Relational structure in the global automotive industry: groups, networks and fields

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Abstract

Purpose – The purpose of this study was to analyze the network structure of automotive companies linked by cross-shareholding, joint ventures, manufacturing contracts and alliances, from 2004 to 2012. The study also explored how the network structure affects the competition in the field.

Design/methodology/approach – The sample involved 3695 dyads. Based on this data, it was possible to build and assess networks using Gephi and UCINET software. The study considered network analysis metrics such as centrality, group and network densities temporally. Thus, associated with a contextual and longitudinal analysis, the construction of sociograms allowed visualization of the interactional structure and the automakers' position in the field.

Findings – Results showed that the internationalization and growth of automakers and suppliers are made possible through these relationships among companies (cross-shareholding, joint ventures, manufacturing contracts and alliances). Connections may generate greater power, access to resources and market opportunities. It also enhanced the elaboration of inferences about how these resources influence the competition in the field.

Originality/value – The increasing importance of this relational resource shapes the industry competitive structure, which is composed of cooperative and competitive relationships found in meso-level orders.

Keywords – Theory of fields; fields; social networks; strategic groups; automotive industry.

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1 Introduction

Meso-level studies are increasingly important in economic sociology, institutional theory and organizational analysis, enhancing the diffusion of the concepts of field (Fligstein & McAdam, 2012), social networks (Granovetter, 1985) and strategic groups (Garcia-Pont & Nohria, 2002; Gomes-Casseres, 2003; Lazzarini, 2008; Nohria & Garcia-Pont, 1991). Different theoretical perspectives co-exist and many research results suggest the need for cross fertilization. Companies tend to relate to others in order to keep or improve their position in the field (Fligstein & McAdam, 2012), by accumulating resources (Garcia-Pont & Nohria, 2002; Gomes-Casseres, 2003) and knowledge of the market (Powell & Smith-Doer, 1994). The configuration of interactions among these groups of companies play a significant role in value appropriation by the actors (Lavie, 2007), defining the incumbents of fields (Fligstein, 1991; Fligstein & McAdam, 2012) and in control and complementarity of resources (Pfeffer & Salancik, 2003). Belonging to a group is strategic to companies, since their performance depends on results and resources held by other actors they are connected to (Lazarini, 2008).

Nohria and Garcia-Pont (1991) and Garcia-Pont and Nohria (2002) argued that the automotive industry is organized in "constellations". The configurations of the property relationships, alliances and cooperation agreements play a significant role in value appropriation and in the complementarities of the groups' resources (Lavie, 2007; Lin, Yang & Arya, 2009). We suggest that groups operate within strategic action fields (Fligstein & McAdam, 2012) and that the position occupied by actors in different networks is a significant measure of the social capital (Bourdieu, 2005) or the relational resources (Gulati, 2007, Lavie, 2008) dominated by companies to maintain or improve their position in the competitive arena. Networks are related to several specific forms of resource, including intellectual property, marketing channels, manufacturing facilities and personnel (Gulati, Lavie & Madhavan, 2011). The social network analysis is herein used to measure resource endowments of different companies in the automotive industry and their changes between 2004 and 2014. This technique is based on the regularity of the structures of ties among nodes (Wasserman & Faust, 1994). The composition of networks based on cross-shareholding, joint ventures, manufacturing contracts and alliances allows mapping groups composing the field.

The internationalization of automotive companies and their strategies for entering new emerging markets are strongly associated with merger and acquisition processes, and with joint ventures (Shi, Sun, Pinkham, & Peng, 2014). It results in increasing concentration of power and new plant locations and design centers worldwide, such as those implemented in China, South Korea, Russia, India and Brazil. Cross-shareholdings, joint ventures, manufacturing contracts and alliances are indicators of these dynamics, in which companies acquire or establish partnerships with other assemblers in the automotive industry seeking strategic advantages. At the same time, companies in the same sub-groups compete and cooperate with each other and compete with other sub-groups and companies.

The current research is guided by one central question: how does the network structure influence the position within the field? Other questions are relevant as well, such as: what are the most central companies along the studied period? What are the strategic groups? Do the sub-groups become denser? How do relationships and relational issues promote a privileged position in the field? The study seeks to dialogue with distinct theoretical perspectives of fields, strategic groups and networks to address the dynamics of industries. So, the purpose of the paper is to map the network structure of the alliances between automotive companies and to explore how it affects the competition in the field.

2 Theoretical foundations

Theoretically, the paper contributes to clarify the relationship between networks and fields. Networks can support other different resources. So, we can infer that corporate and managerial social skills in networks are significantly important to advance to new positions and get new resources. Techniques of social network analysis as the ones used in the paper are useful to get objective measures of social capital. Together with the measures of other resources, these may generate inputs to the drawing of the structure of the field, which may be done either using multiple correspondence analysis, in the Bourdiesian fashion, or, alternatively, also using social networks techniques to interconnect properties and actors, as suggested by Nooy (2003). Visualizing networks may also be useful for a more qualitative assessment of fields. In this case, it is relevant to understand how the position in the network relates to the shared meanings of actors, who are the incumbents in the field and why.

2.1 Fields

Field theories have been commonly used to study the economic realm in contemporary economic and organizational sociologies. There are at least two main basic perspectives using the concept of fields in different ways (Swedberg, 2004). The first one is associated with the sociological institutionalism in organizational analysis (DiMaggio & Powell, 1983; Powell & DiMaggio, 1991). In this case, organizational fields are conceptualized as "those organizations which, in the aggregate, constitute a recognized area of institutional life: key suppliers, resource and product consumers, regulatory agencies, and other organizations that produce similar services or products" (DiMaggio & Powell, 1983, p. 148).

The second approach derives from the sociological approach by Bourdieu (1985), which conceptualizes fields as:

a network, or a configuration, of objective relationships between positions. These positions are objectively defined in their existence and in the determinations they impose upon their occupants, agents or institutions by their present and potential situation (situs) in the structure of the distribution of species of power (or capital) whose possession commands access to the specific profits that are at stake in the field, as well as by their objective relation to other positions (domination, subordination, homology, etc.). (Bourdieu & Wacquant, 1992, p. 97).

According to these authors' view, the concept of field may not be isolated from concepts such as *habitus* and capital, constituting a relational scheme of perception that may be used for a rigorous, but not rigid, empirical analysis. Agents' positions (individuals or organizations) are defined by the relative distribution of resources recognized as valid in the field's competition. For instance, in the case of economic fields, financial, cultural, social, technological, juridical, organizational, commercial and symbolic resources are all important to market competition, with the relative endowments of companies defining their position and possibilities (Bourdieu, 2005).

Inspired by Bourdieu's approach, Fligstein and McAdam (2012) recently suggested a similar perspective that defines fields as arenas with socially constructed sense of belonging, boundaries and understandings for operation (i.e., the understanding of what is at stake in the field, who the incumbents and challengers are, what the rules of the space are and how actors in different positions should act). The authors suggest the adaptation of the Bourdiesian approach to more systematically account for conscious cooperation and collective action by replacing the sense of *habitus* with that of social skills. They also have a more nuanced and strictly symbolic definition of power in the field, suggesting that the existence of incumbents and challengers without any objective

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accounts on how the field structure is defined by the objective and relative distribution of different resources.

The herein presented automotive industry analysis will draw on Bourdieu and Fligstein and McAdam (2012) perspectives without overemphasizing their differences. These approaches define field in a more focused way than it is defined in the institutional account, which demands taking into consideration the interconnection of fields (Fligstein & McAdam, 2012). Thus, the assembling companies in this industry which were approached in the current study will be considered part of the same field – which is possibly composed of subfields, including specific segments (or strategic groups, as suggested by Garcia-Pont & Nohria, 2002) and organizations, which might be assessed as fields themselves.

Based on this working hypothesis, the study will also consider that assembling companies operate in a context in which social capital (Bourdieu, 1985) or relational resources (Gulati, 2007) become increasingly important to their competitiveness. Such proposition meets extensive literature on organizational and economic sociologies, which is focused on assessing the institutionalization of new organizational forms that can change these organizations' boundaries by increasingly conceiving them as networked organizations (Boltanski & Chiapello, 2009; Davis, 2009; Donadone, 2004; Fligstein, 1991; Grün, 1999). According to these authors, this process was driven by changes in the regulation of developed economies and in the increasing control of organizations by the logic of finance, resulting, among other consequences, on drastic changes in organizational dynamics, due to the corporations' growing focus on their core business and interdependence on other actors in their "value chain" (Davis, Diekmann, & Tinsley, 1994).

Empirically, clear examples of this perspective were found. Take the example given

by the Chinese market, whose access was justified by its potential consumers, i.e., the giant Chinese domestic demand, which is an attractive resource in terms of man-power, cost, qualification, inputs and raw materials. The country's internal volume ensures unprecedented competitiveness levels in comparison to other geographical regions. Incumbents and challengers must dominate the local rules within the global competition game. Thus, every group gets access to local resources in China by means of joint ventures (Shi et al., 2014).

It does not mean that all automakers have local presence. However, once a group is formed, its access becomes a common asset. By taking the example of Fiat from 2004-2006 and 2007-2009, the company established three relationships with Chinese companies. After its partnership with Chrysler, from 2010 to 2012, Fiat jumped to 22 partnerships in China. There are also specific findings such as GM and Nissan partnership from 2010 to 2012 in the European and North American markets against Ford and Toyota. These partnerships are based on assembly contracts that allow automakers to produce vehicles with acceptance in specific markets to their partners. They establish a specific partnership system for the manufacturing of a specific vehicle (in this case, a van) and share their facilities. They understand that there are benefits on competing against incumbents within this sector.

The abovementioned examples also emphasize a possible convergent perspective of the social capital as understood by Bourdieu (1985) and the relational resource as prescribed by Gulatti (2007). This convergent perspective is explored by Nooy (2003), who observed that the theoretical background of correspondence analysis is compatible to the one of network analysis. Through network analysis techniques it is possible to assess social capital. Nooy (2003) also argues that:

> people who are involved in a field recognize power relationships from attributes and

from intersubjective relationships: acts of submission are so similar as emblems of power. Thus a researcher may use data on intersubjective relationships for assessing the amount and distribution of particular species of capital. If Bourdieu argues that interaction is driven by the distribution of types of capital, the former can be used to measure the latter. (p. 319)

Interactions represent much more than ties among nodes and may involve recognition and power relationships. Let's take again the examples above. Fiat allied with Chrysler to leverage its presence in China, conforming to the production model in the country. The monetary valuation of Chrysler is a form of conversion of social into economic capital. Also, GM accepts to share a production line with Nissan. Arrangements like this involve a form of domination expressed as a dyad among two automakers like Fiat and Chrysler, or a triplet in the case of GM and Nissan – GM → Shared plant and Nissan → Shared plant. We can use relationships to operationalize different forms of social capital.

However, it is crucial to operationalize these assessments of these variables based on objective relationships, which means:

> differential possession of capital [among actors]: economic, social, and cultural capital. In [Bourdieu's] theory, the relational aspect is not some kind of exchange or interaction, but the fact that relative differences count: do you have more capital, another type of capital, or another property or trait than someone else? This is the reason why Bourdieu prefers correspondence analysis: correspondences are relatively frequent combinations of properties. (Nooy, 2003, p. 325).

In the next section, another body of literature focused on how these companies conceptualize their boundaries in a more focused

way and developed different forms of alliances with other companies, in the same field, as part of their strategy to produce or improve their positions will be revised.

2.2 The rise of strategic groups in fields: Alliances and constellations

The demand for inter-firm cooperation enhanced the formation of strategic alliances (Garcia-Pont & Nohria, 2002). After these changes, several studies started to focus on groups or constellations rather than on individual companies (Casseres, 2003; Das & Teng, 2002; Lazzarini, 2008; Mahmood, Zhu & Zajac, 2011; Powell, 1990). These studies assumed new competition models and became increasingly focused on constellations, instead of focusing on individual firms, competition, formation of oligopolies, differentiation sources, resource acquisitions and management, and profit sources. They assumed that the constellation structure affects the way organizations compete and the position in the group influences the gains appropriated by each firm (Powell, 1990). They have multiplied because they are viewed as efficient in dealing with knowledge-based activities, solving hold-up problems, and reducing contractual hazards (Menard, 2013).

Casseres (2003) defines constellations as a group of companies connected through alliances that compete with other constellations or with a single company in a certain competitive domain. Das and Teng (2002) define them as a strategic alliance composed of several partner companies to compete against other groups and individual companies. Alliances are defined as inter-firm cooperation arrangements established to achieve strategic goals (Powell, 1990), and constellations are alliances involving autonomous companies that compete against each other for clients and members in a specific or nearby sector (Lazzarini, 2008).

Besides being a complex type of strategic alliance, constellations are spreading rapidly among important industries. Das and Teng

(2002) cite a database with 2417 alliances among several sectors and countries, in which more than a quarter of the partnerships consist of multilateral alliances, or constellations. The authors also argue that constellations should be conceptualized as relevant forms of social control and suggest a typology of constellations based on general reciprocity and exchange of information, knowledge and other resources.

It is also important to distinguish constellations from other forms of cooperation. Inter-firm partnerships may be considered as the strategic alliances or the network of alliances (Das & Teng, 2002). Both represent inter-organizational relationships aiming to enhance competitive advantage via cooperation. However, whereas a network of alliances involves several ties with different objects, a strategic alliance involves two or more companies in a specific cooperation agreement.

Constellations may be more or less formalized, and the informal ones are called implicit constellations. In this case, companies are more interdependent within constellations than they are to firms that are not part of them (Lazzarini & Joaquim, 2004; Li, Eden, Hitt, Ireland, & Garrett, 2012).

2.3 Network analysis

As analytical tools, networks are founded in the structure of interactions that shape several market aspects, in which social connections corroborate structures or regular relationships among units (Wasserman & Faust, 1994). The structure of the ties may be economic, political, interactional, and affective, among other forms. Relationships are expressed through linkages among units of analysis, through which material and non-material resources, physical interactions and authority relationships flow (Wasserman & Faust, 1994).

Actors are defined as a set of discrete, individuals, corporations or other collective social units (Carpenter, Li & Jiang, 2012; Scott, 2012; Wasserman & Faust, 1994). They may be

individual or collectivitie, such as informal groups and formal organizations (Berkowitz, 2013; Knoke & Yang, 2008), and are represented by nodes and supported by attribute data regarded as properties, qualities or features of individuals and groups (Scott, 2012). However, as Borgatti and Li (2009) pointed out, the level of the individual partly depends on their position in the network structure and on their relationship patterns.

Connections, relationships or linkages are defined as specific types of contact, connection or tie between a pair of actors or dyad. Relationships may be direct and indirect. By focusing on a specific type of relationship, a researcher may measure a joint dyadic property (Knoke & Yang, 2008). Connections are supported by relational data about contacts and ties. Relational data connect agents in larger relational systems (Scott, 2012) and, by using these connections, some actors have more access to information and scarce resources.

The network structure is the specific pattern assumed by the network (Knoke & Yang, 2008). Positions define the place of an actor within the network structure, which may be assessed in relation to the overall structure of the networks (Granovetter, 1985; Rowley, Behrens & Krackhardt, 2000; Sacomano & Truzzi, 2009), defining the structural and relational embeddedness (Granovetter, 1985). Structural and relational embeddedness works as control elements of the behavior and cooperation of partners within an alliance (Rowley et al., 2000; Tate, Ellram, & Gölgeci, 2013).

There are several properties in network analysis that support the research of the complex relationships among actors. The structural properties presented by Wasserman and Faust (1994) are: centrality, structural equivalence, structural autonomy, density and cohesion. The centrality of an actor in relation to another within the network provides privileged access to resources, information and power. The structural autonomy assures the same effects of centrality, and it happens when an actor intermediates the

relationship between two other actors in the network. Structural equivalence denotes cases in which two actors occupy similar positions in the network structure. Density is the fraction of actual relationships in a network in relation to the number of possible relationships in it. It facilitates the flow of information and resources, thus allowing the emergence of a closed system of confidence and shared standards. Cohesion is understood as the intensity of the relationships, in which strong cohesion is associated with refined information sharing, tacit knowledge, social control and reciprocity. Recent research considering actors attributes in the network also indicated the importance of reach, richness and receptivity as measures of network resources (Gulati et al., 2011). These properties establish a pattern of clustering in the network. The formation of tightly interconnected cliques suggests processes of differentiation into subgroups, and changes in these groups may represent the reconfiguration of competing constellations, discontinuities in the technologies used in the network or shifts in its power structures (Ahuja, Soda, & Zaheer, 2012). A combination of these measures and the attributes of automotive assemblers, used as relational capital metrics of specific companies and groups, may provide the basis to the analysis of the structure of fields. The current study will focus on identifying the most central actors and group formations, by analyzing relationships such as cross-shareholding, joint ventures, manufacturing contracts and alliances.

The study also considered network analysis metrics such as centrality, group and network densities. An algorithm based on non-normalized network was selected to calculate group metrics and its graphical representation.

3 Research method

The research method used is descriptive and exploratory (Bervian & Cervo, 1996). Quantitative data was used to describe cross-shareholdings, joint ventures, manufacturing contracts and alliances, from 2004 to 2012. Data

was not updated from 2012 until today because the Automotive News database has not published the new relationships (cross-shareholdings, joint ventures, manufacturing contracts and alliances) among companies for the last years.

The exploratory design is appropriated to address topics with few or no previous study (Collins & Hussey, 2005) and patterns, ideas or hypothesis to be tested need still to be elaborated. The study is also a descriptive research, aiming to identify and gather information about the features of automotive industry (Collins & Hussey, 2005). The compiled data is quantitative and the statistical techniques will be used for assessing data.

3.1 Data collection

The first step was gathering data of cross-shareholdings, joint ventures, manufacturing contracts and alliances in the automotive industry from 2004 to 2012. Data was obtained from Automotive News, OICA (International Organization of Motor Vehicle Manufacturers) specialized publications and official information released by the companies. Connections involving several countries were addressed.

An intermediate data preparation process was conducted on the VantagePoint platform [www.theVantagePoint.com] in order to get the collected data prepared to build networks and their metrics. A thesaurus was developed to group node names into a standardized list of node names. This feature was applied to the complete set of identified nodes (plants, family investors, banks, pension groups, municipalities, governments, automakers, joint ventures, alliances etc.) and categories (countries and technologies).

3.2 Population and sample

From 2004 to 2012, OICA published the world ranking of motor vehicle manufacturers based on the produced units. This ranking involved 47 to 50 individual automakers each year. The sampled group is a portion of this ranking and it comprises 26 individual automakers associated

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to OICA, which represents 90% of the units produced worldwide. A composition of formal relationships (such as ownership, joint venture, assembly contract and technical alliances) and produced units was taken into consideration to include the automaker or to exclude it from the list. Only small automakers without global operation were kept out of the network map chart.

The data collection method provided more than 98% relational and nodal representativeness in comparison to OICA's ranking. This was because, throughout the data collection process, it was considered that all declared alliances – technical/parts, joint venture, assembly contracts and ownership – should be understood as a relationship between automakers. By applying this ratio, it was possible to collect nodes from the abovementioned list. The list was the main reference, however, in the end, the found nodes were based on production plants, family investors, banks, pension groups, municipalities (in China and Germany for instance), governments (China, the USA, Canada, France, etc.), joint ventures, alliances (based on joint venture, third party contracts, ownership, etc.) and so on. Then, even with a starting point of 21 to 25 nodal automakers, the current study achieved more than 95% nodal representativeness in comparison to the annual OICA ranking of automakers.

The amount of interactions in the sampling was 3695 from 2004 to 2012. The number could vary from 230 to 400 relationships per year. This is a scale free network, which means that alliances such as DaimlerChysler were terminated and those such as FiatChrysler were created throughout this period. Thus, a single node was converted in two nodes and then collapsed into one node again. This led us to certain difficulties in making individual comparisons, which were overcome by using general network metrics and group algorithms based on time stability.

3.3 Data assessment

The construction of the sociograms allowed the visualization of the structure, the relationships and the positions of the assemblers in the network. Networks were presented using the GEPHI software[1] (Bastian, Heymann & Jacomy, 2009). The constellations involve groups of companies with formal or informal cooperation agreements that compete against other groups in the same or in a similar industry (Lazzarini, 2008).

Once the nodes and categories were standardized, the VantagePoint platform was used to produce the matrix of Automaker X Automaker through the logics of co-occurrence over the list of relationships (node, node; categories). Each pair of matrix was established considering the following periods: (i) 2004-2006, (ii) 2007-2009 and (iii) 2010-2012.

Based on the tabulated data, it was possible to assemble networks using Gephi and UCINET software. Metrics such as centrality, group density and network density were then calculated. To do so, an algorithm based on non-dichotomized networks was used. This is the stability principle of a partition which:

> measures the quality of a partition [group] in terms of the properties of a stochastic process applied on the graph, [in which] stability is based on flows of probability on the graph and therefore captures how the global structure of the system constrains patterns of flow (Lambiotte, Delvenne, & Barahona, 2008, pp. 3-4).

It means that the strength of the ties is seen as patterns, which drive the quality of partitions (group), instead of the traditional modularity based on dichotomized interactions. Another property of the quality is that it is equal to modularity when it is applied to a dichotomized network.

4 Research results

The purpose of the research was to assess how the structure of the networks of corporate alliances influences the position within the automotive industry. This is an exploratory

study aiming to generate reflections about the automotive field dynamics. Thus, item 4.1 presents the sample's density and modularity data. Item 4.2 presents the actors who are more or less central in the networks. The following section focuses on the main groups and on the formation of constellations and coalitions. Finally, the study explores how social capital operates as resource to the actors in the field.

4.1 Networks density and modularity

Network density decreased along the three periods, as illustrated in Table 1. It means that many network ties were dissolved between 2007 and 2009. The density decreased sharply before the 2008 financial crisis. At the same time, the network modularity increased, which indicates intense formation and definition of groups. Data revealed that the concentration process and the dynamics of the automotive industry are associated with the composition of strategic groups and not necessarily with the overall density. The industry is organized in groups and coalitions, which suggests increasing concentration of the field through the formation of different ties, such as joint ventures, mergers, alliances and manufacturing agreements.

In practice, what seems to have occurred between 2007 and 2009 was a decrease in the number of new alliances and a greater focus on assembly contracts. Groups tend to disappear when the dynamism of alliances decreases. On the other hand, the increase in assembly contracts imply in a reduction of the number of production plants, which affects the number of network nodes and increases the entanglement among automakers. Thus, slower pace partnerships, fewer network nodes and greater sharing of production lines eventually increased the entanglement between automakers, thereby increasing the total network density. The periods of 2004-2006 and 2010-2012 were times of stability and showed similar relationships between modularity and density.

Based on this regular distribution, the exploratory analysis favored the study of relational

structure in a period right before, during and after the crisis. The year of 2013 was kept out of the analysis to assure the homogeneity in the global metrics in the three years periods.

Network density of approximately 1.2% was stable in the first period (2004, 2005 and 2006). It increased to 1.4% in the second period (2007, 2008 and 2009), but decreased during the crisis. Finally, density dropped to 1.0% in the third period (2010, 2011 and 2012) and then stabilized.

Table 1
Density and modularity

	2004-2006	2007-2009	2010-2012
Graph density	1.2%	1.4%	1.0%
Modularity	70.2%	63.2%	70.4%

According to this sample, the reduction in the overall density from 2004 to 2012 indicates a reduction of possible relationships among network actors. Therefore, the automotive industry faced a disaggregation process in this period, and the network became more dispersed. At the same time, as shown in figure 1, the modularity increased, indicating the formation and better definition of groups. The 2008 crisis was key to the field reconfiguration. Curiously, before 2008, network density decreased and a new pattern was established after the crisis. Along this period, some companies got stronger and others lost positions. New groups were established and forces in the field were reorganized. Next section assesses how companies' centrality changed along the period.

4.2 Network centrality: companies' level

Info graphic 1 shows the composition of groups in three periods and the network index, such as number of nodes, links and groups' density. There is significant reconfiguration in the companies' positions in the network. Companies with higher production volume, according to OICA's data, were selected and had their network indexes assessed (degree, betweenness, eigenvector and cluster coefficient).

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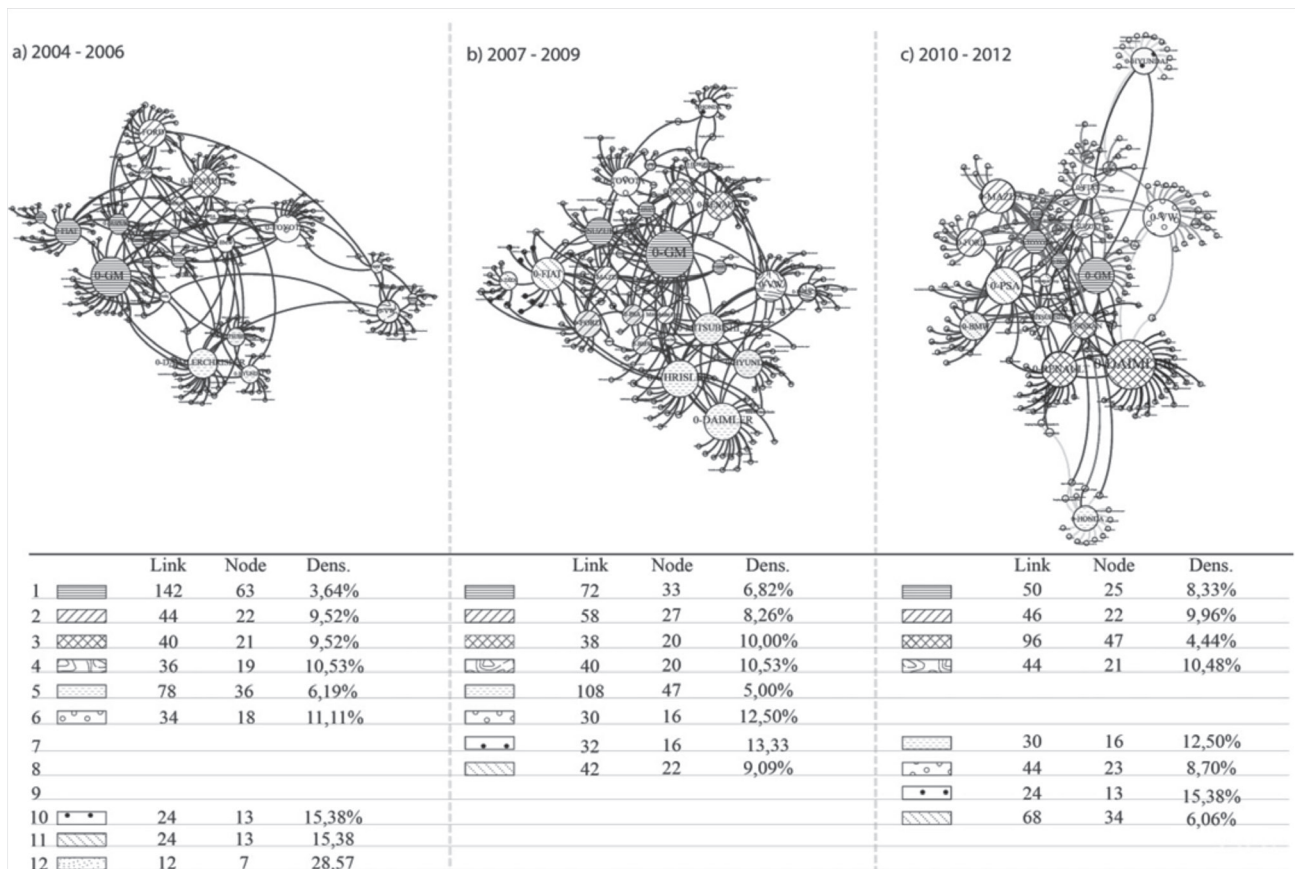
Figure 1. Infographic of strategic groups

General Motors had the higher number of relationships (degree) in the first two periods. However, it lost degree, betweenness and eigenvector from the second period on (during the crisis) and in the third period. The cluster coefficient index significantly increased in the second period and remained stable in the third one. GM was strongly associated with Fiat and Suzuki in the first period. In the second period, it broke its ties with Fiat. In the second period, GM was strongly associated with Suzuki and Isuzo and it was the central company in the network. GM lost some centrality in the third period, and Daimler became the most central company. According to results from the algorithm, GM used its relationship with Isuzo to approach Toyota, and they started acting in the same group.

Toyota had significant degree in the first period (21), but its centrality also decreased over the three periods (17 and 13). The betweenness also decreased and the eigenvector decreased between the first and second periods and increased back between the second and third periods (from 2010 to 2012).

Volkswagen, differently from GM and Toyota, increased its centrality throughout the three periods. Actually, in 2014, the company also became the largest automotive company worldwide. The intermediation degree decreased from the first (2004 – 2006) to the second period (2007-2009), but it increased back in the following period (2010-2012). The eigenvector centrality and the clustering coefficient significantly increased from the first to the second period, but it decreased a little in the third one (2010-2012).

Hyundai's centrality increased from the first (2004-2006) to the second period (2007-2009) and faced a small decrease in the third period (2010-2012). Its intermediation degree increased throughout the three periods. As for the eigenvector, it increased in the course of the second period (2007-2009) and decreased in the

third period (2010-2012). The cluster coefficient got substantially higher and then dropped to zero in the third period. Hyundai became relatively autonomous in its ties in the third period (2010-2012). The trajectory of Hyundai's assembly plant began as defined by the group, which occupied the 10th place in the OICA ranking of produced units and reached the 4th place in OICA ranking as an independent automaker.

Renault-Nissan kept investing in cooperative relationships. In 1999, Renault group acquired 44% of Nissan capital participation. Individually, Renault kept a stable centrality degree, showing small decrease between the first (2004-2006) and the third periods (2010-2012). In terms of intermediation degree, eigenvector decreased in the first period (2004-2006) and increased in the sequence. Its cluster coefficient increased over the three periods. As for Nissan, the centrality degree increased between the first (2004-2006) and the second periods (2010-2012). The intermediation and the eigenvector increased between the first and second periods. Nissan's cluster coefficient was impressively high, as that of Isuzu.

Ford's centrality, intermediation and eigenvector degrees decrease from the fist (2004-2006) to the second periods (2007-2009). In the third period (2010-2012), centrality remained stable and there was increase in intermediation and eigenvector metrics. As for the clustering coefficient, Ford improved from the first (2004-2006) to the second period (2007-2009) and this index remained stable in the passage to the third period (2010-2012).

4.3 Groups and networks

The current item explores the following question: What are the strategic groups? Do the sub-groups become denser? In order to do so, the current study used the algorithm developed by Lambiotte, Delvenne and Barahona (2008), which structures the groups by considering the weight of connections, in contrast to the existing literature, which was entirely focused on grouping nodes. Thus, instead of assuming that a community is a set of nodes with many links between them, the current study considers a community to be a set of closely interrelated links (Ahn, Bagrow, & Lehmann, 2010). Based on this algorithm, data revealed a change in the groups over the three periods. Certain groups became bigger and others were dissolved. In terms of number of ties, during the last period 2010-2012, the main subgroups along the periods were those highlighted in Groups 1 and 3. Group 5 operated during the first two periods and disappeared in the third one, due to Daimler-Chrysler dissolution.

Table 2
Network centrality metrics

Automaker	Year	Degree	Betweenness	Eigenvector	Clustering Coef.
	2004-2006	13	2227	0.0139	0.0256
BMW AG	2007-2009	11	1184	0.0188	0.1273
	2010-2012	16	2670	0.0164	0.0167
	2004-2006	2	-	0.0058	1.0000
CHRYSLER GROUP	2007-2009	23	3244	0.0380	0.0909
	2010-2012	7	1466	0.0067	-
	2004-2006				
DAIMLER AG	2007-2009	23	2966	0.0315	0.0593
	2010-2012	30	5839	0.0281	0.0092

Automaker	Year	Degree	Betweenness	Eigenvector	Clustering Coef.
DAIMLERCHRYSLER AG	2004-2006	23	6702	0.0265	0.0237
	2007-2009	1	-	0.0036	-
	2010-2012				
DONGFENG MOTOR CORP.	2004-2006	9	1234	0.0086	0.0556
	2007-2009	8	2003	0.0070	0.0714
	2010-2012	3	362	0.0052	-
FAW	2004-2006	8	1157	0.0009	-
	2007-2009	5	647	0.0045	-
	2010-2012	6	957	0.0146	0.1333
FIAT S.P.A.	2004-2006	20	4336	0.0239	0.0105
	2007-2009	20	3854	0.0234	0.0368
	2010-2012	15	3246	0.0218	0.0381
FORD MOTOR CO.	2004-2006	21	3815	0.0114	0.0048
	2007-2009	16	1860	0.0150	0.0417
	2010-2012	16	2381	0.0186	0.0417
FUJI HEAVY INDUSTRIES LTD.	2004-2006	8	744	0.0169	0.0714
	2007-2009	3	228	0.0051	-
	2010-2012	4	408	0.0074	-
GENERAL MOTORS	2004-2006	32	9192	0.0537	0.0141
	2007-2009	30	5202	0.0401	0.0437
	2010-2012	21	2892	0.0357	0.0429
HONDA MOTOR CO.	2004-2006	10	1404	0.0131	-
	2007-2009	11	1576	0.0012	0.0182
	2010-2012	14	1971	0.0021	-
HYUNDAI MOTOR CO.	2004-2006	13	2037	0.0087	0.0128
	2007-2009	17	2252	0.0203	0.0441
	2010-2012	15	2559	0.0089	-
ISUZU MOTORS LTD.	2004-2006	6	488	0.0152	0.0667
	2007-2009	9	807	0.0239	0.3611
	2010-2012	8	424	0.0245	0.3571
MAZDA MOTOR CORP.	2004-2006	9	1675	0.0135	0.0833
	2007-2009	14	1490	0.0220	0.1429
	2010-2012	20	4227	0.0301	0.0684
MITSUBISHI MOTORS CORP.	2004-2006	13	1913	0.0122	0.0385
	2007-2009	19	2762	0.0372	0.1345
	2010-2012	11	1870	0.0200	0.0727
NISSAN MOTOR CORP.	2004-2006	11	1697	0.0196	0.1091
	2007-2009	15	3183	0.0286	0.1429
	2010-2012	15	2934	0.0344	0.1429
PORSCHE AG	2004-2006	6	1045	0.0013	-
	2007-2009	10	1392	0.0052	0.0222
	2010-2012	4	200	0.0030	0.3333
PSA/PEUGEOT-CITROEN SA	2004-2006	9	1503	0.0099	0.0278
	2007-2009	12	2872	0.0195	0.0606
	2010-2012	22	3933	0.0331	0.0346

Automaker	Year	Degree	Betweenness	Eigenvector	Clustering Coef.
RENAULT SA	2004-2006	22	3793	0.0246	0.0130
	2007-2009	17	2565	0.0130	0.0147
	2010-2012	21	3471	0.0301	0.0286
SAIC	2004-2006	7	234	0.0078	-
	2007-2009	7	596	0.0094	0.0476
	2010-2012	3	292	0.0070	-
SUZUKI MOTOR CORP.	2004-2006	15	1864	0.0279	0.0762
	2007-2009	17	2155	0.0319	0.1324
	2010-2012	13	3016	0.0334	0.1667
TATA MOTORS	2004-2006	7	1251	0.0039	-
	2007-2009	10	1430	0.0035	-
	2010-2012	6	985	0.0031	-
TOYOTA MOTOR CORP.	2004-2006	21	3802	0.0219	0.0048
	2007-2009	17	2391	0.0117	0.0074
	2010-2012	13	1912	0.0217	0.0641
VOLKSWAGEN AG	2004-2006	17	4526	0.0081	-
	2007-2009	19	3262	0.0226	0.0409
	2010-2012	22	3830	0.0173	0.0130

Group 1, composed of companies such as GM and Fiat, was clearly the dominant one in terms of ties and nodes in the first period (2004-2006). In the second (2007-2009) and in the third periods (2010-2012), this group went through a sharp decrease in the number of ties and nodes, probably as a result of the 2008 financial crisis. Fiat left the group in the second period, and a second force emerged from the association between Fiat and Tata, which is highlighted as Group 8. This group improved its position in the third period, mobilizing more ties and actors with Chrysler and Suzuki.

Group 3 also had significant increase in the number of ties due to the introduction of Daimler in the third period (2010-2012). Initially formed by Renault-Nissan, the number of actors and connections composing the group increased one hundred percent with the Daimler's arrival, which brought all the connections previously associated with the Group 5 and strongly modified the structure of the Group 3 in the third period (2010-2012).

The Group 5 was initially composed of Daimler, Mitsubishi and Hyundai and it increased the number of ties and actors in the second period (2007-2009) but it disappeared in the third period (2010-2012) due to Daimler-Chrysler dissolution. Mitsubishi got associated with Group 10 and Hyundai formed a new group in the third period (2010-2012), which is highlighted in Group 9. This Group 9 lost centrality in the passage to the third period (2010-2012).

The number of ties in Group 2 also increased over the entire period. This was a relatively stable group led by Ford and Mazda. In the second period (2007-2009), its number of ties increased when PSA, BMW and Mitsubishi joined the group, but it dropped down a little in the third period (2010-2012). In general, it remained stable from the second to the third periods. In the first one, the group already held PSA and Mitsubishi, but it became stronger in the third and second one (2006-2009), according to this sampling.

Group 4 increased the number of ties over the three periods. It was led by Volkswagen and Porsche and it remained stable in the second period in terms of the number of ties and actors.

Group 6 was very influenced by Toyota. It lost actors and relationships from the first to the second periods. In the third one, it approaches Group 1, when Toyota and GM became more connected. Here, we see a possible joining of GM and Toyota for the 2010-2012 period, when joint ventures were established with the Chinese FAW.

Certain groups were more stable in terms of their relationship structure and their density presented less variation. They had more stable social capital strategies along the considered period. This is the case of the group led by Volkswagen (4) and the one led by Ford (2). Group 3 was the most unstable group over the period, and it went through a major change when Daimler approached Renault-Nissan.

PSA, BMW and Mitsubishi formed a new group in the third period, Group 10. It was established in first period with PSA and BMW; it disappeared in the second and re-emerged in the third period with the participation of Mitsubishi.

In terms of cluster coefficient, the best positioned companies are those associated with Chrysler and Nissan in the first period and, associated with Group 3 afterwards. In the second period, Isuzu's (Group 1), Nissan's (Group 3) and Suzuki's (Group 1) cluster coefficients were particularly impressive. In the third period, the indexes of Porsche (Group 7), Isuzu (Group 1) and Nissan (Group 3) were the highest ones. These companies had greater level of influence over their neighboring peers, as defined by UCINET (2014).

4.4 Social capital and fields

The automotive industry may be studied as a field, in which companies such as Toyota, General Motors, Volkswagen, Ford and Hyundai dispute for market space. Emergent companies, such as Dongfeng, Faw, Saic and Tata, also play an important role as international partners and network intermediates. As it is possible to see in the network index, these challenger companies have high degree of intermediation (betweenness centrality) and work as bridges to emergent

markets and other production platforms.

Among the incumbent companies, Hyundai, Volkswagen and Renault-Nissan stand out mostly in terms of their position in social networks. Hyundai, for instance, was established in the 1960's and, nowadays, it is the fourth biggest assembler in the world. The Hyundai-Kia relationship (acquired in 1998) also generated positive results to the Korean group. The three companies presented certain positive relationship between network indexes and their growth over the period.

The automotive field had been through important changes along the considered period. Actors were involved in a complex game and strategies with several challenges. Currently, this industry has excessive production capacity, high fixed costs, energetic and other technological challenges and demands for environmental and mobility solutions. The field also competes with other arenas, such as the airline, railway and shipbuilding sectors. Incumbent actors establish strategies to keep their field domain and expand their markets in order to address these challenges. One of these strategies consists of establishing alliances with other companies to assure their access to and control over certain resources.

Social capital may be converted into other resources along with reconfiguration of the global automotive industry. These relationships may assure access to markets, new production forms, new design and manufacture technologies, cost reductions, institutional domain, among other capitals. Networks do not represent the field, but they may be used to measure the distribution of relational resources that affect the dispute in the arena. Thus, networks may help understanding the formation of coalitions within the field, which affects the control conditions and the shared meanings that organize the social space. The longitudinal study of networks may also indicate the existence of stability and change in the field.

There are different ways through which companies may invest in relational resources. Managers' social skills are important to create and

maintain relationships with other actors. These relationships have an intersubjective effect and influence the development of shared meanings that organize the field. Companies also tend to imitate alliance strategies understood as successful, especially those of the incumbents, in a process of mimetic isomorphism. If one thinks social skill as *habitus*, one can infer a positive meeting predisposition in the 2007-2009 period. As previously mentioned, there was higher share of production lines, fact that eventually increased the entanglement between automakers in this period. Establishing a production line requires predisposition to accept competitive technologies.

Network data also reveals the increasing influence of financial actors, such as JP Morgan and Bank of Japan, as intermediate actors in the automotive industry. Another interesting point is related to the emergence of new technologies. Data shows that the number of partnerships organized around sustainable solutions significantly increased in the studied period. Therefore, funding and sustainability appear to have significant influence on actors' behaviors in the field and they might be determinant to the disputes unfolding in the space.

5 Discussion

The automotive industry goes through intense geographic, technological and environmental change processes. Sturgeon, Memedovic, Biesebroeck and Gereffi (2009) mention some modifications associated with this industry: 1) Increased direct investment (FDI) in developing countries by cross-border trade; 2) more value chain activities in supplier firms; 3) final vehicle assembly kept close to end markets; 4) Strong regional structures; 5) customization; and 6) small number of giant companies exert power over smaller firms. These features stimulate the sharing of vehicle platforms among different models. Thus, cross-shareholdings, joint ventures, manufacturing contracts and alliances are fundamental to understand the industry dynamics.

The global overcapacity in the industry also stimulates the formation of groups and alliances. Each business group holds some types of complementary resources and certain geographical locations, as highlighted by Lavie (2007). Thus, the relationship between companies forms a capital that can streamline a significant number of resources (Gulatti, 2007; Powell & Smith-Doer, 1994). These connections create groups, coalitions between companies and may generate important positions in the structure of relationships and industry domain.

More central actors dominate information flows. Certain groups can articulate complementary resources and generate relative impact on the competition between groups, as shown in the findings of Casseres (2003) and Das and Teng (2002). The companies' associative logic is affected by the composition of the groups, as highlighted by the network indices of modularity. Modularity indicates greater definition in the composition of groups. Interestingly, as shown in Table 1, the period of greatest modularity degree in the sample was the second period (2006-2009), during the 2008 crisis. Thus, the 2008 crisis was crucial for the rise and fall of some organizations and new business groups. During this period, many efforts were made to share online platforms among companies when the number of assembly contracts significantly increased. Then, the results suggest that powerful actors (organizational and interpersonal) had to build new coalitions, and group in order to keep their advantages during the crisis, using their social skills (Fligstein & McAdam, 2012). They also sought to manipulate symbols, identities and meanings structuring action in the field to induce cooperation.

The overall connection structures of some companies such as General Motors, Toyota and Ford (centrality and betweenness) also decreased. In contrast, VW, Hyundai and Renault-Nissan gained prominence in intermediation rates and centrality in the network, as pointed out in the infographic 1. According to data from OICA, these companies were precisely the ones

with successful performances in world vehicle production in the last five years. According to OICA's data, Hyundai and VW have been growing consistently since 2005, and Renault started gaining market especially from 2009 on.

In this regard, survey results point towards the formation of strategic groups, coalitions or company constellations (Casseres, 2003; Das & Teng, 2002; Lazzarini, 2008; Powell, 1990). These groups allow access to different resources, such as technology, global platforms, design and other important resources. In addition, intermediary companies - such as Chinese companies - helped connect major manufacturers - such as FAW-, which mediated the relationship between GM and Toyota in the third period (2010-2012).

The idea of social skills can be scaled up to organizations and not necessarily to people, despite the fact that they always originate in individuals and are activated by them. To build and transform networks, individuals have to act inside organizations to build coalitions that may coordinate strategic organizational action. This is achieved by creating shared believes that accommodate the different conceptions coexisting in organizations and that should orient the construction of interactions with external social actors (Fligstein & McAdam, 2012). Socially skilled individuals may even create shared conceptions orienting others to behave strategically, building what would resemble an organizational social skill. These skilled organizations should orient, for example, individuals in key positions to be attentive to the possibilities of building new interactions in order to accumulate social capital more systematically. Managers and executives must develop their interpersonal skills to orient the building of organizational networks and these social skills at individual and corporate social skill level are highly interrelated. Obviously, relationships associated with these networks are commonly agreements between two or more legal entities. To execute these agreements, it is necessary that members of the managerial elite agree with the contractual terms. So, contractual relations among companies somehow reflect the corporate social skills constructed by individuals.

6 Final remarks

It can be inferred that the industry operates in a type of constellation, in which companies tend to keep bilateral relationships with others in the same group as part of their strategy to gain position in the field. However, connections are relatively dynamic and they significantly changed during the studied period. It is possible to see how the social skills and the willingness to work together with an "enemy" are evident in the data.

In this sense, the industry needs to compose complementary relationships in different markets in order to internationalize production and sales structures. This dynamic international business is streamlined by the composition of groups. The generated capital can then support several key features for the dominant players in the field, but high intermediation actors such as the Chinese, may compose an important type of capital to access such markets.

The paper illustrates that relational resources are very important in today's competitive arenas and that the connections among companies are dynamic, and may face drastic changes in contentious periods. Managers have to be social skilled to understand the movements occurring in the field and to build coalitions capable of supporting organizational strategies. In other terms, the ability to induce cooperation in highly competitive settings appears to be an increasingly important skill for managers.

The assessment of the changes in the strategic positions of companies in the network structures over time has significant implications to practitioners. In a context in which the boundaries of the organizations are increasingly fluid, managers have to be socially skilled to recognize the increasing importance of social capital and to induce cooperation in their organizations in order to be well positioned in

the structure of networks. In a highly competitive environment, relational resources are valuable to acquire and retain other resources, such as technological capabilities, managerial expertise, access to domestic markets and governments, access to privileged information, and so on. So, social skills are demanded to build networks and to reconfigure their structures. As the results of our longitudinal research show, coalitions of organizations have to be created and re-created continuously and, to interfere in the process, actors must be able to continuously identify new opportunities to improve their positions. The position in the field can be supported partially by networks positions. The relationships among competitors and partners in the field are also a key strategic asset capable of generating other changes in the field.

From a theoretical point of view, the study presents the analytical potential of social network analysis, composed longitudinally. Without the use of this method, it would have been impossible to map such high volume of relationships. In this sense, social network analysis is elementary for the study of contemporary organizational phenomena, whether in intra-organizational, inter-organizational and field level.

Network analysis is a powerful method to analyze the structural change of a field. However, it is worth understanding that the anti-categorical imperatives of strict network assessment does not offer appropriate theoretical tools to understand the way actors interpret and act in the game in which they are inserted (Emirbayer & Goodwin, 1994). A way to deal with this limitation is to articulate and orient its usage by field theories as the ones used here. For the analysis of fields, it is necessary to deepen the intersubjective field structures, and to understand the relationship between actors occupying different positions in competitive arenas. Either way, data revealed interesting dynamics such as the composition and prominence of groups and companies, suggesting that the generated social capital is increasingly important in economic fields.

Some questions arise from the research: do groups support internationalization? How can the central companies benefit from their position? How can intermediation companies influence the network dynamics? What are the resources obtained by companies and groups? Is social capital a key resource to get another resource in the field? Thus, there are too many efforts to develop complementarity in group, network and field studies. Far from closing the debate, further research on the relationship among groups and fields is important for advancing in the understanding of the contemporary economic and organizational dynamics.

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Note

1   Gephi is an open source software for graph and network analysis

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1. Definition of research problem	√	√		
2. Development of hypotheses or research questions (empirical studies)	√	√		
3. Development of theoretical propositions (theoretical Work)	√	√	√	
4. Theoretical foundation/Literature review	√	√	√	
5. Definition of methodological procedures	√	√	√	√
6. Data collection		√		√
7. Statistical analysis	√	√		√
8. Analysis and interpretation of data	√	√	√	√
9. Critical revision of the manuscript	√	√	√	√
10. Manuscript Writing	√	√	√	√
11. Other (please specify which)				