Business Networks in the Colombian Pharmaceutical Industry

Jorge Enrique Mejía Quiroga, Universidad Central Colombia, jmejiaq@ucentral.edu.co

Sergio Cuellar, Pontificia Universidad Javeriana Colombia, scuellar@javeriana.edu.co

Juan Carlos Cobo, Pontificia Universidad Javeriana Colombia; cobo-j@javeriana.edu.co

David Shepard, Universidad de California; United States; dave@humnet.ucla.edu

David Benavides, Queensland University of Technology, Australia; david.benavides@connect.qut.au

Abstract

Strategic alliances are one of a company's main competitive tools. In some contexts, however, it is difficult to know the value of such alliances because there are no databases that track this information. In this paper, using data mining techniques, we build a database of the Colombian pharmaceutical industry. With Social Network Analysis (SNA) and bibliometric tools, we identify the shape of this ecosystem. We discover two main sub-communities: one international and one national. Finally, we show that, for the most part, players with the largest revenues play the most significant role in the network, while some organizations play a very important role that can only be discovered through SNA.

Keywords: Social Network Analysis – Business Networks– Pharmaceutical Industry – Colombia -– Alliances

1 INTRODUCTION

It would seem easy to quantify strategic alliances between private companies in a specific sector through contracts, agreements and similar arrangements (Kleymann & Seristo, 2017) , yet in practice it rarely is. Access to such information is restricted, and companies are unwilling to disclose it. As a result, researchers resort to the development of databases based on semi-structured data (Rothaermel, 2001). Discovering an industry's structure based on business relationships is

also complex. Therefore, identifying partnerships through public information poses a challenge for researchers. We take this problem as the object of our present research.

Literature on competition shows that a key determiner of competitiveness is collaboration networks, or strategic alliances. Modern models of innovation are based on cooperation during R&D as a key driver (Qi & Wang, 2016; C.-H. Wang, Huang, Chang, Lin, & Chiew, 2015), just as in models focusing on innovation from the market. Therefore, to compete, a company must know how to innovate, and relations between firms, government, and academia play an important role in this innovation (Leydesdorff, Etzkowitz, Ivanova, & Meyer, 2017). This observation shows that it is possible to establish that strategic alliances are fundamental for organisations to compete (Tseng, Lin, Pai, & Tung, 2016).

But what are these alliances? Strategic alliances are relationships between two or more organisations, usually for a common benefit. Alliances are "strategic" when they are formed from voluntary arrangements among the organisations that include trade, share or co-development of technologies, products or services. The factors that lead companies to form these alliances are the identification of a need, and the availability of an alliance to meet this need (Gulati, 1998). Other factors such as the size of a company (Kleymann & Seristö, 2017), its trajectory (Y. Wang & Rajagolapan, 2015), its number of employees, its competitive position, and its importance in the generation of inventions (Qi & Wang, 2016) have been identified as important when defining alliances. Similarly, it has been found that actors generate alliances when they perceive a critical strategic interdependence with another organisation that has resources and capabilities that the other does not have.

It has been demonstrated that the most important factor for an organisation is its network of external contacts. Economic actions, like any other type of social action, take place not in isolation, but within social networks. Different types of networks can be formed such as, for example, supplier-customer networks, import-export networks (Walther, 2015), networks for the exchange of human resources, networks of strategic alliances, and networks for the co-development of inventions. The structure of the network may vary depending on the type of relationship that is maintained (Gulati, 1998), and the importance of different types of networks can vary. The scientific community has studied networks between organisations and alliances for many years. Several authors have found that such networks generate competitive advantages for their members (Verdecho, Alfaro, & Rodriguez-Rodriguez, 2009). Factors such as the maturity of the relationship have a positive influence on the generation of these advantages (Bititci et al., 2007). To understand the importance of stakeholders within a network, it is important to have a complete picture of it. Provan, Fish and Sydow (2007) identify issues such as the evolution of, government, and results generated by the network. They also highlight some aspects in which the analysis of the network in its entirety were

fundamental for understanding innovation, the improvement of negotiation conditions, and to improve the competitiveness of clusters of small companies. These authors also demonstrated that in these networks, the relationships are normally not hierarchical. (Del Monte, D'Esposito, Giordano, & Vitale, 2011) analysed data collected from surveys and databases, to show how the government, enterprises and universities interact in the generation of innovations, in an Italian district. Wang, Huang, Chang, Lin, & Chiew (2015) studied the networks of collaboration between universities and companies from information from surveys to reveal the formation of spinoffs.

Different studies have analysed the importance of the different actors in different networks. They have identified that many networks exemplify the Matthew effect: a prestigious actor in a network is more likely to be the most popular than less prestigious actors (Bothner, Haynes, Lee, & Smith, 2010)

A new model of alliances between competitors emerges, an inter-organizational relationship that combines cooperation and competition. Both partners use this collaboration to meet their own goals (Bouncken, Gast, Kraus, & Bogers, 2015). This is called "coopetition," defined as "a strategic and dynamic process in which economic actors jointly create value through cooperative interaction, while they simultaneously compete to capture part of that value"(Bouncken et al., 2015). Literature on this topic first emerged in the 1990s. One of the first publications studied the alliance that Hewlett-Packard developed with their main competitors to create the 95LX computer (Weber, 1991) but the term was developed for the software company Novell in the 1980/1990s (Bouncken et al., 2015). There are several examples of the benefits and the strategic importance of this type of alliance, for example, the collaboration between Sony and Samsung to develop screens, Toyota and General Motors in fuel cell powered cars, Amazon, and San Benedetto SpA in the food industry (Bouncken et al., 2015). Some of the advantages of this type of alliances are risk mitigation, cost sharing, economies of scale, improved competitive advantage, innovation capabilities, and value creation.

This coopetition has been studied mainly in industries such as tourism (Lin & Zins, 2016) ; (Zemla, 2016)), the public sector (Rusko, 2012) , software (Teixeira, Robles, & Gonzalez-Barahona, 2015) and pharmaceutical industry (Baglieri, Carf, & Dagnino, 2016; Fernandez-Arias, Quevedo-Cano, & Hidalgo-Nuchera, 2016) The main goals of coopetition identified by (Bouncken et al., 2015) have been to gain market power, to innovate, in supply chain relations and in the global competition.

Supplier and distributor networks may be a type of coopetition. The suppliers' networks consist of interconnected firms that assist in obtaining, using and transforming materials for the production of goods and services. Recent research has explored how the analysis of social networks can

provide the management of the supply chain by applying different centrality analyses to understand the roles of the different actors on the network (Borgatti & Li, 2009). Some authors have recognised provider networks as complex (Choi, Dooley, & Rungtusanatham, 2001) systems (Surana, Kumara, Greaves, & Raghavan, 2005) and established how under some parameters of complex systems can be modelled such communities. Provider networks have been studied in some industries specifically. For example, Greve (2009) analysed the importance of actors' centrality within a network to their adoption of technologies in the maritime industry. The generation of competitive advantages from networks of suppliers has also been studied by some authors, for example, Ford (1990) described how companies like Benetton, Toyota and Nissan achieved competitive advantages from provider networks. Other studies show networks in the taxonomies of suppliers (Harland, Lamming, Zheng, & Johnsen, 2001).

In the pharmaceutical industry, organisations have principally cooperated in exchanging technology (He & Fallah, 2011). Such partnerships may provide information for understanding the behaviour of an industry, but do not necessarily reflect agreements between firms for the launch of a product or identify an economic relationship between them. Instead, such R&D-focused partnerships are intended to generate new developments. Some examples of the types of partnerships described above can be seen in Kim and Choi (2014), who analysed the importance of collaborative networks in the performance of the firms in the pharmaceutical industry. Kim and Choi gather information from patent databases, but did not have a description of the network or identify key players. Kim and Choi did establish some centrality ranks related to productivity measured by sales. For this, they used a panel model (48 companies). Okamura and Vonortas (2006) also studied patent information from pharmaceutical and plastic industry. Based on analysis of citations and patents, they constructed networks of the computer, electronics and instruments sectors, and found structural differences between them. With a similar approach (Hu, Scherngell, Qiu, & Wang, 2015) identified the internationalisation of R&D in the pharmaceutical sector in the period of 1996 to 2013, and observed an increase in cooperation and a greater distribution of the network. Scientific information has also been used to understand how links emerge in the pharmaceutical industry: for example, (Cantner & Rake, 2014) investigated the network of scientific collaboration based on 113,057 items of the Web of Science, for three periods of time.

Coopetition in the pharmaceutical industry has been studied in Spain in a competitive intelligence analysis that was done between to 186 laboratories that represented the 85% of the prescription market. They found that it is common in the pharmaceutical industry to share information between competitor about clinical trials, new products, vaccines or assets (Fernandez-Arias et al., 2016).

2 METHODOLOGY

This research integrates two methodologies: first, Social Network Analysis (SNA) (Wasserman & Faust, 1994) and second, Data Mining (Witten, 2005). We used SNA to measure centrality, specially degree and betweenness centrality (Freeman, 1977, 1979). We also used cluster and giant component algorithms (Erdos & Renyi, 1960)

INFORMATION GATHERING

MINING

To obtain the information, we consulted Invima's Database of Health Records (http://farmacovigilancia.invima.gov.co:8082/Consultas/consultas/consreg_encabcum.jsp), which contains technical data of products, such as information from manufacturers and holders of health records, which are allowed to distribute the products in the Colombian market (Distributors). This source of information permits us to obtain data from different industries: in this instance, we examined medicines. The database allows the extraction of sanitary records, from a search by products name using three-letter combinations. To obtain all the sanitary records, we searched with all possible combinations of letters of three digits, for example (AAA, AAB, AAC, AAD, etc).

DATA CLEANING

Using the statistical software package R, we applied data mining methods (regular expressions) to extract the search fields needed to analyse the information. Since our data was semi-structured we found it necessary to normalise the data using Vantage Point Software. With this data set, we de-duplicated records using Vantage Point software, which produced a total of 14334 records. In the normalised database, we found 870 manufacturing companies and 948 companies owning health records.

DATA ANALYSIS

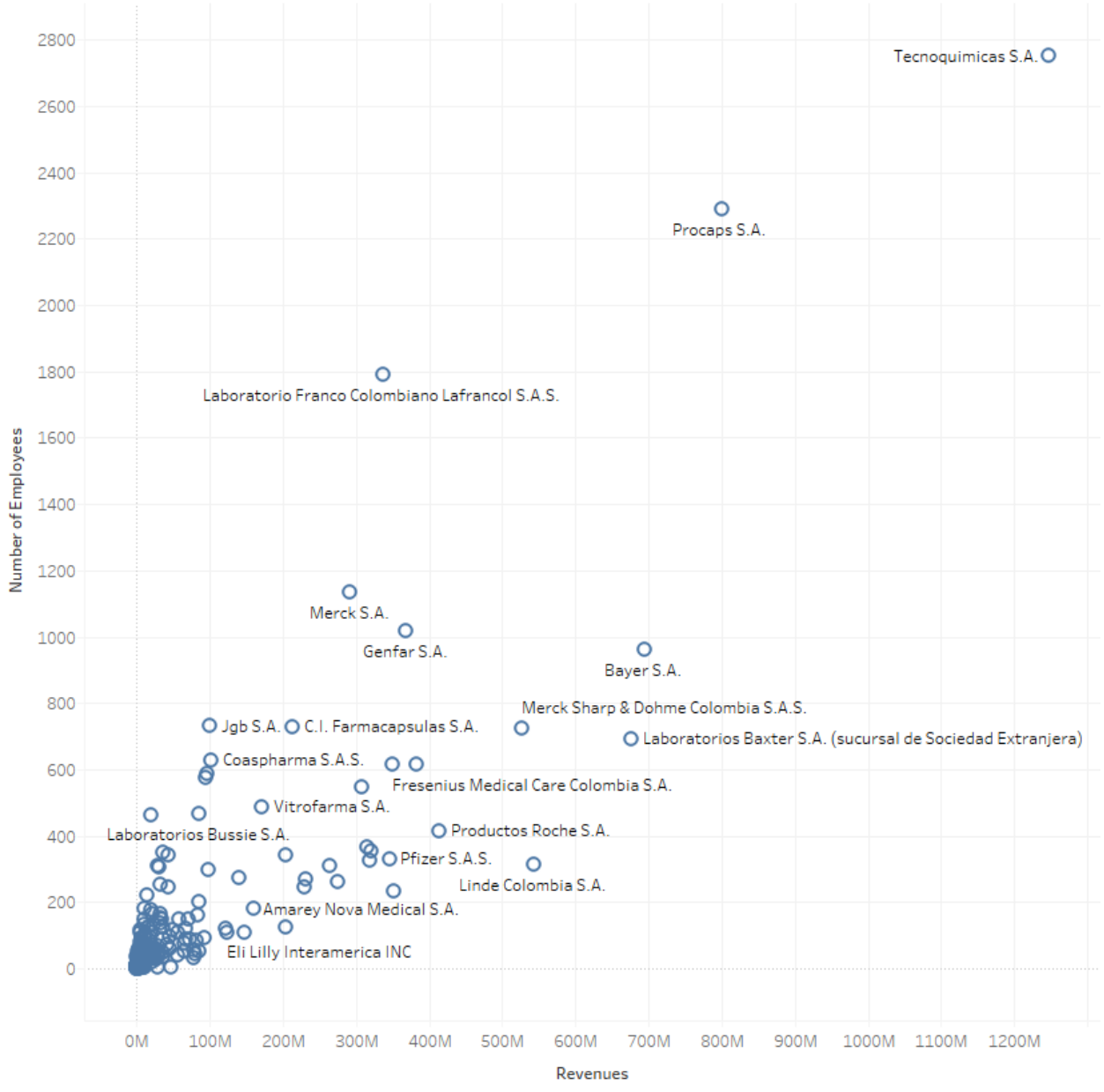
We performed our analyses of social networks of manufacturers and suppliers in the Colombian pharmaceutical industry. We identified sub-communities in these networks using the Louvain method for community detection (Blondel, Guillaume, Lambiotte, & Lefebvre, 2008), with the network analysis program Gephi. We also calculated the various centrality measures using Gephi with an algorithm developed by Brandes (2001)

3 RESULTS

3.1 The Colombian pharmaceutical industry

The top 20 companies in the sector generate 95% of the profits of the pharmaceutical sector of Colombia. A more important result is that only three Colombian companies are listed in the top 20. The most important is Tecnoquímicas, which is the largest company by sales in Colombia. The other two listed companies are Lafrancol and Procaps. The sales growth of companies in the period 2012-2013 reveal that the firms with greatest growth are of Colombian origin, the most outstanding being Procaps with 15%, Siegfried Laboratories with 14%, and Garmisch with 12%. The remainder are Merck, with 11%, Tecnoquímicas, with 10%, Scandinavia Pharma with 16%, and lastly Novartis, Chalver and Avimedi with 9%.

Graphic 1: key competitors in the Colombian pharmaceutical industry by sales and number of employees.

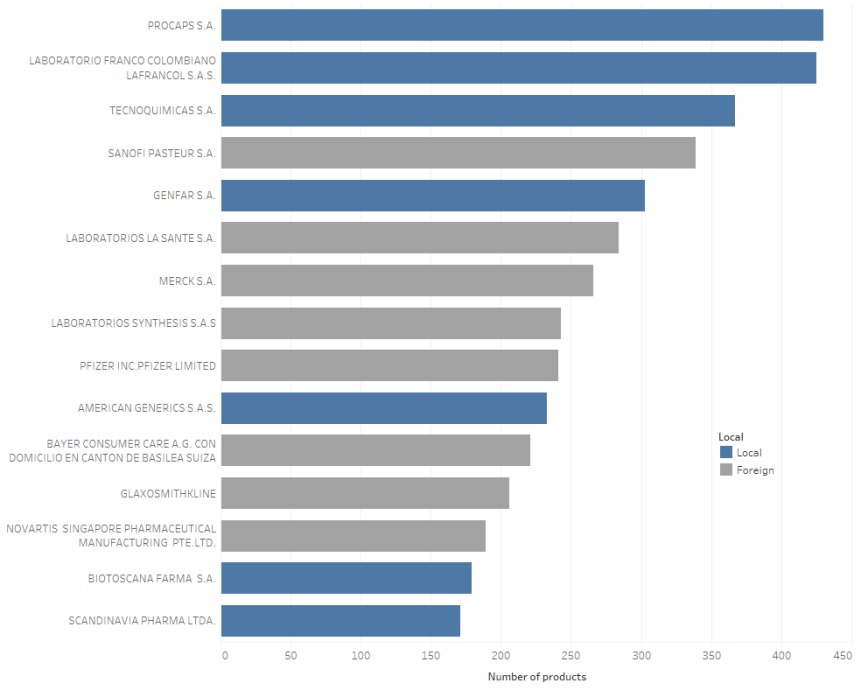


Similarly, we evaluated organizations by two indicators: revenues and the number of employees. These two measures show that the companies with large numbers of employees and high profits are Colombian companies, while companies with high profits and few employees are mostly multinational, indicating that most foreign medicine is produced overseas.

We performed a quantitative analysis based on the number of pharmaceutical products using as primary data those companies with current health registration or who have applied for registration, which yielded 948 companies. According to this indicator, the Colombian companies were relevant for the number of products and three of these are the ones with the greatest number of records. These are Procaps, Lafrancol and Tecnoquimicas. Other companies in the country that accounted for the total of health records are Genfar, Laboratorios Synthesis, American Generics and Scandinavia Pharma. For their part, the most important multinationals ranked by the number of sanitary registrations are Sanofi Pasteur, La Santé, Merck, Pfizer, Bayer, Glaxos , Novartis and Avimedi.

The companies from the Top 20 (based on number of products) hold 30% of the total of products in the country, which is a very representative figure. Johnson & Johnson, an outstanding enterprise ranked by total earnings, figures as much less important ranked by number of products.

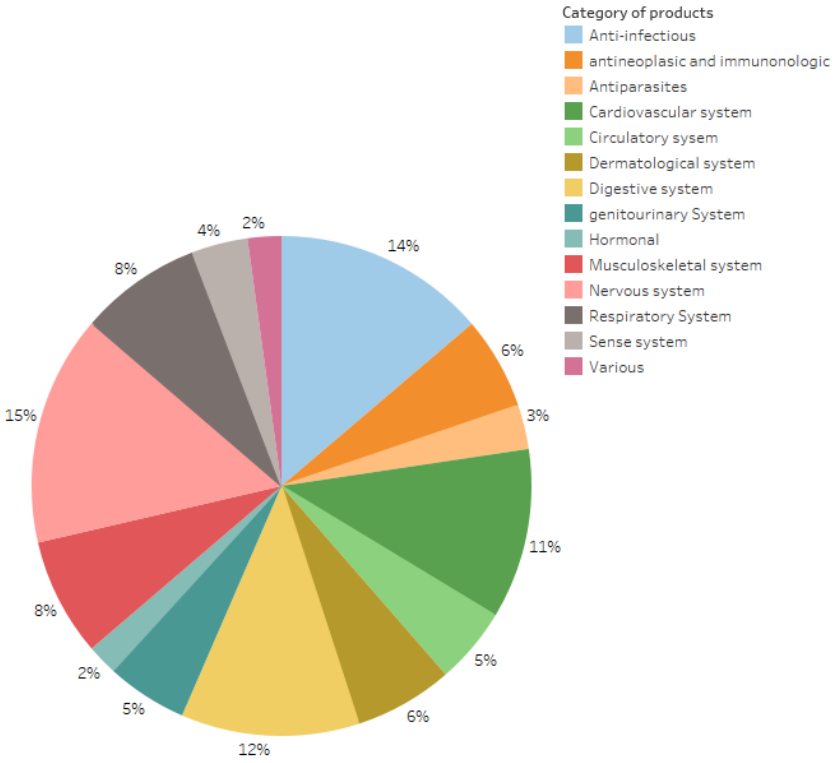
Graphic 2: Key enterprises from the Colombian pharmaceutical industry by the number of current key products. Source:Own elaboration



For the analysis, these records were classified by type of disease or application. We used the Anatomical Therapeutic Chemical (ATC). We analysed 14 categories mainly, the more general of this index.

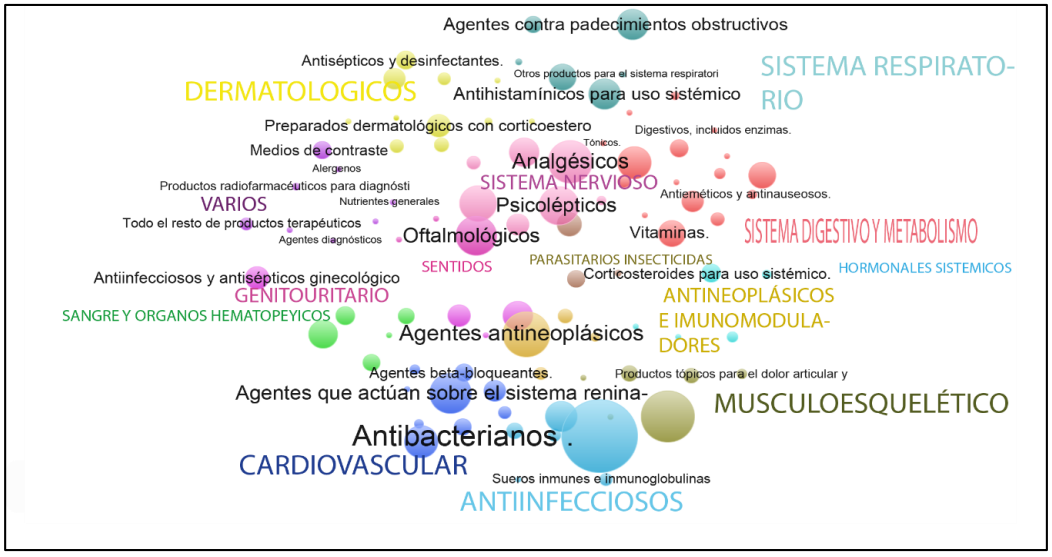
We observe that, in Colombia, the products being developed are for preventing or treating diseases associated with the nervous system (15%), systemic anti-infectious drugs, (14%), digestive system and metabolism (11%) and cardiovascular system (11%), the other main ATC and their percentages can be seen in **¡Error! No se encuentra el origen de la referencia.**.

Graphic 3:Main product categories of the Colombian pharmaceutical industry.



In addition, the ATC three-digit classification was used to recognise specific fields where innovation is being generated in products. The 15 main categories of ATC can be observed in the following commercial map with its main subcategories. Each category is represented by a different colour where the title (a digit ATC) corresponds to the main categories and its uppercase and nodes of the same colour represents subcategories. We see that the nervous system category has subcategories within existing health records or processing. This highlights psycholeptics and analgesics.

Graphic 4: Sub-medical areas where there are products of the Colombian pharmaceutical industry. Source: Own elaboration

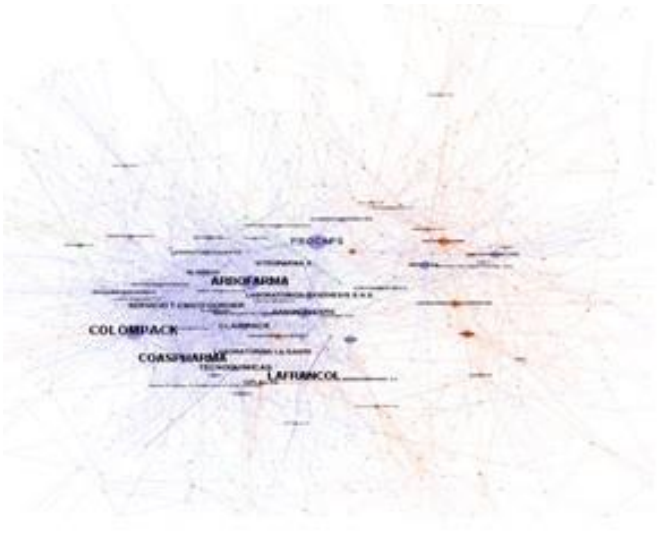


3.2 Subcomponents

We identified networks of socioeconomic exchange between manufacturers and suppliers. It has been demonstrated that strategic partnerships are a way to acquire resources and capabilities unavailable inside the organization (Teece, Pisano, & Shuen, 1997).

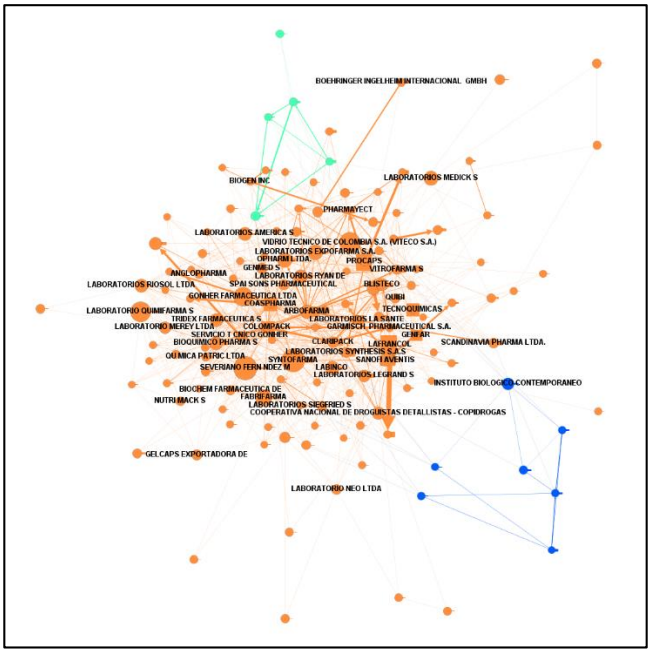
Our first analysis established the most important network measured by the number of actors (**¡Error! No se encuentra el origen de la referencia.**). From 1,413 actors, 1,158 (82%) are part of the giant component or main network.

Graphic 5: Giant component highlighting nodes with greater degree centrality



Using a clustering algorithm, we identified sub-communities within the network. We discovered two clusters within the giant component (GC). The first (Cluster O) contains 64% of all nodes within the GC, while Cluster B contains 37% (**¡Error! No se encuentra el origen de la referencia.**). Component O is mostly composed of Colombian companies, while component 1 is mainly composed of international companies.

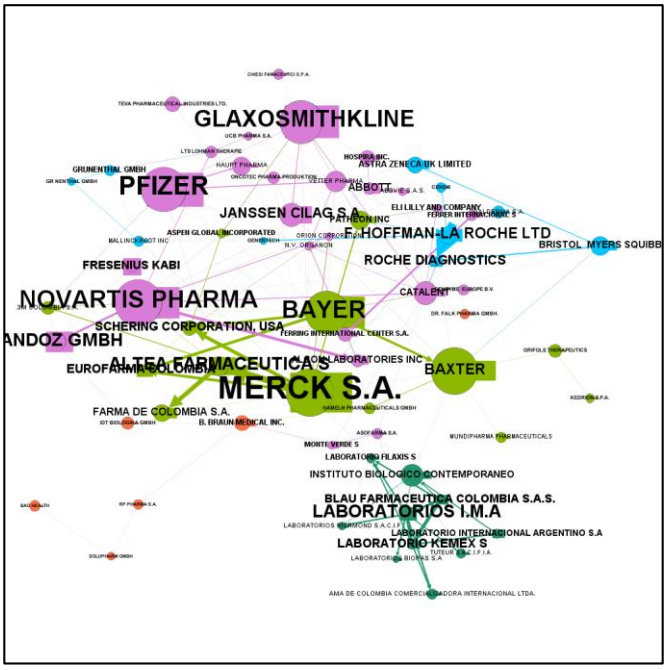
Graphic 6: Cluster O among owners of health records (size node betweenness Centrality)



Measured by number of strategic alliances, the most important actors in this cluster are Colombopack, Arbopharma, and Blitesco. By revenue alone, these companies do not seem relevant in the Colombian pharmaceutical sector, but examining their position in the social network shows their true importance. Procaps, Sanofi, Sintesys, Lafrancol, and Santel stand out because they play an important role in the ecosystem: they each have a large number of strategic partners, and their recognition by sales or prestige makes them important players within the competitive ecosystem, which is reflected in their high degree centrality. The companies that serve as bridges for all subcomponents of the network are Procaps, Arbofarma, Colombopack, and Sanofi; each has high betweenness centrality. The ecosystem of cluster O highlights the presence of Boehringer Ingelheim and Sanofi Aventis, two international companies with strong links to national companies. The most relevant sub-clusters of component O are shown in graphic 8.

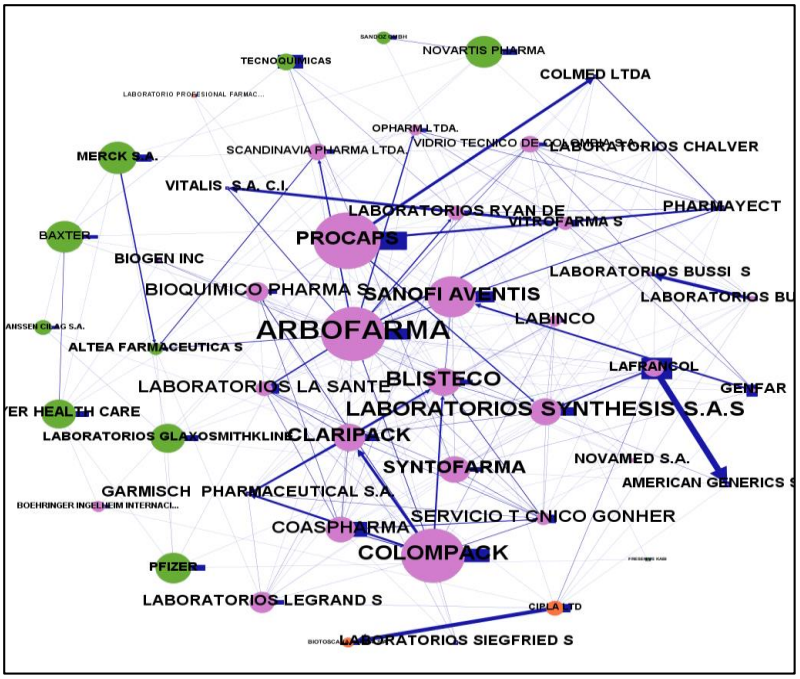
Cluster 1 is composed mainly of international companies (non Colombian). In this cluster, it is even more evident that enterprises with high sales are relevant in the network. Merck, Pfizer, Novartis, Bayer, and Glaxos are the most important measured by degree centrality. The colours of the subcomponents show strategic alliances between multinationals. The alliance between Glaxos, Novartis, Pfizer and Janssen, Hospira and Abbot, which make up part of the same sub-component shows how small sub-communities form within this ecosystem. Other sub-communities can be seen in Graph 9.

Graphic 7:Cluster 1: international partnerships between manufacturers and owners of health records. Size of nodes show degree centrality node intermediation colors micro communities



The following network shows the most important actors within the giant component ranked by degree centrality and betweenness. This graph shows that in Colombia, competitors collaborate in developing many products. Procaps, Sanofi, and Merck are the most important intermediaries in the conformation of the network. Companies such as Lafrancol manufacture many products distributed to other companies within the same ecosystem, which indicates that such networks are other sources of income for these companies, which has not been shown previously.

Graphic 8: Key actors network by number of health records. Cluster A is purple, Cluster B is green, C is orange C and D is blue D. Node size indicates greater betweenness and the size of labels indicate high degree centrality



The identification of networks also illustrates that strategic alliances are the most important and how they exist between organisations with the most products in Colombia. In relation to foreign companies, Novartis's principal ally is Sandoz (Sandoz produce 7% of the products that sell Novartis). Merck, for its part, collaborates primarily with Altea (16% of the products of Merck). The other key relationships can be seen in the following graph. With regard to Colombian companies, Procaps manufactures products that Colmed distributes (72%), Pharmayect (34% of their products) and a Synthesis 13% of its products. Lafrancol produces 96% of American Generics's products and 17% of Synthesis's products.

The network shows that in the majority of cases, the companies themselves are also the manufacturers of their products. Additionally, there are clearly two groups or distinct cliques, of national and international companies that interact by the strategic nodes.

The following table describes what percentage of the main organizations' products are developed in-house and what percentage are developed in collaboration with others, or only as B2B customers. A goal of our analysis was to determine if companies make partnerships to increase

their shares of markets for which they already produce products, or to enter new markets. The analysis showed that most alliances are created for capacity building in areas which companies already hold market share. In addition, it shows that domestic companies have a greater proportion of domestic products than international companies do, which contradicts the expectations we began the study with.

Table 1: CHARACTERIZATION SOME PHARMACEUTICAL COMPANIES.

COMPANY	ORIGIN	PRODUCTS MANUFACTURED BY THE SAME COMPANY (%)	PRODUCTS MANUFACTURED WITH ANOTHER COMPANY (%)	MAIN AREAS OF MANUFACTURING	MAIN AREAS FOR WHICH MANUFACTURERS ARE USED
LAFRANCOL	Colombian	91%	16%	Cardiovascular system Nervous system Digestive and metabolism system Genitourinary system and sex hormones Skeletal muscle system Respiratory system	Nervous system Digestive and metabolism system Anti-infectives in general for system use Genitourinary sistem and sex hormones Cardiovascular system Respiratory system
PROCAPS	Colombian	79%	25%	Digestive and metabolism system Nervous system Genitourinary system and sex hormones Cardiovascular system Skeletal muscle system	Anti-infective in general for system use Nervous system Antineoplastic and immunomodulatory agents Skeletal muscle system Sensory organs Digestive system and metabolism Blood and hematopoietic organs Cardiovascular system
TECNOQUIMICAS	Colombian	93%	12%	Nervous system Digestive system and metabolism Cardiovascular system Respiratory system Skeletal muscle system	Anti-infective in general for use systemic use Nervous system Digestive system and metabolism Genitourinary system and sex hormones
GENFAR	Colombian	94%	27%	Anti-infective in general for systemic use Cardiovascular system Nervous system Skeletal muscle Respiratory system	Anti-infective in general for systemic use Nervous system Skeletal muscle system Respiratory system Cardiovascular system Digestive and metabolism system

COMPANY	ORIGIN	PRODUCTS MANUFACTURED BY THE SAME COMPANY (%)	PRODUCTS MANUFACTURED WITH ANOTHER COMPANY (%)	MAIN AREAS OF MANUFACTURING	MAIN AREAS FOR WHICH MANUFACTURERS ARE USED
BAYER	International	61%	51%	Genitourinary system and sex hormones Anti-infective in general for systemic use Dermatology medicine Digestive and metabolic system Cardiovascular system	Genitourinary system and sex hormones Dermatology medicine Anti-infective in general for systemic use Respiratory system Skeletal muscle system
PFIZER	International	47%	56%	Nervous system Cardiovascular system Antineoplastic agents and immunomodulators Genitourinary and sex hormones Anti-infective in general for systemic use	Nervous system Anti-infective in general for systemic use Cardiovascular system Skeletal muscle system Blood and hematopoietic organs
MERCK	International	43%	60%	Cardiovascular system Digestive system and metabolism Anti-infective in general for systemic use Systemic hormones prepared, excl. Sex hormones Skeletal muscle system	Digestive system and metabolism Respiratory system Dermatology medicine Anti-cancer agents and immunomodulatores system Cardiovascular system

4 DISCUSSION OF RESULTS

Applying Social Network Analysis to the pharmaceutical sector allows us to identify an integrated network that connects national and international organisations (He & Fallah, 2011), with two main groups, one formed mainly by Colombian companies and the other, mainly by international companies. This analysis identified strong coopetition in the Colombian market: in many cases, competitors are strategic allies in the launch of some products or in other competitive activities (Bouncken et al., 2015), in this case supplier-distributor alliances. A highlight of this network is that the majority of companies that compete in developing products for this sector are part of the giant component (82% of the total number of nodes). They are connected in a way that allows them to transfer information to each other. This analysis of social networks allows us to recognize the actors with greater revenues and reputation, and the role that they play in the formation of the network as intermediaries. They have a central position that allows them to largely control the network, be relevant in providing products to other companies in the network or to have a large number of suppliers for the distribution of the products generated. This outcome was similar to the results of (Kim & Choi, 2014), but our analysis used market information, not patents, as its data sources, which are more accurate for the analysis of business networks. We show that this network's centrality measures follow the Mathew effect. Another aspect we identified was to determine what types of products these strategic alliances produced. We found that most companies look to these partnerships to complement the portfolio of products that they have, not to enter new markets. On the other hand, it is interesting to see how the analysis of social networks allows recognizing other types of actors such as Arbopharma and Colombopack, which have a fundamental role in the development of products within the industry.

With regard to competitiveness, various authors have argued that strategic alliances play an important role for companies, but few studies confirm their arguments with business data as we have demonstrated. The competitive position of Tecnoquímicas or Procaps could be positively influenced by its closeness to international businesses and interconnection with national companies. In addition, while Fernández-Arias (2016) show that coopetition is used to share information between competitors about clinical trials, new products, or assets, our research shows that coopetition can also be used to share also tangible assets like products.

The information contained in the results of our research allows companies to better management of its supplier networks of suppliers and addressing these types of strategic aspects within their organisations in a better approach. Finally, this finding shows that many companies benefit not only of have as clients the final consumer (people), also they win money selling products to other companies.

REFERENCES

Baglieri, D., Carf, D., & Dagnino, G. B. (2016). Asymmetric R&D Alliances in the Biopharmaceutical Industry: A Multi-Stage Coopetitive Approach. *International Studies of Management & Organization*, *46*(2–3), 179–201. https://doi.org/10.1080/00208825.2016.1112154

Bititci, U., Turner, T., Mackay, D., Kearney, D., Parung, J., & Walters, D. (2007). Managing synergy in collaborative enterprises. *Production Planning & Control*, *18*(6), 454–465. https://doi.org/10.1080/09537280701494990

Blondel, V., Guillaume, J.-L., Lambiotte, R., & Lefebvre, E. (2008). Fast unfolding of communities in large networks. *Juornal of Statistical Mechanics:Theory and Experiment*, *2008*(10), P10008. https://doi.org/10.1088/1742-5468/2008/10/P10008

Borgatti, S. P., & Li, X. (2009). On Social Network Analysis in a Supply Chain Context. *Journal of Supply Management*, *45*(2), 5.

Bothner, M. S., Haynes, R., Lee, W., & Smith, E. B. (2010). When do Matthew effects occur? Journal of Mathematical Sociology. *Journal of Mathematical Sociology*, *34*(2), 80–114. https://doi.org/10.1080/00222500903310960

Bouncken, R. B., Gast, J., Kraus, S., & Bogers, M. (2015). Coopetition: a systematic review, synthesis, and future research directions. *Review of Managerial Science*, *9*(3), 577–601. https://doi.org/10.1007/s11846-015-0168-6

Brandes, U., Raab, J., & Wagner, D. (2001). Exploratory network visualization: Simultaneous display of actor status and connections. *Journal of Social Structure: JOSS*, *2*(4). Retrieved from http://kops.uni-konstanz.de/handle/123456789/5903

Cantner, U., & Rake, B. (2014). International research networks in pharmaceuticals: Structure and dynamics. *Research Policy*, *43*(2), 333–348. https://doi.org/10.1016/j.respol.2013.10.016

Choi, T. Y., Dooley, K. J., & Rungtusanatham, M. (2001). Supply networks and complex adaptive systems: control versus emergence. *Journal of Operations Management*, *19*(3), 351–366.

Del Monte, A., D'Esposito, M. ., Giordano, G., & Vitale, M. . (2011). Analysis of collaborative patterns in innovative networks. In *New perspectives in statistical modeling and data analysis* (pp. 77–84). Springer.

Erdos, P., & Renyi, A. (1960). *On the evolution of random graphs*. Citeseer.

Fernandez-Arias, M.-P., Quevedo-Cano, P., & Hidalgo-Nuchera, A. (2016). Uso de la inteligencia competitiva en los procesos de colaboracion en el sector farmaceutico espanol. *El Profesional de La Informaci?n*, *25*(5), 778. https://doi.org/10.3145/epi.2016.sep.08

Ford, D. (1990). *Understanding business markets: Interaction, relationships and networks*. Academic Press.

Freeman, L. . (1977). A set of measures of centrality based on betweeness. *Sociometry*, *40*, 35–41.

Freeman, L. . (1979). Centrality in social networks conceptual clarification. *Social Networks*, *1*(3), 215–239. https://doi.org/10.1016/0378-8733(78)90021-7

Greve, H. R. (2009). Bigger and safer: the diffusion of competitive advantage. *Strategic Management Journal*, *30*(1), 1–23. https://doi.org/10.1002/smj.721

Gulati, R. (1998). Alliances and networks. *Strategic Management Journal*, 293–317.

Harland, C. M., Lamming, R. C., Zheng, J., & Johnsen, T. E. (2001). A Taxonomy of Supply Networks. *The Journal of Supply Chain Management*, *37*(4), 21–27. https://doi.org/10.1111/j.1745-493X.2001.tb00109.x

He, J., & Fallah, M. H. (2011). The typology of technology clusters and its evolution - Evidence from the hi-tech industries. *Technological Forecasting and Social Change*. https://doi.org/10.1016/j.techfore.2011.01.005

Hu, Y., Scherngell, T., Qiu, L., & Wang, Y. (2015). R&D internationalisation patterns in the global pharmaceutical industry: evidence from a network analytic perspective. *Technology Analysis & Strategic Management*, *27*(5), 532–549. https://doi.org/10.1080/09537325.2015.1012058

Kim, H.-S., & Choi, S.-Y. (2014). Technological alliance portfolio configuration and firm performance. *Review of Managerial Science*, *8*(4), 541–558. https://doi.org/10.1007/s11846-013-0117-1

Kleymann, B., & Seristo, H. (2017). *Managing strategic airline alliances*. Routledge.

Leydesdorff, L., Etzkowitz, H., Ivanova, I., & Meyer, M. S. (2017). The Measurement of Synergy in Innovation Systems: Redundancy Generation in a Triple Helix of University-Industry-Government Relations. Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2937647

Lin, S., & Zins, A. H. (2016). Intended destination image positioning at sub-provincial administration level in China. *Asia Pacific Journal of Tourism Research*, *21*(11), 1241–1257.

Okamura, K., & Vonortas, N. S. (2006). European Alliance and Knowledge Networks1. *Technology Analysis & Strategic Management*, *18*(5), 535–560. https://doi.org/10.1080/09537320601019677

Provan, K. G., Fish, A., & Sydow, J. (2007). Interorganizational Networks at the Network Level: A Review of the Empirical Literature on Whole Networks. *Journal of Management*, *33*(3), 479–516. https://doi.org/10.1177/0149206307302554

Qi, Y., & Wang, J. (2016). Empirical research on collaborative innovation of strategic emerging industry based on system science. Presented at the Service Systems and Service Management (ICSSSM), 2016 13th International Conference.

Rothaermel, F. T. (2001). Complementary assets, strategic alliances, and the incumbent's advantage: an empirical study of industry and firm effects in the biopharmaceutical industry. *Research Policy*, *30*(8), 1235–1251.

Rusko, R. (2012). The redefined role of consumer as a prosumer: Value co-creation, coopetition. *Production and Manufacturing System Management: Coordination Approaches and Multi-Site Planning*, 162–174.

Surana, A., Kumara, S., Greaves, M., & Raghavan, U. N. (2005). Supply-chain networks: a complex adaptive systems perspective. *International Journal of Production Research*, *43*(20), 4235–4265.

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, 509–533.

Teixeira, J., Robles, G., & Gonzalez-Barahona, J. M. (2015). Lessons learned from applying social network analysis on an industrial Free/Libre/Open Source Software ecosystem. *Journal of Internet Services and Applications*, *6*(1). https://doi.org/10.1186/s13174-015-0028-2

Tseng, C.-Y., Lin, S.-C., Pai, D.-C., & Tung, C.-W. (2016). The relationship between innovation network and innovation capability: a social network perspective. *Technology Analysis & Strategic Management*, *28*(9), 1029–1040.

Verdecho, M. J., Alfaro, J. J., & Rodriguez-Rodriguez, R. (2009). Foundations for collaborative performance measurement. *Production Planning and Control*, *20*(3), 193–205.

Walther, O. J. (2015). Business, Brokers and Borders: The Structure of West African Trade Networks. *The Journal of Development Studies*, *51*(5), 603–620. https://doi.org/10.1080/00220388.2015.1010152

Wang, C.-H., Huang, S.-Z., Chang, C.-H., Lin, P.-J., & Chiew, Y.-Y. (2015). Co-Innovation Network Driven Entrepreneurship in High-Tech Technology-Evidences from China. Presented at the PICMET´15 Management of the Technology Age, Portland, OR.

Wang, Y., & Rajagolapan, N. (2015). Alliance capabilities: review and research agenda. *Journal of Management*, *41*(1), 236–260.

Wasserman, S., & Faust, K. (1994). *Social network analysis : methods and applications*. Cambridge ;New York: Cambridge University Press.

Weber, S. (1991). Anatomy of ´coopetition'. *Electronics*, *64*(8), 37.

Witten, I. (2005). *Data mining : practical machine learning tools and techniques* (2nd ed.). Amsterdam ;;Boston MA: Morgan Kaufman.

Zemla, M. (2016). Tourism destination: The networking approach. *Moravian Geographical Reports*, *24*(4). https://doi.org/10.1515/mgr-2016-0018