish industrialization process was late and was unequally distributed across the peninsula. Towards 1850, Catalonia was the only zone in Spain which had advanced in the industrialization process based on progress in the cotton industry. From the 17th century, and particularly during the 18th century, trade developed in the region, linking the old relationships of the Mediterranean area with those of the Atlantic. This was the basis for the development of the cotton manufacture of the seventeen hundreds and the subsequent industrialization, during the 19th century. In this way, Catalonia experienced industrial development comparable with that of other European regions such as Alsace, the textile regions of Switzerland, Lombardy or Lancashire itself.⁵

The two activities, industry and trade, maintained a strong overlap throughout the century, impacting on the substantial development of the Catalan economy. The industrialization involved a process of modernization of the economy. It is no coincidence that it was in

⁵ (Pollard, 1982; Thomson, 1992).

Barcelona, in the mid 19th century, where one of the first banks of the peninsula emerged (the Banco de Barcelona), nor that one of the main industrial public limited companies had been established in this territory (la *España Industrial*, *Sociedad Catalana para el Alumbrado por Gas*, *La Maquinista*...) or that the first railway in the Iberian Peninsula was constructed between Barcelona and Mataró, also in the same period. This flourishing of businesses was closely linked to the growth of commercial and industrial activities.

The first forty years of the 19th century in Spain were characterized by continuous political unrest, military conflicts and economic stagnation. The first legislation during the 19th century over the mercantilist activity was the Trade Code of 1829, inspired by the French code of 1801. Three firm types were considered: those were the partners share rights and obligations, proportionally to the capital contributed by each of them (*general partnership firm*); in other cases, the partnerships lent the capital to be managed by other members, who became responsible of the firm and, at the same time, they were held responsible with their heritage (*limited partnership firms*) and, lastly, those firms which created a share funds and yield the management to some administrators appointed by the owners (*corporations*). In that legislation, some restrictive criteria were established to the creation of *corporations*, such as the requirement of a previous approval by the commercial court or, if a privilege was desired, the royal approval.⁶

In 1847 the law was modified with a royal decree and, lastly, in 1848 a Corporation Law was approved with restrictive criteria since this firm type had to be approved by a law of the National Court (in the case of the issues banks, transport companies o other firms with an special privilege), or a parliamentary decree (in the case of public utility firms).⁷ This legislation was kept until the rise of the liberal party to power in 1854. The result of its derogation was the proliferation of companies throughout the territory.⁸ In Catalonia, there was a long tradition of the company model based on general and limited partnership companies. By 1855, most companies had adopted these legal formulas, the former being the predominant form of joint ventures.⁹ Corporations only emerged strongly in the mid 19th century, led fundamentally by the railways. On the other hand, in mid 19th century Catalonia, investment decisions were conditioned by personal relations, and consequently depended to a large extent on the reputation of the managers of the companies. Thus, these decisions were determined by trust relationships among business people. Investment agents obtained the necessary information to make decisions through social networks. Social influence and trust-based relationships were strong enough to ensure that investments decisions were not strictly individual, but rather occurred in the framework of a social network.

The analysis of the investments made in the Catalonian economy in the mid-19th century can be approached from a dual perspective: on one hand, by emphasising investor networks where links appear when two individuals invest in the same company; and on the other hand, by concentrating on the company networks in which the link between two companies means that both share at least one common investor. The first type of network was analyzed in (Badia-Miró et al., 2007; Blasco et al., 2007). The aim of this study is to analyze the second type of network. For this reason, we consider the participation of investors in the main business initiatives in Catalonia in that time.

⁶ *Código de Comercio, decretado, sancionado y promulgado en 30 de mayo de 1829*, Madrid. Oficina de D.L. (Amanita, 1829, p. 123).

⁷ 28th January, in 1848 law. (Tortella, 1968)

⁸ It is especially important the liberalization of the possibility to create a *Corporation* and the deregulation of railway and financial sector (Desamortization law of Pascual Madoz, railway law in 1855 and law of 28th of January, 1856).

⁹ (Sudrià & Pascual, 1999).

Between 1815 (end of the Napoleonic wars) and 1855 (change in the regulatory framework)¹⁰ about 2,152 companies were established in Catalonia which meant an investment of approximately 174 million pesetas. The bulk of investment during this period went into industry. However, at varying paces and proportions, the financial sector, the railways and, in general, the other economic sectors (other means of transportation, construction...) intensified their dynamism after 1840, signalling the appearance of a new investment cycle, which occurred after 1855.¹¹

Table 1
Investment in Catalonia by economic sectors, 1815 – 1855 (current pesetas)

	Industry	Trade	Finance	Railroads	Others	Total
1815-1825	1,381,734	2,257,256	0	0	334,006	3,972,997
1826-1835	4,407,761	3,484,946	106,800	0	612,663	8,612,170
1836-1845	20,283,482	9,153,944	1,927,500	0	6,839,286	38,204,212
1846-1855	70,992,989	15,740,808	2,672,500	19,680,000	14,429,587	123,515,884
Total	97,065,967	30,636,955	4,706,800	19,680,000	22,215,542	174,305,263

Source: Database BDEC – DHiE_UB.

This investment process reinforced Barcelona's central role as the city where most of these initiatives were concentrated. The groups of traders, *indianos*, manufacturers, dealers and rich farmers who converged during the mid-19th century in diverse business investments (industries, business concerns, railways, finances and insurance) were mainly responsible for industrialization. An analysis of their economic strategies improves our understanding of the process of Catalan industrialization.

Although our period of study is between 1815 and 1855, much of the investment effort was made during the last decade, pointing out the period with a maximum of business development. As can be observed in Table 1, industry represented 56% of investments over 1815-1855, however, with a downward tendency, as in the following decade it represented just 43% of total investment. Finances and railways grew significantly and trade maintained its participation touching on 20% of total investment. In all these sectors, the creation of companies was very important in the mid-19th century. In the industrial and commercial sector, most of the companies were dormant companies and, particularly in the industrial companies, resorted to proximity networks and the reinvestment of profits to finance both the fixed capital needs as well as, often but to a lesser degree, those of working capital. However, in the transport, finance and insurance sectors important experiences in public limited companies occurred. The first Corporation created in Catalonia was the *La Sociedad Barcelonesa de Seguros Marítimos* (1838) and the first Corporation bringing together more than 300 shareholders was the *Banco de Barcelona* (1844). As a result of the liberal laws of 1855-56 favouring the expansion of the railways and of issuing banks and credit companies, companies with stockholders and bondholders multiplied.

These investment mechanisms still elude researchers. According to what we know to date, during this period, the profitability of the industrial companies, while not extraordinary, surpassed the usual interest rate, set at around 5% or 6%. As has already been indicated, this permitted them to avoid debt, maintain investment in fixed capital and, additionally, to regularly share out profits among shareholders.¹² From the perspective of the individual investor, what we

¹⁰ The so-called "bienio liberal" (1854-56) made possible important changes in the regulatory framework. The most important laws approved were those which favoured the railway extension (1855), the law which facilitated the confiscation of Church properties (1855, known as the Madoz disentitlement laws), and the law which favoured the openness of new banks and issuing societies (1856).

¹¹ On the investment cycles in Catalonia, see (Carreras & Sudrià, 1987; Sudrià & Pascual, 1999).

¹² (Soler, 1997).

know to date indicates that the Catalan investors of the mid-19th century opted for diversification above specialization. It appears that individuals systematically opted against concentrating their investments in one sector or one company only. Therefore, apart from industry, there was a whole range of alternatives: the debt of a state always facing financial problems, real-estate property, transport, etc¹³. This probably responded to a secular tradition of small-scale investment in a variety of options to diversify the risks involved in getting ahead in an economy subjected, cyclically, to crises and an unstable political system. To go further in the study of those mechanisms, we use the *BDEC – DHiE_UB* and we apply our own methodology to the analysis of social networks.

3 INVESTMENT NETWORK OF FIRMS DURING THE FIRST INDUSTRIALIZATION IN CATALONIA

3.1 DATABASE

The proposed analysis required a database which would permit us to combine the companies with the people who ran them and who participated in them by contributing capital. To that end, we have had at our disposal the data from the *BDEC – DHiE_UB*. This database was generated from an exploration of practically all the Catalan notary registry offices available: Figueres, la Bisbal d'Empordà, Santa Coloma de Farners, Girona, Olot (in the province of Girona); Barcelona, Berga, Sant Feliu de Llobregat, Igualada, Manresa, Mataró, Sabadell, Terrassa, Vic, Vilafranca del Penedès, Vilanova i la Geltrú (in Barcelona); Montblanc, Reus, Tarragona, Tortosa, Valls, el Vendrell (in the province of Tarragona). With this, we obtained extensive coverage of the territory that the Catalan regions constitute.

In order to explain the origin of the data, we should pause for a brief description of the *BDEC – DHiE_UB*. This database includes two types of information. On one hand, it contains 9,921 entries concerning companies from the period 1815 to 1866 (although this study is restricted to 1855) including deeds of constitution, reconstitution, modification of social pacts, capital widening or any other type of contract which contributes relevant information about a specific company. In these registers, data compiled included the company name, the activity or corporate purpose, the capital, the address or location of the activity and a comprehensive summary of the principal clauses of each of the social contracts. In cases where the document identified the members who constituted such companies, information was collected about name, profession, place of residence and of birth (if indicated) and capital furnishing. Thus, a database of 44,218 entries about people was obtained. With all the information available, a process of cleaning up and homogenisation of the data was undertaken in order to work with them.¹⁴

Based on this, the main companies and their most relevant public figures can be distinguished and thus we constructed our own database in order to analyze of the existence of business networks in 19th century Catalonia. In this sense, the first step was to establish a ranking of the companies founded between 1815 and 1855 based on the investment carried out in each one of them. This timeframe was selected because during this year one of the main cycles of investment in Catalonia, focused particularly on industry, closed. This cycle was influenced by the railway law (1855) and the law of credit companies and issuing banks (1856) which stimulated a new investment cycle. Thus, we can affirm that we would find ourselves faced with a different framework of analysis. For this reason, we have also excluded the investment in railway companies from our database.

Based on the ranking of companies established, we have considered those that, throughout the period of analysis, paid out capital between 300,000 and 8.000.000 pesetas. From this group,

¹³ See (Vicens Vives, J. & Llorens, M., 1954; Pascual, 1990) and the case study of (Gali, 2002). On Catalan entrepreneurship, see (Cabana, 2006) monograph.

¹⁴ A detailed description of the corrections and adjustments applied in the construction of the database *BDEC – DHiE_UB*, can be consulted in (Soler, 2003).

those companies without references to members have been excluded, that is to say that they did not serve any purpose for the analysis.¹⁵ In this way, a database was created of 93 companies and 1,124 members distributed among the sectors and socio-professional categories illustrated in Tables 2 and 3. These data should permit us to determine whether or not business networks operated during the process of modernization of the Catalan economy of the 19th century.

Table 2
Number of firms by economic sectors

	Companies	%
Agriculture	1	1,08%
Mining of coal, energy (gas) and water	4	4,30%
Mining (metal and non-metal) except coal	2	2,15%
Metal and metallic constructions	6	6,45%
Textile	39	41,94%
Other industries	5	5,38%
Construction and public works	4	4,30%
Commerce	19	20,43%
Transport not railways	5	5,38%
Finances and insurance	4	4,30%
Others	4	4,30%
Total	93	

Table 3
Investment by profession

	No.	%
Trader	386	34,34%
Manufacturer	101	8,99%
Landowner	47	4,18%
Professional workers	34	3,02%
Artisan	12	1,07%
Civil servant	10	0,89%
Firm	7	0,62%
Technical workers	6	0,53%
Others	2	0,18%
Not mentioned	519	46,17%

3.2 METHODOLOGY

As previously explained, in this analysis we have constructed and analyzed investment networks based on data about the participation of more than 1,000 investors in the main companies operating in Catalonia between 1815 and 1855. The networks obtained from this type of information are the so-called bipartite or membership networks. This type of network is made up of two types of elements, one normally of individuals and the other of projects or organizations to which the individuals belong (and from there, the name) or where they

¹⁵ See (Badia-Miró et al., 2007).

coincide.¹⁶ In our case, we deal, respectively, with investors and companies in which they participated. The usual way of working with this type of network is to break them into two, one for each of the two types of elements. In this way, a network of investors and another one of companies was obtained. This article focuses on the study of the company network.

In general, the networks are made up of vertices or nodes and ties or links. In our company network, every one of the vertices represents one of the companies and the existence of links between two of them indicates that these have at least one mutual investor (as explained further on, this criterion can be made stricter establishing a minimum of 2 or more mutual investors). This definition of the ties between companies can be understood in the context of the recent bibliography on studies of company networks whose connections are based on the ownership of a part or all the capital, referred to previously in the introduction.

Once the company network was constructed, we proceeded to its analysis by means of a graphic representation of the network and a calculation of the centrality of the different companies within it. The *centrality* of a node in a network measures its importance in the network as a whole. The concept of centrality has traditionally received a lot of attention from analysts of social networks, particularly since Freeman analyzed and formalized mathematically three of its main types of measurement.¹⁷

3.2.1 Measures of centrality

In this study we have used two types of centrality measurements: that of degree and of intermediation (or *betweenness*).¹⁸ Both measurements contribute information about the importance of each vertex in the network, however each one of them presents certain nuances which will be clarified in the following paragraphs. In general, the degree of centrality of a specific node corresponds to the number of ties it has, that is to say, the number of vertices it is connected to. In the case of our company network, the importance of this type of centrality lies in the fact that the greater the degree centrality of a company in our network (e.g. greater number of companies to which it is related), the more complex and richer its relationships of supply/contracting, collaboration and interchange of information may be, traditionally the object of study in literature on company networks.¹⁹

On the other hand, in order to calculate the ‘betweenness’ centrality of the nodes of a network, first we obtain the minimum existing paths between each pair of vertices, that is to say, the shortest list of intermediaries necessary to bring two nodes into contact following the ties of the network (for example, if two companies are directly connected, the distance is 0 because intermediary nodes are not needed). Once all the minimum paths are defined, the ‘betweenness’ centrality of a specific node v is calculated as the proportion of minimum paths which go through it:

$$C_B(v) = \sum_{\substack{s \neq v \neq t \in V \\ s \neq t}} \frac{\sigma_{st}(v)}{\sigma_{st}}$$

Where σ_{st} is the number of minimum paths between s and t (each of the possible pairs of nodes), and $\sigma_{st}(v)$ is the number of minimum paths between s and t which cross the vertex v .

In our case study, the importance of the measure of centrality lies in that this permits us to identify and quantify the relevance of certain companies as mutual or strategic projects carried

¹⁶ (Wasserman & Faust, 1994).

¹⁷ (Freeman, 1978).

¹⁸ (Freeman, 1978).

¹⁹ When two or more firms share an investor, the number of links between them is considered in our analysis, thus, the existence of a link between two firms considers the number of investors shared.

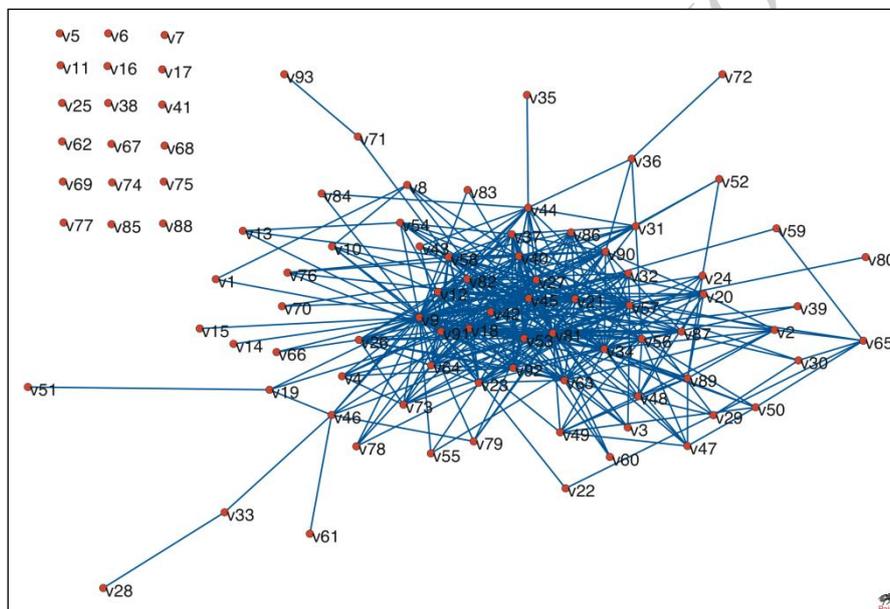
out by different *holdings* of investment groups which, in general, participate in different projects. Thus, if most of the minimum paths between two companies s and t , which different groups have shares in, pass through a third company v (where both investment groups share ownership), this means that company v is an exceptional case of a mutual project between both investment groups.

3.3 RESULTS

We have obtained a network from the companies established (or whose ownership experienced important changes) in Catalonia during the early 19th century, in such a way that the ties between the two companies represented the existence of, at least, one mutual investor.

The construction of the social network which emerged from the coincidence of investors in the same company allows for the application of the analysis of social networks which we have just described. A set of outstanding results emerges from this. We can hereby observe which companies occupied a central position in the business framework of mid-19th century Catalonia or, which occupied a secondary place, whether because they were not in the main network or because they were outside of it (see Figure 1).

Figure 1 - Company investment network



Source: Own elaboration from the data of BDEC – DHiIE_UB. *Pajek* was used for the graphic representation of the network.

3.3.1 Basic network

As we have shown, the networks which we analyse derive from the common investments of all those individuals with some participation in the 93 enterprises with an initial investment of over 300,000 pesetas. In light of this distribution we can state that there are several degrees of centrality in enterprises.

A first group would be composed of those enterprises with a greater degree of centrality in the network (reflected in both of the measures considered). Among these, of note are *Juan Soler de la Torre y Cía.* and *Banco de Barcelona*, which obtain significantly greater values than the rest of the enterprises (above all in degree centrality). Of the ten enterprises with a greater degree of centrality, those from the financial sector predominate (3 which is 75% of the total) and those

belonging to Other Industries (3 of a total of 5 enterprises). By contrast, companies from the textile sector are underrepresented (2, both public limited companies) as well as those in the Trade sector (0). These central firms are, apart from the two abovementioned: *Industrial Quincallera*, *Fabril Algodonera*, *Lloyd Barcelonesa de Seguros Maritimos*, *Manufacturera de Cardas y Objetos de Cuero*, *Canal de Urgell*, *España Industrial*, *Gran Teatro del Liceo*, *Hispano Inglesa de Vapores* and *Maquinista Terrestre y Maritima*.

The second group of companies was made up of those with a low degree centrality but a high *betweenness*. Within this group we can detect the presence of numerous textile firms. In this case, 4 of the 10 leading firms are textile ones, two of which do not appear in the group of enterprises with the greatest degree centrality (all of these are public limited companies). The rest of the companies can be grouped together in second place in the network, where we find most textile and commercial firms.

The last group of companies was composed of those which are isolated, that is, which do not share a single investor. We would be speaking of 17 enterprises (20% of the total), with a strong predominance of textile companies (10, which is 25% of all textile companies), followed by Commercial enterprises (4), Other Industries (2) and all of the Mining enterprises (2). Among the textile companies, one noteworthy company was *Batlló Hermanos*, established in 1849 with the participation of the seven Batlló brothers. The company started with a factory in Barcelona and then acquired others in Monistrol de Montserrat, in Sitges and in Tarragona until in 1870, it concentrated its production in Barcelona.²⁰

With the aim of demonstrating the robustness of the results obtained we have applied a more restrictive supposition and we have analyzed the network once more. In this case, our objective is to test if the resulting outputs vary when we introduce changes in the definition of the network. This supposition consisted of defining that there will be a link between companies whenever there are two or more mutual investors. Of the eight enterprises with the greatest indexes of centrality, seven retain similar positions and only *Teneria Barcelonesa* (which previously occupied 10th place) appeared in the place of *España Industrial* (which moved to 14th position). The other significant change is that *Juan Soler de la Torre y Cía.* and the *Banco de Barcelona* swapped places. Also, the number of firms without any links increased, from 17 to 37 companies (close to 40% of the total).

If we go one step further, we repeated the exercise without taking the mining companies into consideration, which were constituted according to specific formulas determined by the legislation in force at the time (Trade Code of 1829, Law of Mercantile Companies by Shares of 1848, Law of Mines of 1849) and in most cases without even specifying the division of shares.²¹ We also separated from the exercise the firms *Juan Soler de la Torre y Cía.* and *Gran Teatro del Liceo* since they were companies with very specific characteristics (the first, as already indicated, had a particular role in the industrial network of Barcelona and the second was set up with the aim of building the Liceo Theatre). The new results do not show any significant changes compared with the previous results. The *Banco de Barcelona* becomes the firm with the greatest index of degree centrality, followed by the *Industrial Quincallera*, *Fabril Algodonera*, *Lloyd Barcelonesa de Seguros Maritimos*, *Canal de Urgell*, *Manufacturera de Cardas y Objetos de Cuero*, *España Industrial* and *Hispano Inglesa de Vapores*. That is, if we compare this with the data obtained from the whole series, practically all the cases remain in their privileged positions. The same occurs if we observe the *betweenness* index. In this case, once again, the textile sector plays an important role. The number of isolated firms in the network diminishes only minimally, from 17 to 16 (by not taking account of mining companies, some of the firms

²⁰ See (Cabana, 1993)

²¹ (Naharro, 2005)

that were isolated in the previous network disappear, specifically two, which leads us to affirm that only one new company remained isolated after this change)²².

We repeat the exercise, but now we consider only the firms that are general or limited partnership companies. In this manner we aim to check the centrality of those companies which share investors and those cases where the intensity of the existing link is stronger (the degree of commitment required by these types of firms is greater than in public limited companies). In this case the decision on whether or not to include *Juan Soler de la Torre y Cía.* is highly relevant to the network formation. If we include the firm, we find that 25 of the companies are isolated (40%). If we decide not to include it, 46 of the companies do not share a single investment (75% of the total).

3.3.2 Firm case studies

Analysing the outputs of the different networks with detail, it is not surprising that the company *Juan Soler de la Torre* should show high indexes of degree and betweenness. In fact, this company was known as the *Sociedad General de Almacenes del Comercio*, something similar to the English *docks* which issued documents similar to *warrants*. We already knew that at the time that the company was formed (1851) almost all the members of the board of directors of the *Banco de Barcelona* participated in the company. For this reason, it is no surprise that this company, in which many traders of the time also participated, should occupy such a central position.

As regards the *Banco de Barcelona*, it was founded in 1844 by a group of traders and a few industrialists. Its activity during the years that concern this study was important in two areas. Initially, it was vital in the financing of cotton, although after the crisis of 1848 cotton-secured loans became less important and it focused its operations on discount to suitably authorised companies and on loans on movables (public debt and shares). As from 1856 the appearance of new credit institutions opened up a new period for the Bank.

Note the presence of a wide range of initiatives generated around the Girona family. Between them were the firms with a higher level of centrality. The Girona family funded a firm between their members and an external partner during the mid 19th century (1839-1967), which participated in the creation of many of the most important Catalan firms. When the firm was settled, after 25 years of activity, its capitals had been multiplied by 125, with a spectacular growth index after 1854.²³ Those firms were some of the Girona's family participates and, at the same time had a higher degree of centrality were: *Canal de Urgell*, *Industrial Quincallera y Manufacturera de Cardas y Objetos de Cuero*, besides the *Banco de Barcelona*.

The *Canal de Urgell*, was an initiative created with expectations of huge revenues. The first step was a project initiated several decades before, during the 16th and the 17th centuries, with the objective of built an irrigation canal to enhance the agriculture of the Lleida's region, near Barcelona. During the 18th and early 19th century, were several initiatives seeking to develop it, however, the project has not been implemented or, when the work began, they didn't finish it. Lastly, the channel was inaugurated in 1862, the starting point of the irrigation of the zone, more that 350 years after they first rose.²⁴

There are two initiatives that will be owned by the *Girona Hermanos* (the familiar firm) and which are industrial firms. The cases of two Corporations (the *Manufacturera de cardas y objetos de cuero* and the *Industrial Quincallera*), which have developed an activity out of the

²² Again, we only consider the existence of links between nodes from two or more joint investments. In that case, the results went in the same direction as for the whole network.

²³ (Blasco & Pla, 2009), p. 87-88

²⁴ See (Renyer, 1990; Junqueras & Marti, 2003; Ramon i Muñoz, 2004).

leadership sectors of the Industrial Revolution, but we have to understand it as an example of their diversification strategy of their investments. The *Manufacturera de Cardas* was founded the 7th of April, 1854 with a nominal capital of 2,000,000 of pesetas, with a half of the total amount already paid. In that firm also came together one of the subgroups of the Catalan bourgeoisie of the 19th century. This firm was a producer of combs, belts or other industrial accessories, and also prepared the shoe's leather. The *Industrial Quincallera* was created in 1853 and their main objective was the “production of the pearl, ivory, hippopotamus, bone, wood, whalebone, cane, paper, leather, cardboard, feathers, hair and feather”; probably it had an important trade section due to the fact that many members of the Catalan trade bourgeoisie participated on it (*Coma, Ciuró y Clavell, Pau Maria Tintoré, Clot Hermanos,...*).²⁵

Outside the influence of Girona, there are many firms with a higher value of centrality degree: the *Fabril Algodonera* and the *España Industrial*, the shipping firm *Hispano Inglesa de Vapores* and the insurance firm *Lloyd Barcelonesa de Seguros Marítimos*. With regard of the textiles firms, we have to stress the fact that the *Fabril Algodonera* was a firm founded in Reus²⁶ by Matías Vila but which had many stores in Igualada, Barcelona and Vinaroz (in the province of Castelló). In 1851 this firm became a corporation and many important characters were part of it as the Catalan banker who lived in Madrid, Jaime Ceriola or the Navarre's politician Pascual Madoz, who became Finance's Minister in 1855.²⁷ Likewise, Madoz also participated in the foundation of the *España Industrial*, although the main driver was José Antonio Muntadas, member of a family of industrialist from Igualada, in Barcelona. One of the most interesting facts was that it was founded in Madrid; from the belief that Spain could become an important manufacturing producer if some specific conditions coincide (this was the explanation of the name). The founders acquired a water jump in the Piedra river, in Alhama de Aragon (a hundred kilometres far from Zaragoza). Finally, several financial difficulties and higher transportation costs eventually determine its location in Sants, a neighbourhood of Barcelona, becoming the largest cotton textile mill in Spain.²⁸

Moreover, the *Lloyd Barcelonesa*, a maritime insurance firm founded in 1855, and the *Hispano Inglesa de Vapores*, created in 1852 with the objective of set up a navigation line between Spain and Great Britain, were some of the most important people of the Barcelona's trade bourgeoisie as Pablo Maria Tintorer (motor of the *Hispano Inglesa de Vapores*), Antonio Jover, Carlos Torrents Miralda, *Serra Hermanos* or *Coma, Ciuró y Clavell*.

From all of this the results obtained from the network of basic investment which includes the main Barcelona firms according to volume of investment, are sufficiently robust as demonstrated in the different comparative exercises conducted. Secondly, the role of strong centrality played by sectors such as the financial one, and in particular the *Banco de Barcelona*, in the whole of the investor network. Thirdly, the secondary position of those sectors with a greater number of firms, specifically the textile and commercial ones, whether because these firms occupy a peripheral position in the network or because a significant percent of them are isolated, without joint investments. Fourthly, as expected, the enterprises constituted as corporations, have greater degrees of centrality. What is not so obvious is that the corporations should become the place of confluence of investors in general or limited partnership companies, and hence, that they make possible the existence of connections between firms which would otherwise not exist.²⁹ That is, the corporations which occupy a central position in the network are centres of investment where a variety of investors come together. The fifth and last point to

²⁵ (Cabana, 1992).

²⁶ Reus is a city in the Tarragona province which was an important node in the brandy trade during the 18th century and, for that reason became the second city of Catalonia during the 19th century.

²⁷ See (Pascual, Estrada & Ferreras, 2004).

²⁸ See (Nadal, 1975; Gutiérrez, 1997).

²⁹ When we consider the network of the collective and limited firms, the number of the isolated firms, with no connections among them, was much higher than in the whole network.

be highlighted is, despite the fact that textile firms (and industrial firms in general) do not play a central role in the network; they do play such a role with regards *betweenness*. That is, among those enterprises which play a relevant role in the confluence of various investment groups, we find textile and metallurgical firms, as well as those from the financial sector such as the *Banco de Barcelona y Lloyd Barcelonesa de Seguros Maritimo*.

4 SUBGROUPS WITHIN THE NETWORK. SPECIALIZED OR DIVERSIFIED?

On analyzing the most relevant firms, we have seen how the collection of those which form the network of investment is divided into four groups of firms, according to whether they are more or less isolated. A step further in this direction is, considering basically those companies that make up the main network, to group them according to the existence of a greater link. To this end, we apply the analysis of communities to the set of data. In order to avoid problems with this analysis we have not considered those mercantile companies which are isolated, joined only by partners or by groups of three firms.

4.1 METHODOLOGY

In the previous section we obtained relevant information from the study of the network of investment from a macroscopic or global perspective (a general structure formed by a large central component, diverse smaller components and a set of isolated enterprises) and the microscopic or individual (e.g. the different measurements of centrality of certain firms in particular).

In this section we aim to extend our study by focusing of the mesoscopic aspects of the network, that is, those which refer to the intermediate levels (between the individual and the global), corresponding to the groups they form. In our specific case, this type of approach is especially useful for analysing the central component of the networks built, which is difficult to carry out in another way, given the high density of ties it has.

In the recent literature on the analysis of social networks, we find different forms of mesoscopic analysis. Of all of these, the study of the structure of communities is among those which have received most attention. From a structural perspective, we can qualitatively define a community as a subgroup whose vertices are more densely connected among them, than with the rest of the network.³⁰ We can subdivide a given network multiple times into sub-networks or sets of nodes and ties. In order to determine quantitatively which of these multiple subdivisions corresponds better to the list of communities that make up the network (according to the previous qualitative definition), Newman and Girvan proposed a quality function known as *modularity*.³¹ The division of a network into communities is, therefore, that which maximises the value of modularity, defined as:

$$Q = \sum_r (e_{rr} - a_r^2)$$

Where e_{rr} corresponds to the fraction of links that connect two vertices belonging to the same community r , a_r is the fraction of ties which have, at least one of their ends in the given community, and the summation includes the set of communities which form the network studied.³² Given a certain way of dividing a network into sub-networks, the *modularity* corresponding to this partitioning represents the difference between the probability of finding

³⁰ (Girvan & Newman, 2002)

³¹ (Newman & Girvan, 2004)

³² (Newman & Girvan, 2004)

internal ties (that is, which do not connect different communities) in the network studied, and the same probability calculated for an equivalent network with the same number of vertices and ties, but reorganised at random. In other words, the modularity of a specific division of the network into sub-networks will be greater the more this division resembles the organisation into subgroups typical of the different types of real social networks and consequently, will less resemble the disordered and structure, lacking of subgroups, typical of completely random network.

In recent years, a wide variety of algorithms has been developed for the division of networks into communities (a good comparative study of some of these can be found in (Danon, Díaz-Guilera, Duch & Arenas, 2005)). In this case, we have used one based on the heuristics of Extremal Optimization (EO).³³ A detailed description of this algorithm can be found in (Duch & Arenas, 2005). To give a broad outline, this algorithm optimizes a global variable as the result of a progressive optimization of different interdependent local variables. More specifically, the global variable is the Q modularity described above and the local variables correspond to the individual contribution of each i vertex to this modularity:

$$q_i = \kappa_r(i) - k_i a_r(i)$$

where $r(i)$ is the number of ties which the i vertex belonging to the community r has with other nodes in the same community, and k_i is the degree of the vertex i (the total number of links it shows). Note that:

$$Q = (1/2L) \sum_i q_i$$

where i corresponds to each one of the vertices that make up the network, and L is the total number of ties. Starting from an initial random division of networks into two sub-networks, (and, therefore, with a very low modularity value), the algorithm seeks the partition of the network into two communities, which maximizes Q by trying different possibilities (assigning the nodes to one or other community) and recalculating the different individual contributions to modularity. Once a division has been achieved into two optimum communities, the algorithm repeats the previous step by subdividing each one of the resulting communities into two, a process which can imply an increase in modularity (since the real networks can present more than two compact groups). The process ends when further subdivision does not entail an increase in Q .

4.2 RESULTS

If we apply the analysis of communities to the whole of the network, without exceptions, we obtain five groups, in addition to that which is made up of the enterprises that do not share investors (and which we have called *Isolated*). On looking at the sectorial structure of these communities (see Table 4) we observe that these groups have a similar economic structure to that of the sample³⁴, with the exception of community 2 which, being a group of only two companies would distort the results. We also observe that the resulting groups are formed by all types of firms, with the exception of the group of isolated firms.

³³ (Boettcher & Percus, 2001)

³⁴ In this case, the Gini index reflects the inequality among the communities and within the whole sample. We chose this correction because the sample is not balanced. Some sectors were overrepresented, such as the textile, and others like the financial sector were underrepresented.

Table 4
Sector Specialization by groups

	Gini Index	Number of firms
Isolated	0.30	18
Community 1	0.21	21
Community 2	0.58	2
Community 3	0.38	18
Community 4	0.25	20
Community 5	0.29	14

If we repeat the exercise without considering the mining companies, the *Gran Teatro del Liceo* and *Soler de la Torre*, what appears is a group with higher values than those in Table 5. Community 5 is the one which includes a more diversified group of enterprises.

Table 5
Sector Specialization by groups

	Gini Index	Number of firms
Isolated	0.28	16
Community 1	0.37	17
Community 2	0.56	2
Community 3	0.20	20
Community 4	0.27	18
Community 5	0.44	15

In order to interpret these results, we must take into account the meaning of the communities in our case study. As mentioned in the previous section, a community is a set of vertices which are more tightly linked amongst themselves than with the rest of the network. If we translate this to our networks of companies, this means that the companies belonging to the same community share more common investors among them than with the rest of the sample, or in other words, the same investors or investment groups tend to participate in them. Consequently, the internal economic structure of a community is the result of an investment strategy on the part of a certain investor group.

In the light of this interpretation, if the internal economic structure of the communities presents a degree of homogenization clearly superior to the whole of the sample, we would be dealing with a case of specialized investment (within the same type of enterprises, textile with textile, metallurgical with metallurgical, etc.). However, the results show communities with a heterogeneous economic structure, which indicates that the predominant investment strategy was that of diversification. We reach this conclusion when we compare the structure of the set of firms in the sample and the sectorial structure of the communities based on their Gini Indexes (0 when the structure of the group is similar to that of the whole of the sample and 1 when the group's structure is totally different). This type of approach is necessary because of the sample's strong bias in favour of the textile sector.³⁵ Analyzing the sectorial specialization of the communities without taking this into account would show us a sectorial over-specialization of the groups. The case we are dealing with gives values close to 0, and hence, close to the structure of the sample itself. Specific cases that deserve separate mention are those such as

³⁵ When we analyse the sector specialization of the communities without considering that we are working with non-random samples, the result strongly correlates with the number of firms.

community 5 in the second network, whose composition (combining textile, commercial and financial firms) seems to be the result of a strategy of oriented investment throughout the value chain of the textile business.

5 CONCLUSIONS

In mid-19th century Spain, only Catalonia had managed to develop a process of industrialization comparable with the rest of Europe. Stemming from the development of agriculture and trade, during the 18th century the first cotton manufacturers had been established which formed the base of the industrialization process. Once they had recovered from the Napoleonic wars, these manufacturers were to take the definitive step towards converting themselves into modern industries. The process was not consolidated until the relative stabilization of the liberal State, around 1840, but from this date there was a leap forward in the process of investment in and creation of the widest variety of enterprises. We can hereby identify a first investment expansion from 1845, which is when most of the great business initiatives were established in 19th century Catalonia.

Our point of departure was to determine whether in these initiatives the formation of social networks of investment played a fundamental role, in a context in which investment decisions were conditioned by personal relationships and relationships of trust (even today, these relationships retain their importance in decision-making about investment, despite the development of information and communication technologies). We know that the prestige of certain important figures, the trust that they inspired and their mutual acquaintances, were the elements that permitted investors to take a decision.

In this sense, the analysis of networks which we have applied allows us to demonstrate their existence and the existence of some firms which played a central role. On one hand, we can conclude that investments converged in those firms which offered a service to other sectors such as textiles and commerce or, on the other hand, they could be part of strategic alliances in the infrastructure sector or in the whole economy. All of this was before the promulgation of laws which boosted the creation of corporations in 1855 and, at the same time, stimulated railway investment. Hence, it is not surprising that the financial sector, in which the *Banco de Barcelona* stands out above the rest, should play a central role. Together with the Bank, other enterprises which appear as central in the basic network, *Juan Soler de la Torre y Cía.*, also offered services (warehouses) to both individuals and traders. As well as these two firms, it was the public limited companies in general which permitted the coming together of different investor groups in the biggest business initiatives, those which are considered fundamental to Catalan economic development, whether they were industrial, financial or of another nature (for example the *España Industrial*, the *Maquinista Terrestre y Marítima*, the *Banco de Barcelona* itself, and the *Canal de Urgell*, etc.) and required enormous quantities of capital. It also seems clear, in the same line of our findings, that the prestige of certain people favoured the convergence of existing networks or individual investors in this set of strategic initiatives. In this sense, the *Girona* family appears as the most important in Catalonia in the first half of the nineteenth century, commanding initiatives such as the *Banco de Barcelona*, the *Canal de Urgell*, the *Industrial Quincallera* or the *Manufacturera de Cardas y otros objetos de Cuero*.³⁶

On the other hand, what is striking is the scarce centrality of the textile companies, bearing in mind that this is the most numerous group and that it was a driving force in industrial expansion. This phenomenon is reinforced if we only consider the networks formed by general and limited partnership companies. In this case, the number of those which do not share investors is much higher than in the general or basic network. Precisely in this group, textile sector companies are under-represented. This concurs with the fact that textile sector companies

³⁶ About Girona see (Blasco & Pla, 2009)

required a smaller volume of capital, and therefore, in general, were of reduced size in Catalonia and the overwhelming majority were family companies. Although textile companies did not play a central role, what is noteworthy is their intermediation role. However, it is clear that the higher the level of centrality relates directly to the size of the company. The Corporations such as *Fabril Algodonera*, the *Manufacturera de Algodón* or the *España Industrial*, are examples of this trend. This point should be emphasized, especially because in the latter case the company was designed with the objective to demonstrate the possibilities of modern industrialization in Spain.

Finally, the analysis of communities has shown us that those groups of enterprises with the most intense investment ties had a markedly heterogeneous character in terms of sector of activity. This fact permits us to affirm that an important number of those industrialists who had shares in a few general and limited partnership companies in the textile sector, simultaneously invested in public limited companies in several economic sectors. This phenomenon is rooted in an unstable economy and in a long tradition of the development of initiatives based on small shares. This strategy, although implying a broad social extension of the base of investors, also meant a lesser dimension of business initiatives, whereby the typology of Catalan business has become known as 'Lilliputian'.

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Appendix 1 – List of the thirty firms with higher degree of centrality and their characteristics

Number	Degree	Closeness	Betweenness	Community ID	Firm	Investment (until 1855)	Year of establishment	Sector	Type
9	44	0,052	702,3	1	BANCO DE BARCELONA	2.125.000	1845	Finance	3
81	43	0,052	434,9	2	SOLER DE LA TORRE, JUAN (Y CIA.)	771.000	1851	Other	1
45	30	0,051	228,9	3	INDUSTRIAL QUINCALLERA	562.500	1853	Other Industries	3
27	29	0,051	112,9	4	FABRIL ALGODONERA	3.000.000	1855	Textile	3
53	28	0,051	77,9	4	LLOYD BARCELONESA DE SEGUROS MARITIMOS	300.000	1855	Finance	3
18	26	0,051	103,8	4	CANAL DE URGELL	1.600.000	1853	Construction	3
57	26	0,051	187,4	4	MANUFACTURERA DE CARDAS Y OBJETOS DE CUERO	1.000.000	1854	Other Industries	3
91	26	0,051	130,8	3	ESPAÑA INDUSTRIAL	8.000.000	1853	Textile	3
34	25	0,051	91,4	2	GRAN TEATRO DEL LICEO	1.040.000	1847	Others	4
40	24	0,051	54,0	4	HISPANO INGLESA DE VAPORES	1.500.000	1855	Transport	1
82	24	0,051	60,3	3	TENERIA BARCELONESA	1.500.000	1855	Other Industries	3
21	23	0,051	27,1	4	CATALANA GENERAL DE SEGUROS	600.000	1845	Finance	3
12	22	0,051	57,0	4	BOFILL Y MARTORELL	1.200.000	1852	Transport	1
58	22	0,051	183,5	4	MAQUINISTA TERRESTRE Y MARITIMA	4.500.000	1855	Metallic	3
92	22	0,051	42,9	3	VETERANO	2.936.500	1841	Metallic	Unknow
63	20	0,051	33,7	2	NAVEGACION E INDUSTRIA	3.750.000	1850	Transport	3
56	18	0,051	42,0	2	MANUFACTURERA DE ALGODON	1.500.000	1853	Textile	3
90	18	0,051	69,4	4	CARBONERA CATALANA	500.000	1846	Coal and Energy	5
64	17	0,051	67,8	3	NOGUES, JOSE (Y CIA.)	300.000	1853	Metallic	1
37	15	0,051	4,9	4	GUELL (Y CIA.)	1.405.000	1848	Textile	1
44	15	0,051	141,1	4	INDUSTRIAL LANO-ALGODONERA	2.500.000	1853	Textile	3
23	14	0,051	11,2	2	DILIGENCIAS Y MENSAJERIAS DE CATALUÑA	750.000	1842	Transport	3
26	14	0,050	14,3	3	ESPAÑOLA	585.000	1848	Textile	3
20	12	0,050	12,3	2	CATALANA DE GAS	1.500.000	1843	Coal and Energy	3
31	11	0,050	39,2	4	GAS REUSENSE	325.000	1854	Coal and Energy	3
86	11	0,050	0,8	4	VAPORES POR EL EBRO	750.000	1842	Transport	3
32	10	0,050	0,0	2	GIRONA (HNOS.)	2525000	1854	Trade	1
48	10	0,050	8,8	2	JORDA GELABERT, MARIANA	625.000	1843	Construction	2
87	10	0,050	0,6	4	VIDAL RIBAS, JOSE	375.000	1855	Trade	1
89	10	0,050	8,8	2	ZULUETA, ANTONIO	625.000	1843	Construction	2

Note: Type: 1 – Limited partnership firm, 2 – General partnership firm, 3 – Corporation, 4 – Partnership firm by shares, 5 – Mining firm.

Source: BDEC – DHIE_UB.