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Social Network Analysis: Not Merely a Visualisation Tool? Insights from the Study of Business Networks and Groups in Biscay, 1879-1913

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ABSTRACT
This paper introduces a scientific meta-experiment that aims to explore, by means of Social Network Analysis (SNA), a database previously worked with a traditional qualitative analysis (Valdaliso, 1988 and 1993). The sample is made up of more than 500 incorporated companies registered in Vizcaya between 1879 and 1913, which represent 30 per cent of the number and more than 90 per cent of the total capital of the companies created in that province between those dates. Although the use of SNA does not show substantially different results in the representation of the main business groups, it does provide numerous and very notable advantages, especially related to a better visualisation of the networks. However, the new methodology also poses some problems, especially when interpreting large networks. Moreover, beyond graphical and statistical techniques, qualitative information is essential for a correct understanding of the networks.

KEYWORDS: Social Network Analysis, business groups, Biscay, 19th and 20th centuries

JEL CODES: D85, N01, R39, Z13

1. Introduction

Using Social Network Analysis (hereinafter SNA) has led to better detection and, above all, visualisation of the networks of investors and business groups in different Spanish regions during the 19th and 20th centuries, than with earlier statistical and graphic techniques (Badía et al., 2010; Garrués et al., 2013; Rubio, 2014; Rubio and Garrués, 2017a and 2017b; Catalán et al., 2017). However, it is still not fully proved whether its application really offers new findings and new questions and lines of research that would not have emerged using the traditional analysis (Wetherell, 1998; Kilduff and Brass, 2010; Buchnea, 2017). This paper presents a heuristic scientific experiment that may be particularly useful to respond to that issue; with the help of the SNA technique, it intends to analyse the main incorporated companies (and their founders) established in Biscay between 1879 and 1913, a database that had been previously studied using a traditional methodology over 30 years ago. Specifically, the sample consists of 507 incorporated

companies, which account for 28 percent of the number and 95 per cent of the capital of all the incorporated companies created in that province in that period, and of the 3,308 investors who took part in founding those companies (the number of identified investors stood at 1,652 after removing the presence of a single investor in more than one company).[1] The ultimate objective of the paper is to use SNA to identify the most important business groups and investors of the province and check whether the results tally with those obtained using the traditional analysis.

The case of Biscay is particularly interesting as the province at that time was the driving force behind the spread of the Second Industrial Revolution in Spain, led by sectors much more capital- and technology-intensive. That required large amounts of capital to be raised: at the turn of the century, Biscay was the province of Spain with most capital invested in new incorporated companies, representing 34 percent of the total between 1896 and 1902 (Jiménez Araya, 1974: 164). By 1914, Biscay had the highest rate of capital formation and private saving in Spain, and Bilbao was, along with Madrid, the country's most important banking marketplace. Furthermore, many incorporated companies that operated in other regions in Spain had their registered offices in Bilbao, due to its active and dynamic capital market, to the relative abundance of business initiatives and qualified human capital and, from 1901 onwards, to less burdensome business taxation than in the rest of the country thanks to the Basque Economic Agreement (Alonso Olea, 1997; Valdaliso, 2002c, 2003 and 2006b).

The paper is divided into three main sections. First, it considers the state of play of the historiography of the business groups and networks in Spain from the SNA perspective and its key implications for research in this field. Second, the results of the original research and its context (techniques, research questions and state of knowledge) are set out. Third, the SNA results are then presented and compared to those of traditional research and also to the results in other regions where the same technique were used. Finally, the paper concludes.

2. The SNA of business networks and groups in Spanish industrialisation: state of play

SNA, beyond its statistical methodology and its visualisation tools, is conceived as a differentiated research perspective within behavioural and social sciences (Freeman, 2004, Wasserman and Faust, 2004). It is based on the principle that the agents and their actions are not autonomous, but rather interdependent. Although the simplest unit of analysis is the dyadic relationship between two actors, they are not only linked through dyads, as they are also immersed in multiple connection patterns (Wellman, 1988). These relationship data allow the existence of groups and their best located stakeholders to be

[1] See Valdaliso (1986) and (1988) for more details. The database cleaning increased the number of investors from the 1,636 in Valdaliso (1993) to the current 1,652. Despite the source limitations, indicated by the specialists (the share capital of each founding partners or all the investor partners in each company are not always indicated), there is a generalised agreement on the validity of this source to analyse the investment and the business networks and groups.

analysed. Their conduct is influenced by their position within that social structure but, at the same time, they can influence the network patterns and, consequently, affect the behaviour of others. The vision of the network as a dynamic set of links with a core-periphery structure stems from there (Morgan et al., 1996).

At a business level, companies can be linked through alliances such as commercial associations, business groups, clusters, consortia, cartels, joint ventures or interlocking directorates. The trust and sociability accumulated by the network members facilitate its smooth running and generate unique competitive capacities for the company (Bolino et al., 2002). The company's position in the social structure is also decisive, as companies with greater centrality have access to the resources of others. This attracts other companies to work with the central stakeholders to obtain potential access to their resources and they, in turn, become even more central. However, according to the structural hole approach, the advantages are not necessarily obtained by creating a huge set of links, but rather by configuring an optimum structure with many contacts that are divided haphazardly among different companies with a variety of characteristics (Burt, 1992).

The extensive literature on corporate social capital suggests that those links act as facilitators (or constraints) of a flow of tangible and intangible resources. According to Nahapiet and Ghoshal (1998), social relations are a vehicle to access and disseminate information. Social capital can also help companies to access technology (Stuart, 1999), financial resources (Freeman, 1999) and human resources (DiMaggio, 1992). Other authors have shown that, apart from transmitting resources, social interchange also transfers reputations (Stuart et al., 1999) and imposes standards of behaviour in terms of trust, cooperation, coordination and reciprocity (Gulati, 1995). In short, network relationships produce different benefits, provided that participation does not threaten the autonomy of a company and, therefore, its ability to act.

In order to acquire and exploit those benefits, an organisation needs absorptive capacity, in other words, the ability to recognise and assimilate the intangible and tangible assets available in the network. Cohen and Levinthal (1990: 136) suggested that the absorptive capacity of an organisation tends to be developed accumulatively, and the company that does not invest in it may not recognise new opportunities when they emerge. Furthermore, several authors have argued that social capital is also path dependent, in the sense that previous links determine the formation of future links (Gulati, 1995; Walker et al., 1997). Thus, some territorial networks address knowledge transfer more effectively and that partly explains the differences in regional economic development (Rutten and Boekema, 2007).

In the field of economic history in Spain, research into the establishment of incorporated companies has been based on Jiménez Araya's seminal work (1974), whose fundamental purpose was to construct a time series of investment in new incorporated companies created in Spain, a variable that is highly indicative of the economic cycle. Following the discovery of this source and drawing on the company records of the provincial Business

Registries, other authors replicated the original study for different provinces and/or regions, but also conducting a more detailed analysis of the investor partners and the most important companies (Martínez et al., 1977, for the Autonomous Community of Valencia; Germán, 1981 and 2003, for Aragón; Abreu, 1984, for Pontevedra; Valdaliso, 1986, 1988 and 1993, for Biscay; Erro, 1997, for Navarra; Lindoso, 2003, for La Coruña; García Zúñiga, 2009, for Álava). More recently, with the development of the network theories and the computer applications that allow large-scale data analysis, SNA has begun to be used to study business groups and networks in different Spanish regions and provinces. The ground-breaking work of Badía et al. (2010), based on notarial protocols, considered investment strategies in Catalonia in the mid-19th century and revealed the existence of companies and business networks that played a key role in the start of Catalan industrialisation. In turn, Garrués et al. (2013), Rubio (2014) and Rubio and Garrués (2017a and 2017b) identified several business networks that operated in Andalusia between 1886 and 1959, showing that there was an endogenous business impetus in the region and thus challenging the old chestnut of a lack of Andalusian business mentality. As regards the Basque Country, several papers were published in the last decade that analysed in detail the main investor groups in different territorial and historical contexts. For example, Catalán et al. (2017) analysed the business networks that emerged in Guipúzcoa between 1886 and 1925, Etxabe (2018) unearthed the informal and formal networks underpinning the success of the industry of Eibar in the 20th century, while Etxabe and Valdaliso (2016) outlined the network resulting from the application of the cluster policy from 1990 onwards.

3. Methodology

Since the end of the 1970s, there has been a huge increase in technical contributions to SNA methodology, along with its application. On the one hand, numerous network theories, such as the theory of the strength of 'weak ties' (Granovetter, 1973) and the 'small world' theory (Watts and Strogatz, 1998), have been published. On the other hand, analysts have developed a series of computer applications to analyse social network data. Authors including Freeman (2004) believe that SNA was fully consolidated in social sciences in the late 20th century.

However, one of the problems that persist in the literature refers to the high network density, that can hinder the identification and visualisation of key nodes and subgroups, and affect the accuracy and effectiveness of the algorithms (Wasserman and Faust, 1994; Easley and Kleinberg, 2010). Due to the fact that computer applications offer very low possibilities to find subgroups in two-mode networks (those that link both the partners and companies), we decided to focus the study on one-mode networks. In this line, the option of considering only partners with two or more investments (as done, among others, by Garrués et al., 2013), or companies with a share capital above a certain amount (following the model of Badía et al., 2010), has been assessed, but in both cases the

reduction of the nodes is low[2]. Moreover, this modus operandi would mean a loss of information that, albeit slightly, could alter the selection of the most important investors and business groups, thus conditioning the most important objective of this article.

Many experts in the field (for example, Maillard Álvarez, 2023) advocate the modularity analysis, which allows densely connected nodes to be grouped into communities, revealing the organisation and modular nature of the network. However, this algorithm, for the standard resolution[3], detects in our sample 64 communities of actors, an excessively high number for a correct interpretation of the cloud. For higher resolutions, some partners who a priori belong to different family and business groups appear grouped together in the same community (as in the case of the Ybarra and De la Sota families), and others, such as the Chávarri brothers, are separated, when we know that they had very close business links with each other. These results, which are clearly not very coherent and at odds with the historical reality, have led us to rule out the possibility of carrying out a modularity analysis.

A third way to reduce the size of the network could be the partition of the 1879-1913 time series into different phases. To test this alternative, we have created a dynamic presentation of the network, in which companies appear in the cloud starting from their date of incorporation. Nor has this recreation suggested specific dates to break the network into several periods. Moreover, the diachronic analysis of the formation process of the general network shows that it had acquired its basic characteristics by 1901 as far as its structure was concerned, and this fact makes it inadvisable to break up the already reduced temporal space even further.

In light of these drawbacks, we have finally chosen to apply centrality measures to the original network (see section 5) in order to detect the most important partners, and afterwards, we have represented them in two-mode egonets[4], linking partners and firms. According to Crossley et al., (2015), egonets afford analysing big networks by abstracting the ego and all other actors with whom an ego enjoys a tie. Furthermore, egonet analysis is entirely compatible with sample data and, under some circumstances, can be used to infer the characteristics of the whole network. For this reason, we think that egonets can be a very good proxy to represent the business groups built around the core partners mentioned before.

The selected application to draw these actor-centred networks was Gephi, a free and open code software that allows data of any type of networks to be analysed and then presented

[2] If we take into account the individuals who, between 1879 and 1913, participated in the constitution of more than two incorporated companies in Vizcaya, the network still has 500 investors. And if we eliminate the companies with a share capital of less than 300,000 pesetas, only 99 companies would disappear from the initial 507.

[3] The standard parameter is 1. For lower resolutions, the algorithm detects more communities (smaller ones) and for higher resolutions, less communities (bigger ones).

[4] An egonet is the network of contacts formed around a particular node (ego).

in interactive and attractive graphics (Bastian et al., 2009). It is a powerful and useful tool, particularly for researchers interested in exploring dense and complex networks[5], as it provides a broad range of features to analyse and visualise networks, such as the use of multiple filters, detecting influential nodes, exporting data for their use in new workspaces, creating dynamic graphs, etc. (Faysal and Arifuzzaman, 2018).

As is the case of all programs, Gephi has its specific idiosyncrasies, with its main characteristic being the fact that the data has to be entered in two steps: first, the nodes have to be entered in the database, and, second, the edges, with all the connections existing between the nodes. That means having to adapt the data extracted from the original source, when not in that format, as has been our case[6]. Indeed, we had to calculate all the possible combinations with repetitions of size n = 2 among the m partners of each society, by means of the following formula[7]:

$$C_n^m = \frac{n!}{m!(n-m)!}$$

Thus, we would obtain a single edge in companies with two partners, three edges in companies with three partners, there would be six edges in companies with four partners, and so on. In practice, and taking the case of the company *Florentino Castaños y Cía.* as an example, the database design would change as follows:

TABLE 1a. Original initial database of Valdaliso (1988)

CodPart	Partner	Profession	CodComp	Company	Year
217	ASLA EREÑO, Fermín	Contractor	2	FLORENTINO CASTAÑOS Y CIA.	1886
394	CASTAÑOS ALLENDE, Florentino	Miner	2	FLORENTINO CASTAÑOS Y CIA.	1886
507	ECHEVARRIA ESTANCONA, Andrés	Contractor	2	FLORENTINO CASTAÑOS Y CIA.	1886
658	GARAY BILBAO, Jose	Merchant	2	FLORENTINO CASTAÑOS Y CIA.	1886

TABLE 1b. *Node file in Gephi*[8]

CodPart	Partner	Profession
217	ASLA ERENO, Fermin	Contractor
394	CASTANOS ALLENDE, Florentino	Miner
507	ECHEVARRIA ESTANCONA, Andres	Contractor
658	GARAY BILBAO, Jose	Merchant

[5] Gephi works with networks of up to 100,000 nodes and 1,000,000 edges.

[6] The database used was the original of Valdaliso (1988) extended to 1879 in Valdaliso (1993).

[7] The calculations were performed thanks to a combination generator of the Planetcalc portal. For further information: https://es.planetcalc.com/3757

[8] Note that the ñ and accents have been removed in Table 1b and 1c as Gephi does not recognise them, even when using the programme in its Spanish version.

TABLE 1b. *Edge file in Gephi*

Source	Destination	CodComp	Company	Year
217	394	2	FLORENTINO CASTANOS Y CIA.	1886
217	507	2	FLORENTINO CASTANOS Y CIA.	1886
217	658	2	FLORENTINO CASTANOS Y CIA.	1886
394	507	2	FLORENTINO CASTANOS Y CIA.	1886
394	658	2	FLORENTINO CASTANOS Y CIA.	1886
507	658	2	FLORENTINO CASTANOS Y CIA.	1886

Source: compiled by the authors using company records from the Business Registry in Biscay.

In short, the process to create the node and edge files in Gephi from the original database involves a significant investment in terms of time and effort, but it is worthwhile in the long term as it allows a data laboratory to be created (with a similar interface as to Excel) that facilitates the handling of the underlying structures in the general network and finding hidden patterns.

4. The business groups of Biscay from the traditional analysis perspective

In addition to using a different methodology, the early research into the business groups and capital investment in Biscay was conducted in the context of the historiographical debate on the sources of the capital invested in the industrialisation of the province; and, more specifically, the role of the accumulated capital in the iron ore mining sector as a source to capitalise other sectors of activity. The research sought to, on the one hand, ascertain the most active investor groups in the province, an area that was largely unknown at that time, and, on the other hand, the provenance of their capital.[9] Therefore, many of the pertinent points of SNA, such as the degree of centrality of a company or an investor, or the connectivity between the members of a group or a network, were not among its concerns.

One of the contributions of that early research was to identify the main business groups of Biscay at the end of the 19th and early 20th centuries, conducted using three basic criteria (although not all clearly stated): the number of companies in which each investor held a stake, directors serving on the boards of one or more companies, and the relative importance of the companies (inferred from their share capital). The most important groups were that of Sota and Aznar (Ramón de la Sota, Eduardo Aznar de la Sota and Luis Mª Aznar Tutor) in mining and shipping; the group of José Mª Martínez de las Rivas and his partners (Alzaga, Procter and Palmer) in iron and steelmaking and shipbuilding; that of Francisco Martínez Rodas in mining and shipping, connected to other mining groups (Zunzunegui, Llodio-Goicoechea, Amézola-Zaráuz-Seebold) around the Naviero-Minero and Vascongado banks; the group of the Ybarra-Vilallonga-Zubiría families in a wide range of sectors (mining, iron and steel, banking, electricity…); the Echevarría-

[9] See Valdaliso (1986), (1988) and (1993) for more details.

Zuricalday-Picavea family group, which was also very diversified (iron and steel, electricity, food and retailing…); and the Chávarri-Salazar group (the Chávarri Salazar brothers and their uncle Benigno Salazar MacMahón and his sons) in mining and iron and steel, connected in turn with other mining groups such as the Lezama, Gandarias, Castaño-López, Ibáñez de Aldecoa, and others in the *Crédito de la Unión Minera* bank (Valdaliso, 1988). Other less important groups were the Gurtubay-Greaves-Arbaiza group in the food sector; Errazquin in chemicals (explosives); Aznar-Arzuaga-Urrutia, Barandiarán-Gómez-Mendialdúa-Garteiz Gogeascoa, Uriarte-Eguiráun-Cortina-Acillona, Serra, and Portillo-Ibáñez-Pozzi in shipping; and Salvatierra-Crespo-Márquez de la Escosura-Zuasti in electricity (Valdaliso, 1986 and 1988). Some important investors were also detected in many newly founded companies, but without any clear affiliation to any of the aforementioned groups (such as the Aresti Torre and Allende Plágaro brothers, Fernando Carranza, and José Luis Costa Arana). A later study tidied up and improved the data of that investor base, in particular regarding variables such as the profession of the investor and of his father (Valdaliso, 1993).

Despite the robustness and representativeness of the sample, the research was descriptive, qualitative and impressionistic. The criteria used to define the makeup and limits of the identified groups were not explicitly explained, as neither were those for including the most important companies in the text or in the figures produced (although the reference variable was the share capital in this case). Neither were points such as the degree of centrality or the connectivity of the investors addressed, as already mentioned. In any event, the study helped to foster new research into individual entrepreneurs, and business families and groups in the Basque Country, which strengthened the main arguments and results and significantly enriched knowledge in that regard.[10]

5. The business groups and networks of Biscay from SNA

As has already been stated, Biscay was one of the most active and dynamic capital markets in Spain during the period being studied; a factor that, along with other motives, attracted numerous major national business projects to the province. However, the capital market continued to be strongly local or, at most, regional, where direct knowledge of the investors and the companies (and their reputation) continued to be a fundamental aspect for investment decisions (Valdaliso, 2003). Therefore, the SNA used in this paper has prioritised analysing investors (founding partners, in reality) over incorporated companies, even though there may also be companies that, given the great volume of capital mobilised or the investment project (banks, railway and electricity companies, in particular), can connect several groups and/or communities of different investors.

[10] Many papers have subsequently been published that have added to our knowledge on many of the business groups described or discovered in that early research: see, for instance, Díaz Morlán (1996, 2002, 2003 and 2004) on the Echevarrieta, Ybarra and Martínez Rivas groups; Torres (1998) on the Sota group; Valdaliso (1991), (2002a) and (2006a), on the shipping groups, some colonial entrepreneurs and the Aznar group; and Alonso Olea (2006) on the Chávarri group.

This empirical part seeks to use the SNA methodology to identify the most important founding partners and business groups of the sample of incorporated companies of Biscay.[11] In other words, the same database is analysed to see if the results obtained, at least when identifying the most important investors and business groups, tallies with those provided by traditional analysis. The SNA was performed at two different and complementary levels. First, a general analysis of the network was carried out and the investors with a more important role were identified, following different criteria; and the business groups (investors and incorporated companies) set up around those investors were then mapped. The research questions in this section were as follows: 1) Who are the most significant investors of the network (what is the selection criterion, beyond the number of companies involved)? 2) How to identify the most important business groups (investors and companies)? and 3) Is there a tool that most faithfully replicates, or improves, the results of the traditional analysis (identification of the investor groups and business groups)?

5.1. General analysis and density measurements of the network

First, it should be noted that 10 of the 507 original incorporated companies of the sample were eliminated to avoid duplication. The majority were cases of restructuring, in other words, second and even third registrations of existing incorporated companies, in the same sector of activity, and with minimum changes in the make-up of the partners, who were in reality continuity of previous signatories, a frequent practice in the case of partnerships. As can be seen in Table 2, 135 of the resulting 497 companies were mining and 105 shipping, accounting between the two for roughly 51% of the partners and 35% of the invested capital. Special mention should be made of the weight of the iron and steel sector, which accounted for 10% of the companies and nearly 13% of the capital, and the banking and insurance sector, not in number, but yes in capital (over 214 million pesetas, the second sector after mining with 17% of the total).

TABLE 2. Sector distribution of the sample of companies registered in Biscay, their partners and capital (1879-1913)

	Companies	%	Partners	%	Capital (million pesetas 1913)	%
Food	15	3.02%	79	2.39%	21.70	1.71%
Shipyards	4	0.80%	27	0.82%	41.27	3.25%
Bank-Insurance	17	3.42%	121	3.66%	214.55	16.89%
Construction	28	5.63%	142	4.29%	29.81	2.35%
Electricity	32	6.44%	210	6.35%	111.51	8.78%
Railways	25	5.03%	313	9.46%	92.27	7.26%

[11] The majority of the SNA papers cited in Section 2 differentiate between networks and groups, assuming the existence of a closer relationships between the investors and the companies that the groups founded, but without further clarifications. Note that a more precise definition of business group (Valdaliso, 2002b) requires complementary qualitative information to SNA.

	Companies	%	Partners	%	Capital (million pesetas 1913)	%
Mining	135	27.16%	805	24.33%	300.95	23.69%
Shipping	105	21.13%	890	26.90%	137.99	10.86%
Paper	7	1.41%	67	2.03%	25.76	2.03%
Chemical	24	4.83%	143	4.32%	61.22	4.82%
Iron and Steel	51	10.26%	295	8.92%	159.63	12.57%
Various	54	10.87%	216	6.53%	73.75	5.81%
TOTAL	497	100.00%	3,308	100.00%	1,270.42	100.00%

Source: compiled by the authors using company records from the Business Registry in Biscay. The capital series has been deflated by the Consumer Price Index of Maluquer de Motes (2005).

The high number of partners (3,308, 1,652 of whom are sole) hindered a structural analysis of the network overall with visible significant results. In fact, the first statistical calculations showed the existence of a very dense network (see Table 3), particularly due to the fact of working with founding partners data that, once the company had been established, remained in the cloud until 1913 as there was no information on the winding up of the company. If the existence of some partners with many investors and the large number of partners of some incorporated companies are then added[12], the outcome is a very dense graphical representation (see Figure 1) in which, at first glance, subnetworks are not seen, as happens, for example, in the Andalusian case (Garrués et al., 2013).

TABLE 3. Basic statistics of the general network

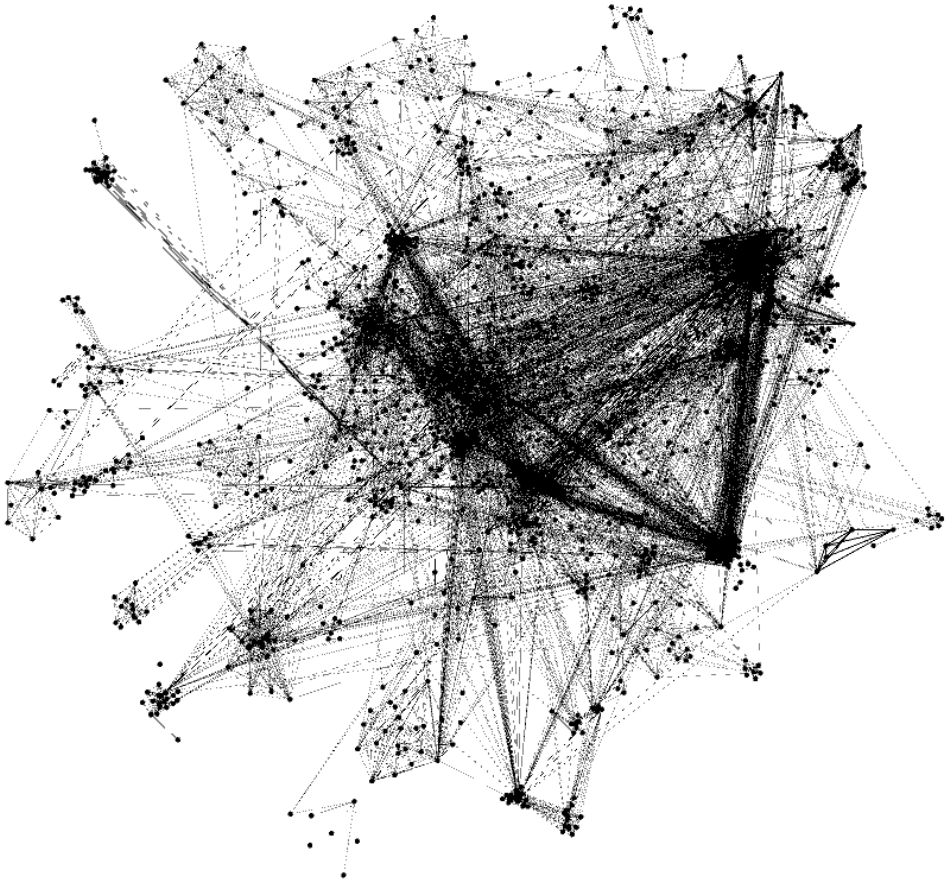
Number of nodes (single)	1,652
Number of edges (untargeted)	13,263
Average clustering coefficient[13]	0.86
Triangles	89,175

Source: compiled by the authors, using Gephi.

[12] Particularly in the case of railway and mining companies, and most specifically single-ship companies, the most usual type of corporate investment in shipping at the end of the 19th century, one of the most dynamic sectors in Biscay at that time, see Table 2 and Valdaliso (1991).

[13] Indicates how the nodes are embedded between its neighbouring nodes. The average value gives a general indication of the clustering in the network, see Cachero Vinuesa and Maillard Álvarez (2022).

FIGURE 1. *Giant component*[14] *of the general investor network (1879-1913)*



Source: compiled by the authors, using Gephi.

As stated in section 3, we first considered different alternatives to address this problem, without clear results. For that reason, we finally have opted for employing four objective criteria to select the most relevant stakeholders of the network and, presumably, the heads of the main business groups (see Table 4):

- Companies: the total number of companies in whose incorporation each partner participates.
- Degree: the number of partners with whom each partner connects.
- Weighted degree: the number of edges or relationships that a partner has.[15]
- Betweenness: this refers to the ability of a partner to serve as a link between two others.

[14] It is the result of eliminating the disconnected nodes in the central cloud.

[15] Note that a partner *x* can be connected to another partner *y* on more than one occasion, if they are both present in different companies. Therefore, the values of the weighted degree are always equal to or greater than those of the degree.

TABLE 4. Ranking of the 20 investors with greater weighted degree and betweenness

Partner	Companies	Weighted Degree	Degree	Betweenness
Sota Llano, Ramón de la	40 (#1)	395 (#1)	122 (#7)	54,574 (#5)
Aznar De La Sota, Eduardo	27 (#3)	362 (#2)	218 (#1)	90,039 (#1)
Azaola Basagoitia, Miguel	26 (#4)	306 (#3)	106 (#10)	26,743 (#16)
Zubiría Ybarra, Tomás	29 (#2)	300 (#4)	128 (#5)	58,726 (#3)
Eguidazu Arana, Ciriaco	21 (#7)	256 (#5)	62 (#42)	7,177 (#97)
Chávarri Salazar, Víctor	24 (#5)	232 (#6)	172 (#2)	47,772 (#6)
Sierra Castet, Antonio	18 (#9)	222 (#7)	47 (#109)	7,619 (#91)
Landeta Aburto, Eduardo	15 (#12)	201 (#8)	35 (#173)	193 (#357)
Arteche Osante, Fco. Antonio	10 (#32)	200 (#9)	134 (#4)	31,878 (#12)
Bajineta Portuondo, Andrés	14 (#13)	198 (#10)	36 (#163)	273 (#343)
Uncilla Vidaurre, Fco. Javier	14 (#13)	198 (#10)	36 (#163)	273 (#344)
Martínez Rodas, Francisco	17 (#10)	174 (#12)	126 (#6)	37,802 (#9)
Albizuri Arrotegui, G. Francisco	11 (#23)	171 (#13)	64 (#39)	22,016 (#23)
Arteche Osante, José Mª	12 (#19)	168 (#14)	52 (#102)	5,035 (#126)
Chávarri Salazar, Benigno	21 (#7)	161 (#15)	116 (#9)	41,267 (#8)
Allende Alonso, Tomás	11 (#23)	158 (#16)	143 (#3)	63,590 (#2)
Viar Egusquiza, Toribio Nicolás	12 (#19)	153 (#17)	45 (#116)	6,752 (#104)
Aznar Tutor, Luis Mª	11 (#23)	151 (#18)	35 (#173)	325 (#336)
Aresti Torre, Enrique	14 (#13)	149 (#19)	117 (#8)	25,301 (#19)
Echevarría Rotaeche, Federico	22 (#6)	138 (#20)	104 (#13)	56,766 (#4)
…	…	…	…	…
Carranza Arroyo, Fernando	11 (#23)	121 (#26)	102 (#15)	25,541 (#18)
…	…	…	…	…
Coste Vildósola, Eduardo	7 (#51)	111 (#32)	106 (#10)	31,427 (#13)
Aznar Tutor, Eduardo	13 (#17)	109 (#33)	72 (#29)	30,826 (#14)
Allende Plágaro, Plácido	17 (#10)	101 (#34)	68 (#35)	23,725 (#20)
…	…	…	…	…
Amézola Viriga, Jose	7 (#51)	99 (#36)	95 (#16)	42,439 (#7)
…	…	…	…	…
Costa Arana, José Luis	11 (#23)	86 (#43)	73 (#28)	32,731 (#10)
…	…	…	…	…
Martínez Martínez De Pinillos, José	5 (#106)	69 (#70)	62 (#42)	32,331 (#11)
…	…	…	…	…
Muñoz Rubio, Pedro	5 (#106)	58 (#91)	52 (#102)	27,993 (#15)
…	…	…	…	…
Picavea Leguía, Rafael	13 (#17)	47 (#151)	40 (#135)	26,020 (#17)

Source: compiled by the authors, based on the data laboratory in Gephi.

N.B.: The partners are ordered according to their weighted degree; the most important 20 investors according to both criteria are included.

At first glance, a high correlation can be seen between the number of companies founded and the weighted degree (the more shareholding stakes held by an investor, the greater the number of their relationships), and the degree and betweenness ratios (if a node is very connected to the others, it will be more likely to act as a bridge in the network). However, these two dimensions (for simplicity, we will call them centrality and betweenness) reflect very different realities between them. For example, Ramón de la Sota has the greatest number of investments (and with greater centrality in the network), but is not the most connected node, a position held by Eduardo Aznar de la Sota, who, with 13 shareholding stakes less than his cousin and partner, manages to be the best broker. Something similar happens with Tomás Allende Alonso who is second in betweenness, being present in the incorporation of only 11 companies.[16] By contrast, there are partners with many shareholding stakes, but with a smaller bridging role (such as Ciriaco Eguidazu, Antonio Sierra and Eduardo Landeta, all of whom were investors in the Sota and Aznar group and the last two employees in the company of the same name). Therefore, we see that, as was to be expected, all the partners do not have the same impact on the network.

That said, the question is: methodologically speaking, how can the hard core of the Biscay network be identified? The degree (that is, the number of connected partners) is very high for those central nodes (Eduardo Aznar de la Sota, for example, has a subnetwork in which he is connected to another 218 partners, and many of the other stakeholders of Table 4 are likewise immersed in ego-centric networks that exceed a hundred members), which, obviously, again hinders the analysis given the high number of nodes involved. This fact means that the network has to be simplified to have a more interpretable visualisation for the human eye. After conducting different tests and based on the methodological process explained in section 3, we opted to build egonets with the following characteristics:

- In mode two (representing, as well as the investor, the incorporated companies to which they belong), to have more accurate information on which companies link the partners.
- With distance two (in other words, including only two vertices in each of the ramifications built around the central node), in order not to overload the egonet with too much information.

[16] Among the central nodes, he might be the closest one to what Granovetter (1973) defines as a weak link, that is, the actor that offers the greatest opportunity to integrate other members of the network. This characteristic is due to his stakes in very important companies such as the *Crédito de la Unión Minera*, *Hulleras de Sabero*, *Vasco Asturiana*, *Marítima Unión*, and his connection with investors such as Francisco Martínez Rodas and the Chávarri brothers, or their family ties with other active investors such as Manuel Allende Villares (son-in-law) and his offspring, the Allende Plágaro brothers (brother-in-law), see Paliza (2012). Allende is also related to another mainly mining investor with similar attributes in the network, José Amézola.

- Requiring multiplicity two (that is, only representing those partners that have a minimum of two companies in common with the ego) in order to obtain better visualisation[17].

Note that, as shown in Figures 2 and 4, Gephi allows the egonets of two or more investors to merge and represent, even though additional qualitative information on the relationships (family, business, friendship) between them is needed to perform this step.

5.2. Egonets and business groups

For reasons of space, this section is only going to represent the egonets of the most important investors (according to their degree of betweenness) whose groups were shown in the original study by Valdaliso (1988): Ramón de la Sota and Eduardo Aznar de la Sota (Sota and Aznar),Víctor and Benigno Chávarri Salazar (Chávarri), Tomás Zubiría Ybarra (Ybarra-Zubiría-Vilallonga), and Federico Echevarría Rotaeche (Echevarría-Zuricalday), along with the one configured around an investor with very high degrees of centrality and betweenness, Francisco Martínez Rodas, and related to the investor groups of the Naviero Minero and Vascongado banks also represented in Valdaliso (1988).[18] In general, the results obtained replicate the business groups identified using the traditional analysis, but with, at least, two added advantages: a better and more comprehensive visual representation of the business group (companies, grouped according to the activity sector, but also partners) in all the cases, and a much more accurate identification/selection of the partners and companies belonging to it.

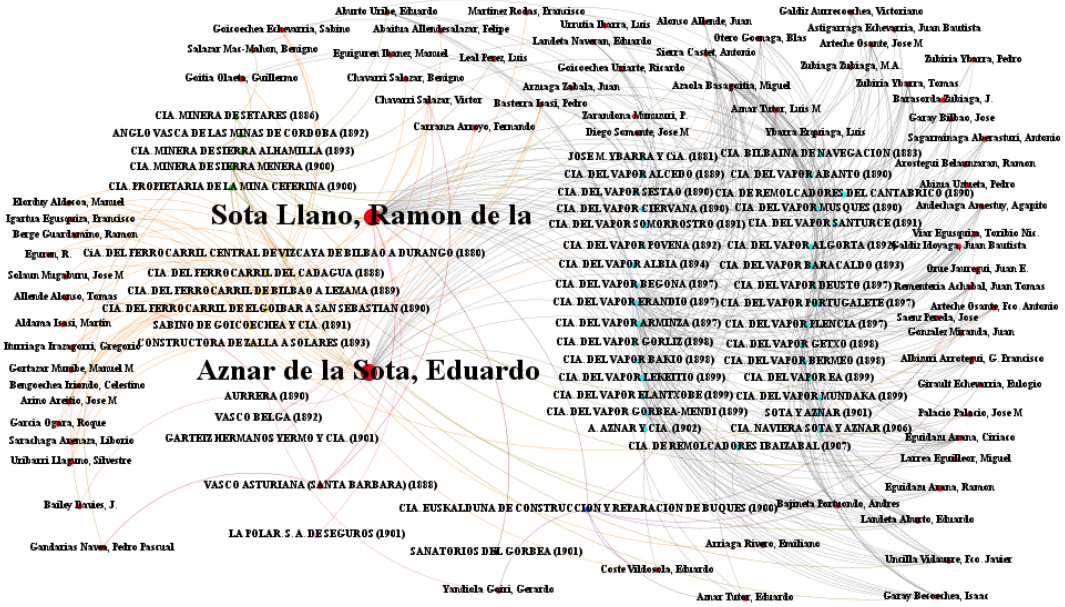
We build the first egonet for Ramón de la Sota Llano (1857-1936) and Eduardo Aznar de la Sota (1830-1902), cousins and founding partners of the Sota and Aznar business group, the investors with more edges (companies) and with greater centrality (Sota) and the highest degree of betweenness (Aznar), respectively. Although Eduardo, who originally was a shipbroker, was active in the shipping business since the 1860s, the origins of this group trace back to the 1880s after Ramón finished his law studies in Madrid, in the export and maritime transport of iron ore, then diversifying into related sectors such as shipbuilding, banks and maritime insurance, becoming one of the largest business groups of Spain in the first third of the 20th century (Torres, 1998; Valdaliso, 2006a) The contrast of Figure 2 with the one represented in Valdaliso (1988: 38), which only showed companies (and not all of them), is obvious: the new methodology offers a better and more comprehensive visualisation of the business group, including not only all the

[17] This step, in practice, eliminates the *pendants*, the nodes that have only one connection and which hands on the periphery of the egonet.

[18]See Table 4 for the place on the betweenness ranking. For reasons of space, other important partners, such as Tomás Allende, José Amézola and José Luis Costa, related to some of the groups described, are not represented here.

companies (which they helped to found), but also the most connected partners in each of them.[19]

FIGURE 2. *Giant component[20] of the general investor network (1879-1913)*



Source: compiled by the authors, using Gephi.

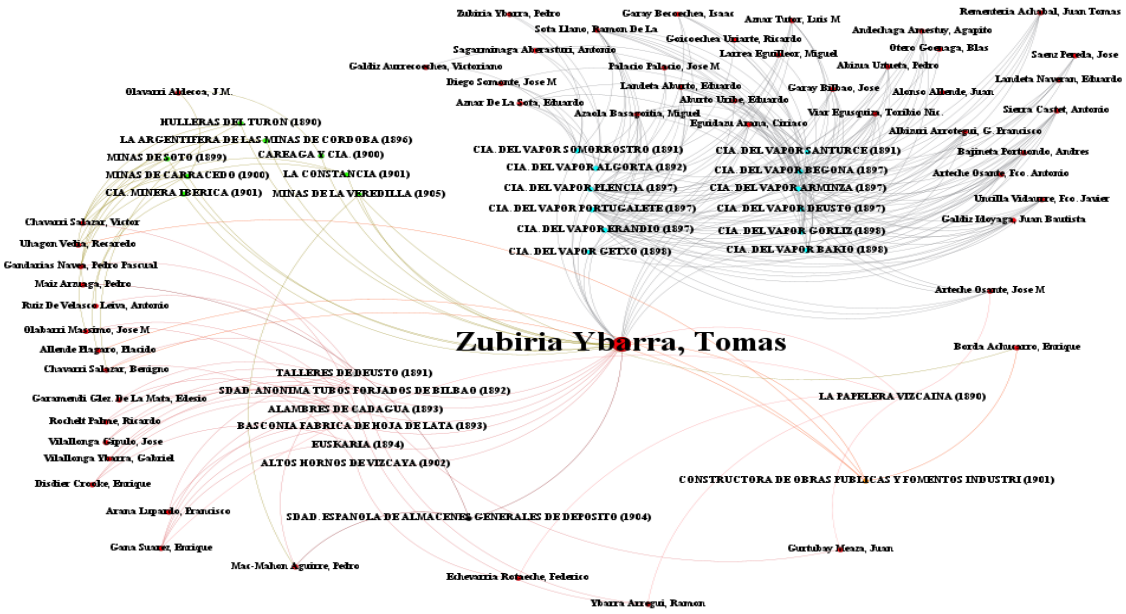
The second egonet is formed around Tomás Zubiría Ybarra (1857-1932) (in 2nd position by number of investee companies and 3rd for its degree of betweenness), one of the leading members of the Ybarra group at the beginning of the 20th century. After graduating in engineering in Liege (Belgium), where he met the Chávarri brothers, Zubiría followed his father's steps in the family business, becoming director of the newly created *Banco de Vizcaya*, and president of *Altos Hornos de Vizcaya* in 1902 (the firm that merged the iron and steel businesses of the Ybarra, Chávarri and Echevarría families) and, later on, of other flagship company of the Ybarra group such as the *Sociedad Española de Construcción Naval* (Rojo, 2000; Díaz Morlán, 2002). In comparison with the network in Valdaliso (1988: 36), that only included some companies and for the period 1886-1900, the new Figure 3 offers a more exhaustive representation of the mining and iron and steel companies in which the Ybarra (in this case, by Tomás Zubiría) held a stake, and also a new investment sector, maritime transport, on this occasion due to the active involvement of the Zubiría Ybarra brothers in the setting up of different shipping companies of the Sota and Aznar group[21].

[19] Furthermore, it should be noted that Valdaliso's figure (1988) included a company founded outside the timeframe of the analysis, *Compañía Siderúrgica del Mediterráneo*; see Torres (1998) and Valdaliso (2006a) regarding the Sota and Aznar group.

[20] It is the result of eliminating the disconnected nodes in the central cloud.

[21] Moreover, it should be noted that the Valdaliso figure (1988) included two companies founded prior to the timeframe of the sample, Orconera and Franco Belga, see Díaz Morlán (2002) for further information on both firms.

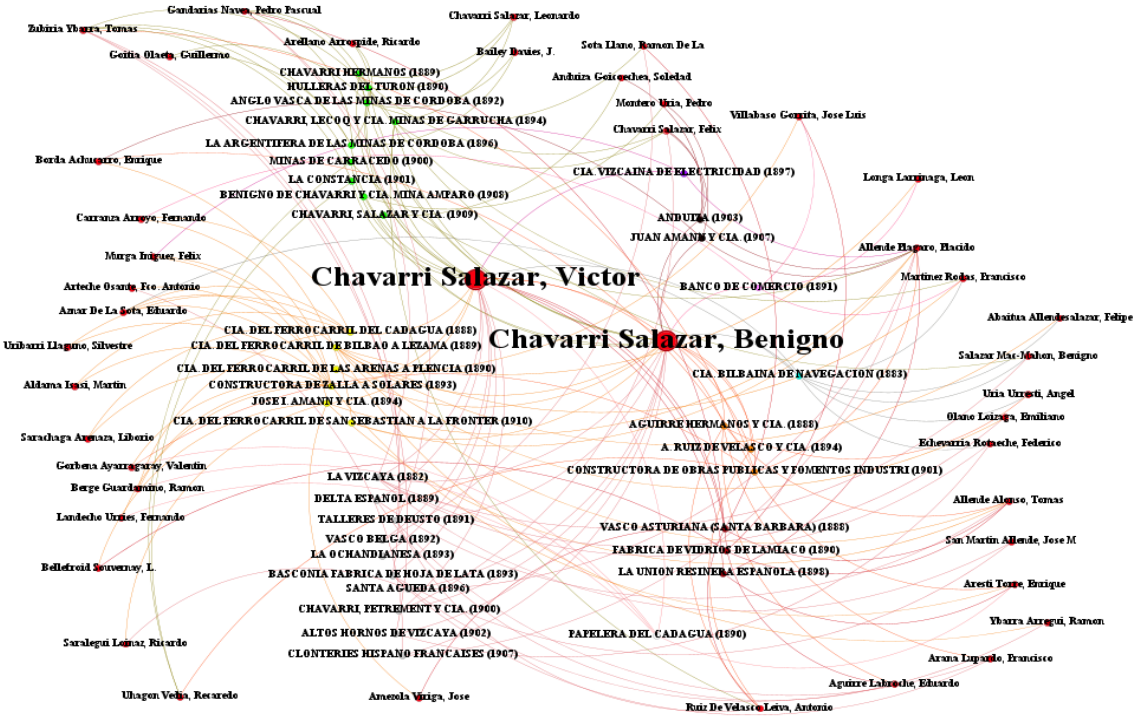
FIGURE 3. *Mode two and distance two egonet for Tomás Zubiría Ybarra*



Source: compiled by the authors, using Gephi.

Víctor Chávarri Salazar (1854-1900) is in sixth place both in centrality and in betweenness and his brother Benigno (1856-1933) ranks 15th and 8th, respectively. Coming from an entrepreneurial family involved in the iron ore mining sector, they both studied engineering at the Liege school, like Tomás Zubiría, before starting to promote the creation of several companies in iron ore and coal mining, iron and steel, metallic products, banks and real estate, among other businesses, in alliance with other important entrepreneurial families and investors such as the Ybarra family, Enrique Aresti or Tomás Allende (Alonso Olea, 2006). For the sake of a better comparison to Valdaliso's figures (1988: 36 and 39) for the periods 1886-1900 and 1901-1913, we have opted to represent an egonet of these two brothers showing in Figure 4 both the companies and the cross-partners with whom they are related in each company. This new figure makes a much better and clearer visualization of the members and boundaries of the Chávarri group, whose head, Victor, in spite of his early death in 1900, was one of the most outstanding entrepreneurs and political leaders of Biscay in those years.

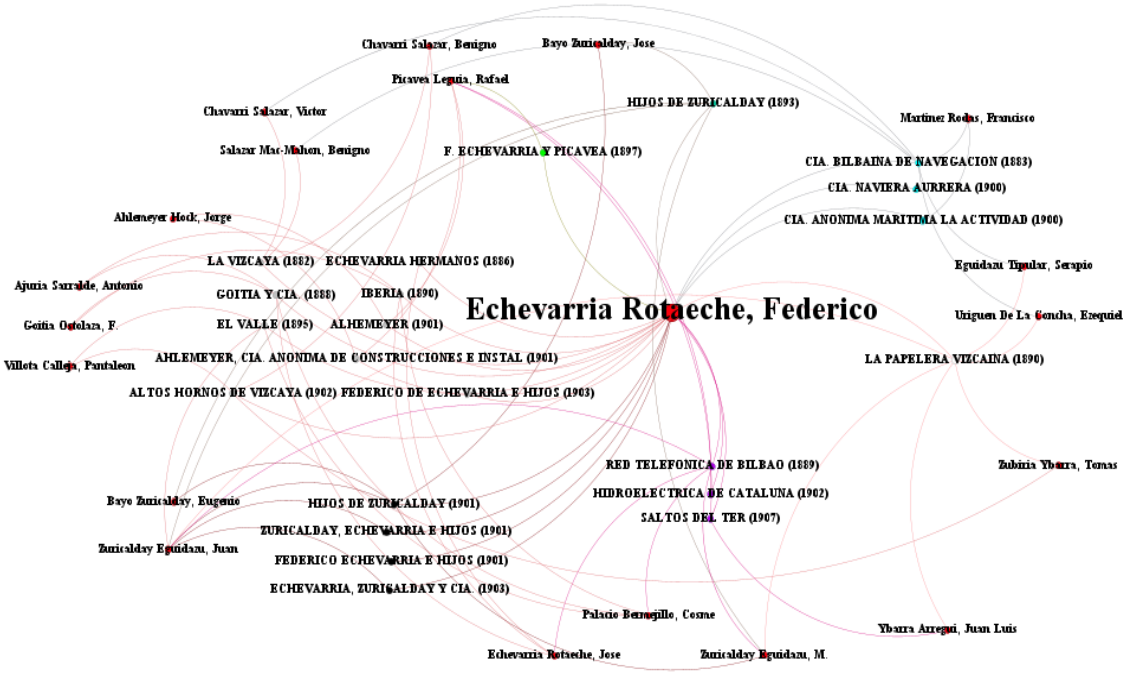
FIGURE 4. *Mode two and distance two egonet for Víctor and Benigno Chávarri Salazar*



Source: compiled by the authors, using Gephi.

Another investor with a high degree of betweenness was Federico Echevarría Rotaeche (1840-1932), who was well connected with the Chávarri and Ybarra groups in mining, iron and steel and electricity companies, and with the Martínez Rodas group in shipping companies, and with the Vizcaya and *Crédito de la Unión Minera* banks. Figure 5 is not strictly speaking to that shown in Valdaliso (1988: 37) as the latter referred only to 1901-1913, but well reflects the breadth of investee companies for the analysis period overall, focused mostly on iron and steel, metallic products, electricity, shipping, food and retailing. Echevarría came from a modest entrepreneurial family in the metal industry and eventually became one of the most powerful actors in the iron and steel industry of Biscay, along with the Chávarri and Ybarra families. The merger of the companies of these three families in 1902 resulted in the creation of *Altos Hornos de Vizcaya*, the largest iron and steel company of Spain (Arana and Alonso Olea, 2000),

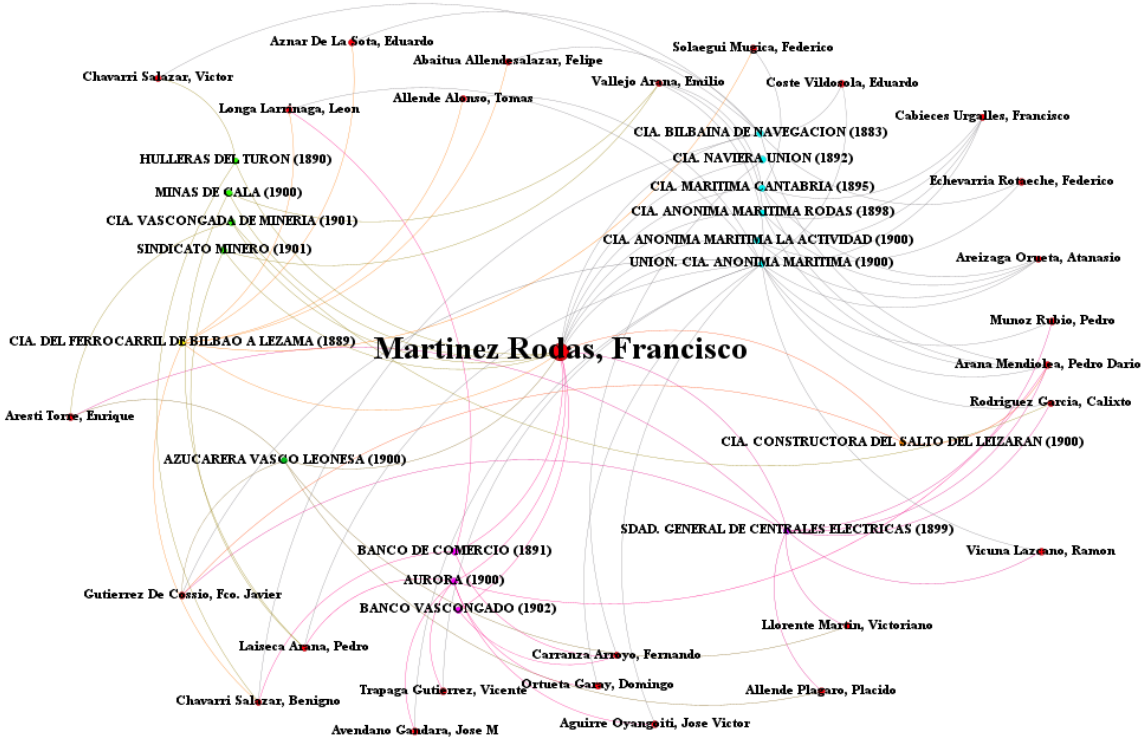
FIGURE 5. *Mode two and distance two egonet for Federico Echevarría Rotaeche*



Source: compiled by the authors, using Gephi.

Francisco Martínez Rodas (1847-1909), the last of our selected investors, likewise holds a very similar position in terms of centrality and betweenness. A senior army officer, he came to Biscay during the Third Carlist war in the early 1870s. After his marriage to Eloisa Arana Mendiolea, the daughter of a wealthy mining family of the province, he began to invest in several shipping companies, along with other participations in banks and insurance firms (Valdaliso, 1988: 16; Serrano, 2008: 106). Besides, he held stakes in several mining companies and in other large railway, food, and electricity companies, being connected to other very important investors of the Biscay network, such as the Allende brothers (Alonso and Plágaro), the Chávarri brothers, Eduardo Aznar de la Sota, Federico Echevarría, Enrique Aresti, or the group of Madrid investors made up of Calixto Rodríguez, Victoriano Llorente and Pedro Muñoz (see Figure 6).

FIGURE 6. *Mode two and distance two egonet for Francisco Martínez Rodas*



Source: compiled by the authors, using Gephi.

6. Conclusions

The paper has sought to verify whether SNA offers different and/or additional results to those obtained using a traditional analysis, in addition to allowing better visualisation of the business networks thanks to more sophisticated representation and mapping tools. The Gephi application was therefore used to analyse the database of the main incorporated companies founded between 1879 and 1913 and their founding members previously traditionally analysed. The analysis has been conducted at two levels: first, the most important investors were identified using different objective criteria of centrality and betweenness; then, the business groups configured around those investors were mapped by producing mode, distance and multiplicity two egonets.

Even though neither the research goals nor questions, nor the composition criteria for the business groups were strictly the same, the comparison between the results obtained by traditional analysis and by SNA leads to several conclusions of interest, as far as the investor network and the main business groups were concerned. First, the use of SNA does not show substantially different results: the main business groups and most important investors of Biscay between 1879 and 1913 identified over thirty years ago following the criteria of number of investee companies and cross-partners, also appear in our analysis. Neither does the composition and sphere of action of the business groups substantially differ from what was indicated in the original research, although the new methodology has allowed several changes to be detected in the composition of the investors or in the companies to which some belong. However, the new SNA

methodology offers many and very significant advantages: it is a better way to visualise and present the business groups and networks as it allows companies (grouped by activity sector and ordered chronologically) and investors to be represented; it improves the traceability of the relationships (between investors, companies and investors, and companies); it includes more objective and uniform criteria to identify groups and networks; and therefore facilitates the comparison with other similar samples and networks. On the other hand, it should be noted that the use of SNA also implies a different research methodology. In traditional analysis, a certain prior knowledge of the relevant actors in the network (investors and companies) is necessary, through qualitative information, in order to identify the existing groups and sub-networks; in contrast, the SNA first identifies the most relevant investors, companies and business groups, which must then be analysed qualitatively. In this sense, the SNA also considerably reduces the amount of research time required.

Nevertheless, SNA also raises some interpretation problems for the researchers, particularly for large networks, due to our cognitive limitations when processing a great deal of data, which requires more restrictive (and in many cases subjective) criteria to be introduced to analyse the whole network. Among the different SNA computer programmes, special mention should be made of the potential of the Gephi application, which offers the possibility to operate with the original network and to empirically analyse its different groups. In this article, instead of reducing the population of actors or conducting a modularity analysis to detect communities, we have opted to use the many filters offered by Gephi to construct two-mode egonets of the most important investors. This procedure makes the study more objective, as it follows the focus to be on statistically relevant subnetworks without losing even a single detail of the reality. It was in the last step of representing the network when we incorporated the only subjective restrictions (namely, requiring multiplicity and distance two, and eliminating the pendants) so that the presented structures could be interpreted by the human eyes. Furthermore, as we have stated, the analysis has been conducted for the whole network and using exclusively the objective criteria of centrality and betweenness.

Even though the mode, distance and multiplicity two egonet configured around an investor does not, strictly speaking, represent the dimension and the contour of business groups made up of several members of a single family and/or partners and friends, it does provide an initial objective and very reliable approach for the mapping and visualisation of the business group, as can be seen from the comparison with the results of the traditional analysis. In any event, the qualitative information in both types of analyses is essential for a correct understanding of the network and identifying and representing the business groups. In this regard, even though the SNA was conducted as if the traditional analysis had not existed, it is undeniable that the availability of prior results, demonstrated and refined by the historiographical development considered for over more than three decades, has facilitated and guided our work, along with the experimentation with different representation indicators and statistical applications.

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Author contribution statement

The authors confirm contribution to the paper as follows: methodology, software and code, and formal analysis: Igor Etxabe; framework, investigation and supervision: Jesús M. Valdaliso. All authors participated in the elaboration and presentation of research data and the creation of the manuscript, including revisions and edits. All authors approved the final version and agreed to be held accountable for the published work.

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Anàlisi de xarxes socials: no només una eina de visualització? Reflexions de l'estudi de les xarxes i grups empresarials a Biscaia, 1879-1913

RESUM

Aquest article planteja un metaexperiment científic amb l'objectiu d'explorar, a través de l'Anàlisi de Xarxes Socials (AXS), una base de dades sobre la qual s'ha treballat prèviament a partir d'una anàlisi qualitativa tradicional (Valdaliso, 1988 i 1993). La mostra inclou més de 500 societats mercantils registrades a Biscaia entre el 1879 i el 1913, les quals representen el 30 per 100 del nombre total i més del 90 per 100 de tot el capital de les societats creades en aquesta província entre les dates assenyalades. Tot i que l'ús de l'AXS no mostra resultats substancialment diferents pel que fa la representació dels principals grups empresarials, aquesta metodologia sí que presenta nombrosos i molt notables avantatges, especialment relacionats amb una millor visualització de les xarxes. No obstant això, és cert que la nova metodologia planteja alguns problemes, sobretot a l'hora d'interpretar xarxes de grans dimensions. A més, més enllà de les tècniques gràfiques i estadístiques, la informació qualitativa esdevé imprescindible per a una comprensió correcta de les xarxes.

PARAULES CLAU: anàlisi de xarxes socials, grups empresarials, Biscaia, segles XIX i XX

CODIS JEL: D85, N01, R39, Z13

Análisis de Redes Sociales: ¿algo más que un instrumento de visualización? Una reflexión desde el estudio de las redes y grupos empresariales en Vizcaya, 1879-1913

RESUMEN

Este artículo plantea un meta-experimento científico que pretende explorar, mediante el Análisis de Redes Sociales (ARS), una base de datos previamente trabajada con un análisis cualitativo tradicional (Valdaliso, 1988 y 1993). La muestra está compuesta por más de 500 sociedades mercantiles registradas en Vizcaya entre 1879 y 1913, que representan el 30 por 100 del número y más del 90 por 100 del capital total de las sociedades creadas en esa provincia entre esas fechas. Aunque el empleo del ARS no muestra resultados sustancialmente diferentes en la representación de los principales grupos empresariales, sí presenta numerosas y muy notables ventajas, especialmente relacionadas con una mejor visualización de las redes. No obstante, la nueva metodología plantea igualmente algunos problemas, sobre todo a la hora de interpretar redes de gran tamaño. Además, más allá de las técnicas gráficas y estadísticas, la información cualitativa se torna imprescindible para una correcta comprensión de las redes.

PALABRAS CLAVE: Análisis de Redes Sociales, grupos empresariales, Vizcaya, siglos XIX y XX

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