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Formal Structure and Informal Networks in
Organizations. An application of the Social
Network Analysis to a real-world case.

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Abstract

In this Master Thesis, we applied Social Network Analysis (hereafter: SNA) in the Italian division of Novelis, a multinational company. The work has a dual purpose: on one hand, investigating inner informal dynamics, which exist in the organization and interact with the formal structure; on the other hand, advancing the understanding of the determinants of advice ties creation in informal networks.

We developed a case study in which we adopted the SNA to identify main actors and network patterns inside the firm. Specifically, we focused firstly on informal networks in the whole company and in BUs and production plants. Secondly, we addressed the accessibility problem arisen through interviews and network data, focusing on the two core BUs: Operations and Sales. Thirdly, we dig into the core-periphery distinction in the information network. Finally, we identify individuals who play a significant role inside the firm: the brokers, the bottlenecks, the leaders, and those we labelled as the Lochagoi.

Moreover, we base on literature to formulate hypotheses on the determinants behind the creation of ties in the advice network in business contexts. We tested our hypotheses on Novelis's data and found that ties in other networks (Utility, Accessibility and Friendship) and in formalized communication mechanisms (reporting relationships and meetings) have strong predicting power.

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EXECUTIVE SUMMARY

INTRODUCTION

A network is not just an idea. On the contrary, it represents an extraordinary detailed picture of the reality that surrounds us. Networks depict the system in which countries, organizations, and people are embedded. Networks have the capability to shape the success or the failure of individuals and enterprises. We are all familiar with the truism “It is not what you know, it is who you know”. Managers invariably use their personal relations when they need to meet impossible deadlines or get advice on a strategic decision. It is through these informal networks, not only through traditional organizational hierarchies, that information is found and work is done. Unfortunately, many firms treat informal networks as an invisible enemy, which hampers the decision-making process. There is the widespread belief that informal networks are unobservable and ungovernable and, therefore, not a valuable tool for achieving an effective management.

OBJECTIVES

The main purpose of this thesis is to combine qualitative and quantitative research methods to study informal networks in an organizational context and their interplay with the formal structure. We combined theories and empirical approaches of formal and informal organization to provide a comprehensive explanation of firm’s inner dynamics. In particular, we adopted as main approach the Social Network Analysis. The context of research is the Italian subsidiary of Novelis, a multinational firm, leading producer of aluminium. From one hand, we aim at providing Novelis feedbacks on the informal structures that “live” inside the organization; from the other hand, we want to enhance the understanding of the determinants behind the creation of ties in informal networks, focusing our attention on the advice network.

LITERATURE

Contrarily to formal structures, one can detect informal networks only through a detailed analysis, namely Social Network Analysis – hereafter SNA. SNA relies on a graphical representation of networks in which nodes represent the actors and lines represent relations among them. The stream of research about informal networks started with the sociologist

Moreno, but its applications were confined to the study of social behaviors (Moreno and Jennings, 1932, 1934; Warner and Lunt, 1941; Lewin and Lippit, 1938). Anyway, it was not until 1984, with Brass (1984), Burt (1992) and Krackhardt (1992,1999) that SNA started to be applied in organization studies. In essence, Organizational Network Analysis gave scientists the capability to study organizations from a different perspective, giving them the possibility to apply concepts from sociology into the economic and management fields.

Initially, the organizational research collocated at two opposite poles the study of the formal structure and the study of the informal networks; looking at them separately rather than jointly.

Scholars have devoted much attention to the formal organization's design (e.g. Burton & Obel 2004; Galbraith 1971; Mintzberg 1979; Donaldson, 2001; Milgrom & Roberts, 1995) proposing several organizational architectures depending on factors such as environment's complexity and uncertainty.

Likewise, many researchers have given their own definition of informal networks. Of notable importance, we cite Tichy and Tushman (1979), who distinguish between technical, political and cultural networks. Another definition is proposed by Monge and Eisenberg (1987), who give a definition of social networks according to which each type is based either on expression of affect, or influence attempt, or exchange of information, or exchange of goods and services. Additionally, a landmark in the studies of informal networks is proposed by Krackhardt and Hansen (1993), who identify the advice network, the trust network and the communication one. In this work, we adopted the definition provided by Cross and Parker (2004), who define several networks that can emerge in an organization. Among them, we selected those networks that are the most significant for our case study and that provide a meaningful picture of all the relations. Namely, the communication, information, utility, accessibility, and advice networks.

It is doubtless the importance for both firms and individuals of having a central position in informal networks (Zaheer, McEvily and Perrone, 1998; Hansen 1999; Sparrowe and Liden, 2005; Burt, 2000). Just as the formal organization, the informal networks tend to develop hierarchical structures (Simon, 1969); anyway, in informal networks the most important

individuals are not those at the top, but rather those at the center of dense cluster of interactions (Krackhardt, 1994). In fact, being at the center of a given network influences the amount of social capital an individual is empowered with (Nahapiet and Ghoshal, 1998). Besides, the position of an individual in the overall network and her interactions with the others is key to understand critical processes such as interpersonal trust within and among organizational contexts (Zaheer et al. 1998), knowledge transfer and exchange (Hansen,1999), team dynamics (Reagans, Zuckerman, and McEvily, 2004) and social influence (Sparrowe and Liden, 2005). For instance, a central position in the advice network has been demonstrated to correlate with a positive rating of performances not only by the co-workers but also by team leaders (Sparrowe, Linden, Wayne, Kraimer, 2001). Researchers have also investigated the determinants behind the creation of ties generally in informal networks. According to literature, the rationales are psychological (Baker 1981; Han 1983), linked to homophily (Lazersfles and Merton,1964; McFarland 2005, Ibarra 1993, Kleinbaum, Stuart and Tushman 2013), or arising from the formal structure that is replicated in informal ties (Reif & Monczka, 1973; Simon, 1976; Diefenbach and Sillince, 2011, Monge & Eisenberg 1987; Groat, 1997; Mintzberg, 1983). As regards the last point, researchers tried to blend these concepts explaining how one formal and informal structure influences each other, still there is not a clear understanding about the interplay between formal and informal organizations (Soda and Zaheer, 2012). Anyway, according to another research stream, formal structure and defined formal principles tend to be replicated in the informal network (Diefenbach and Sillince, 2011), while the structure of informal networks influences the functioning dynamics of the organization (Reif & Monczka, 1973; Simon, 1976).

HYPOTHESES

The advice network is a particular type of informal network and it “shows the prominent players in an organization on whom others depend to solve problems and provide technical information” (Krachardt, 1993). Researchers consider it as fundamental since it is closely relate to organizational power (Brass, 1992; Ibarra et al. 1993), job performance (Sparrowe et al. 2001), self-efficacy, attitude towards technology (Burkhardt, 1994), and work transfer inside organizations (Gibbons, 2004).

In our literature review, we did not find many papers investigating the determinants of the creation of advice ties. Social network researchers have largely focused on the importance of personal ties in the construction and acquisition of information (Granovetter, 1973; Burt, 1992; Rogers, 1995; Hansen, 1999; Borgatti and Cross 2003). Nevertheless, there has been little exploration of the rationales behind the fact that organizational members go to specific others for work-related advice and help (Nebus 2006; Cross, Borgatti, Parker, 2001). Specifically, Nebus (2006) found that accessibility and perceived willingness to share the advice are predictors of advice tie creation, while Cross et al. (2001) remarked the importance of homophily.

Hence, we base on literature to propose several hypotheses, which relate the probability of the formation of a tie in the advice network to several dimensions: the presence of a tie in other informal networks, the formal structure, and individuals' characteristics. As regards informal networks, we formulated a first set of hypotheses in which we argued that a tie in Utility (H1), Accessibility (H2) and Friendship (H3) networks predicts the creation of a tie in the Advice one. The second set of hypotheses was focused on formal structure characteristics, specifically with formalized communication mechanisms (H4), and with formally induced homophily- i.e. working in the same plant (H5), belonging to the same BU (H6), and being at the same hierarchical level (H7). The last set of hypothesis was focused on personal characteristics. Indeed, we wanted to check if a tie in the advice network is predicted by gender homophily (H8) and by the effect of tenure (H9), arguing that individuals seek for advice from those who have spent more time in the venue.

METHODOLOGY

The analysis was conducted with Novelis, specifically, with the Italian subsidiary located in the Milanese area. The firm is a multinational leading producer of flat-rolled aluminium products and the world's largest recycler of aluminium. It was selected because it represents a suited subject for a SNA study.

In order to perform the analysis, we adopted a mixed method approach (Johnson and Onwuegbuzie 2004; Brewer and Hunter 1989; Creswell 2003; Johnson and Christensen

2004), mixing qualitative and quantitative evidence. Initially, we conducted a series of preliminary interviews with Novelis's Operation Director and HR Manager to obtain information on the main characteristics of the firm, on the formal structure and on the communication practices in place. We managed to detect the individuals whose relations and mutual interdependence contribute to the proper functioning of the organization, so to define the group of interest (Cross et al., 2004). Because of the strong ties and relations among the two plants that Novelis has in the Milanese area, we agreed that the study would have encompassed both. We identified 101 actors, belonging to the 7 functions (Operations, Sales, Supply chain, Procurement, Finance, IT, HR). We proceeded with a series of presentations of the project to the selected group: this step was aimed at describing the scopes of our analysis, explaining how we would have managed their data and specifying that it would not have had evaluation purposes. We also remarked that the results would have been presented in an anonymous way. In addition, we claimed our availability in receiving emails for further details, curiosities or doubts. This was a crucial step to gain the trust of the people and to increase the likelihood of accurate and truthful answers.

After a clear understanding of the company and several presentations to employees in which we specified the aims of our study, we submitted a questionnaire to collect interpersonal data. The survey was conceived relying on affirmed literature of SNA (Wasserman and Faust, 1994, Scott 2017; Cross et al., 2004).

NETWORK	QUESTION
INFORMATION	<i>“Think now of the people you talk the most about issues related to your work (directly, via telephone or via email):to whom do daily require information necessary to accomplish your activities?”</i>
COMMUNICATION	<i>“Think of the people with whom you most frequently talk inside your firm, both of private-related and working related topics (directly, via telephone or via email). For example: who are the ones with whom you interact every day in the office or during breaks?”</i>
UTILITY	<i>“Identify the people inside the firm that give you the most useful and valuable information”</i>
ADVICE	<i>“Identify the people you seek the most for advice when you have to face a problem or to carry out a task. For example, who do you ask for help at least once a week or who does help you to better understand the problem?”</i>
ACCESSIBILITY	<i>“When you need information or help who are the people you find accessible inside the organization? For example, who are those who are available in sharing with you a sufficient amount of time to help you?”</i>

Table 0-1 - Informal networks questions included in the survey

The questionnaire was administered through the online platform SurveyMonkey and we performed two follow-ups to increase the response rate. We included questions regarding generic information that we could not derive from the formal chart nor from previously given data (for instance, the plant in which they work and the job satisfaction), but questions mostly dealt with the individuals' informal network. We based on literature to design the questions (Cross et al. 2004; Krackhardt and Hanson 1993; Brass 1994; Cross, Borgatti and Parker 2002; Borgatti and Cross 2003; Ibarra 1993; Rizova 2006; Scott, 2017). This allowed us to uncover the following networks: information, communication, utility, advice, and accessibility. The answers were converted in binary sociomatrices (Wasserman and Faust, 1994).

Once collected, we processed the data through the UCINET software (Borgatti 2002) and visualized them through to Netdraw software.

To perform the analysis of the firm and to identify criticalities and crucial actors, we relied on key concepts of the SNA (Wasserman and Faust, 1994; Scott, 2017, Borgatti, Everett and Johnson, 2018), summarized in the table below.

MEASURE	MEANING
DENSITY	The <i>density</i> of a graph is the proportion between lines, which are actually present in the graph and all possible lines
GEODESIC DISTANCE	It indicates the shortest path between two nodes
CUT POINT	A node is a cut point if deleting it implies the creation of higher number of components ⁶ (i.e. disconnected subgraphs)
DEGREE CENTRALITY	The <i>degree</i> of a node equals the number of lines, which are incident with it
INDEGREE CENTRALITY	Number of incoming ties
OUTDEGREE CENTRALITY	Number of outgoing ties
BETWEENNESS CENTRALITY	Betweenness centrality quantifies the number of times a node acts as a bridge along the shortest path between two other nodes. ⁷
BROKERAGE MEASURES	They identify people that broker connections within the same group (coordinators); those who broker connections between their own group and another (representatives and gatekeepers); and those who broker connections between two different groups (liaisons).

Table 0-2 - Main SNA concepts adopted in the analysis

The hypotheses were tested using QAP techniques. Their adoption is common in SNA (e.g., Krackhardt et al., 1990; Kilduff, 1992; Burkhardt, 1994; Labianca, Brass, and Gray, 1998; Shah, 2000; Labianca et al., 2001). Observations in individual rows or in individual columns do not represent independent data, but instead show a certain degree of dependence in relation

⁶ Component subgraphs (or simply *components*) are portions of the network that are disconnected from each other.

⁷ A comprehensive definition is provided in the Methodology chapter. For further details see Freeman (1977)

to the column or row to which they belong (i.e. structural autocorrelation). Thanks to QAP, we can overcome this key issue, since it uses a randomization/permutation technique (Edgington 1969, Noreen 1989) to build the significance tests. The QAP “scrambles” the dependent variable data through thousands of permutations and this allow to exceed the dependency. Through this procedure, we can overcome the structural autocorrelation (Krachardt 1987) and the seriousness related to multicollinearity of data (Dekker, Krachardt and Snijders, 2003). Moreover, since QAP allows to perform Dyadic test only, we had to transform non-dyadic information into relational. Hence, to test the hypothesis we converted information on Plant (*Colocation*, H5), BU (*SameUnit*, H6), Hierarchy (*SameHierarhcy*, H7) and Gender (*SameGender*, H8) into binary matrices, putting 1 if the individuals to which the cell refers have the same characteristic, 0 otherwise. On the other hand, to build the matrices related to tenure, we firstly divided the tenure into ranges, then we converted into binary matrices by placing 1 if the individual on the row belonged to a lower range, 0 otherwise (*Tenure*, H9).

CASE STUDY: RESULTS and DISCUSSION

As said, Novelis is organized in 7 BUs, namely Operations, Finance, IT, Supply Chain, Sales, Human Resources, and Procurement. The firm has a multinational structure and in the Italian subsidiary, it runs the production of aluminum, its sale and distribution. Hence, the core functions are Operations and Sales. Among the people to whom the questionnaire was submitted, 56% work in Operations, 15% in Sales, 8% in Finance, 7% in IT, 6% in Supply Chain and finally 4% in Procurement. Employees are divided almost evenly across the two plants: 50% in Bresso and 43% in Pieve while the remaining 7% reported to work in both the plants indistinctly. For what concern gender, 79% of the employees are men while 21% are women. Finally, the rate of respondent to our questionnaire has been of 78%, a quite high rate given the organizational context and acceptable to perform a meaningful SNA (Borgatti et al. 2008). We also performed a detailed analysis of Novelis’ formal organization, formal communication mechanisms implemented and distribution of gender across BUs.

After processing the data, we were able to identify key players and criticalities in Novelis’ networks.

Firstly, we analyzed of the connectivity of Novelis across different networks. In information and communication networks, a low density across different BUs and different plants emerged. Moreover, it appeared that employees tend to create informal ties within their BU, instead of looking for connections outside. Criticalities have been found in HR, between Supply Chain and Procurement, and between Sales and Procurement.

Owing to the importance of Supply Chain in the coordination process among Procurement, Operations and Sales, we would have expected a high Outdegree and Indegree densities between the couples. However, this does not hold for Supply Chain- Procurement, whose density is equal to 0. A possible explanation to this can be the reliance on information systems that allow a widespread distribution of data and information across BUs: this can partially explain the absence of ties between these BUs.

It must be noticed that low level of density should not necessarily be interpreted negatively, since a very high number of connections among BUs would hamper and increase the complexity of the information flow. On the other hand, extremely low level of density can be dangerous for the firm. (Hansen, 1999). Following Cross et al. (2002), to promote the connectivity among different units we suggest to: change the formal structure, enhance work management practices, enhance employee management practices, focus on the development and reward of collaborative behavior, focus training on integration points and finally reinforce cultural values. Another solution we propose for BU generally isolated – like HR and Supply chain – is to define individuals that would act as brokers among poorly connected BUs.

From interview and questionnaire results, it emerged the widespread sensation that colleagues are perceived as not easily reachable. For this reason, we analyzed the accessibility network and discovered that there are few connections among BUs. We focused our attention especially on Operations and Sales, given their crucial importance for the firm. The low number of connections make the coordination of these two BUs a complex issue. This situation is not optimal for Novelis since Sales is directly in touch with customers and needs a high support by Operations in order to meet customers' requirements. To improve the *status quo*, we suggest creating figures with the formal authority to query Operations'

members. Alternatively, we suggest establishing a weekly meeting with representatives specifically selected from these two BUs: they should be individuals endowed with high betweenness or indegree centrality or acting as coordinators in their BU. All the above approaches are aimed at increasing the probability an informal tie will form between the two BUs (Krackhardt, 2000). Another solution we propose is to assign joint projects, which require a high level of collaboration between the two functions. We believe in the long term this solution can bring to the creation of ties vital for the optimal functioning of Novelis (Cross et al. 2002).

Afterwards, thanks to the application of a hill climbing algorithm, Novelis' employees, were divided into two major groups: the core – dense and cohesive – and the periphery – sparse and unconnected. What emerged was that the density among the core group was almost 9 times higher than the density in the periphery, having huge impact on the information flow. The effect of having a core network inside the organization should not be underestimated by the management: since the core is much denser than the rest of the organization, it can display higher velocity in the transmission of information and can also lead to the polarization of opinion dynamics. For those reasons, we remark the importance of trying to include in the core group actors who belong to different BUs or who represent different groups inside the organization. This will lead firstly to a higher level of heterogeneity of the core and secondly to the inclusion of individuals who belong to isolated subgroups, thus spreading information to sparse and otherwise disconnected clusters.

We then analyzed several crucial roles inside Novelis. The first group we identified consists in the brokers (Burt, 1992, 2007). Brokers are essential for the transmission of information among different groups. We identified who in Novelis play the role of Coordinator, Consultant, Gatekeeper, Representative and Liaison across different BUs (Gould and Fernandez, 1989). The identification of these brokers can be of fundamental importance for Novelis' management, since the removal of one of them can cause the system's paralysis. Brokers assume a critical role in every information network effectiveness because they retain the power of central connectors without necessarily possessing the elevated number of direct

ties that central actors have. It is said that they are characterized by a wealth of indirect connections (Cross and Prusak, 2002).

We also identified bottlenecks in the information network. To detect them, we compared the actual status in terms of density and centralization of the information network and the what-if status once higher degree scorer were removed. What emerged was that once three actors belonging to Operations BU were removed, the Indegree network score fall by 17%, suggesting these are bottlenecks of the system. Hence, as managerial implication aimed at relieving a bottleneck we refer to what proposed by Burt (1992), who suggests to reallocate some of the information domains – who is responsible for what information – and change the attribution of decision rights – allow others to make decision.

Subsequently, we identified leaders inside Novelis's informal networks. Leaders emerged by combining the communication and information networks (Cross et al. 2004). Firstly, we analyzed the two networks separately and identified actors with the highest Indegree centrality. Then, we obtained a matrix summing the information and the communication networks and performed the same analysis. These two different procedures gave us two lists of players who act as leaders in Novelis. We subsequently compared these two lists to spot the actors who were present in both. Namely, simultaneously having a high Indegree centrality in communication and information networks taken separately and have a high Indegree centrality in the network obtained by adding these two. These individuals own a great social capital because they lie on important paths in the information and communication flows. They are able to build meaningful connections with the people in the organization and have greater access to, and a larger amount of, information and social support from organizational social network (Adler and Kwon, 2002). Assessing their identity can be useful in the moment in which Novelis will decide to or will have to implement a major change or face complex problems.

To conclude, we identified a new informal role, which we labelled as Lochagos. We applied an intersection between the utility and the accessibility matrices to report actors who are perceived at the same time accessible and useful by their colleagues. Among the actors who resulted from this analysis, we took the highest 95-percentile to identify a strategically

important subset of individuals in the organization, who would be barely replicable thanks to the greater number of people relying on their wisdom and help. Following this approach, we identified 13 individuals who play the role of Lochagos. We believe this new role has a great importance since it often happens in organizations that most knowledgeable employees are overwhelmed by requests, and, in the end, cannot help their colleagues for a lack of time. On one hand, this new role can represent a step forward in the SNA research, on the other hand, the identification of the employees that play this role can be significant also for firms, since they are the ones that others perceive as holding valuable information and accessible to help them to accomplish their tasks.

HYPOTHESES: TEST AND DISCUSSION

Firstly, we computed the QAP correlations among the variables, which allows to understand whether two individuals who are tied in one network are likely to be tied also in another one.

Then, we ran the LR-QAP regressions with 1000 permutations. This analysis tests if similarities between two individuals and/or the presence of a tie in one network predicts the creation of a tie between them also in the dependent variable.

Results provided strong support to the first set of hypotheses. In particular, the presence of a tie in the Accessibility and in the Utility networks seem to strongly predict the choice of the advisor. Results gave also credit to our hypothesis according to which formalized mechanisms of communication foster the choice of the person to whom asking for advice. Colocation (i.e. working in the same plant) and working in the same BU were also significant predictors of tie creation, though less than the previous mentioned relations.

We did not find support in favour of asking for advice to people belonging to the same level nor of the one related to gender homophily.

HYPOTHESIS	SUPPORT
1. Utility	Strongly in favour
2. Accessibility	Strongly in favour
3. Friendship	Strongly in favour
4. Formal communication	Strongly in favour
5. Colocation	In favour
6. Unit	In favour
7. Same hierarchical level	No evidences
8. Gender	No Evidences
9. Tenure effect	Weakly In favour

Table 0-3 Summary of Hypotheses testing

CONCLUSIONS

The main purpose of this thesis was to apply the SNA's techniques to study informal networks and their interplay with the formal structure on a real case.

As regards the Case Study, we aimed at discovering some criticalities and spotting key people inside the organization. First, we focused our attention on the connectivity and the cohesion of the whole firm and among units looking at the information network. Second, we addressed the accessibility problem arisen through interviews and surveys, focusing on the two core functions, i.e. Operations and Sales. Third, we dig into the distinction core-periphery in the information network. Fourth, we identified those actors that play a significant role inside the firm informal networks i.e. the brokers, the bottlenecks, the leaders, and the ones we labelled as the Lochagos. While the first three roles are based on the reference literature, we developed the last one thanks to the combination of two fundamental networks, the utility network and the accessibility one. For all the cited topics, we have provided managerial implications and solutions that can be adopted to limit the effect of criticalities and better control/leverage on the actors to whom a significant role was associated.

The collected data has also allowed us to test hypotheses that we formulated based on the reference literature. Indeed, we found a gap in the backgrounds related to the determinants behind the creation of ties in the advice network, i.e. a specific type of informal network- and thought it could have been interesting to provide further evidences on this topic. We developed several models aimed at testing if the advice network linkages are predicted by: i) ties in other informal networks, ii) formal characteristics of the firm; iii) individuals' characteristics. According to our results, ties in other informal networks (specifically, Utility, Accessibility and Friendship) and in the formal communication one have the highest predicting power for tie creation in the advice network. Among these, Accessibility (i.e. considering the person available in sharing her time and knowledge) and Utility (i.e. having the opinion that a person has a valuable and useful knowledge) appear to affect the most the decision of whom seeking advice from. Furthermore, colocation, belonging to the same unit, and having a higher tenure seem to predict also the tie formation, though less relevantly. In particular, the latter two appear to be mitigated by the presence of ties in formal networks. Despite the evidences provided by literature on the significance of gender homophily in building relationships, results did not provide support to the hypothesis related to this theme. On the other hand, for what concern tenure, we obtained weak results against tenure homophily. This work provides new evidences on the rationales that lead to the creation of ties for a specific type of informal network, namely the advice network. Indeed, researchers have widely investigated the importance of social interaction as a vehicle for knowledge acquisition and transfer (e.g. Nahapiet & Ghoshal, 1998, DeToni et al. 2010; Maurer, Bartsch & Ebers, 2011, Hansen 1999), and information seeking (Borgatti, 2003), but little is known for what concerns advice seeking and help in problem solving.

Our results lead also to formulate managerial implications. Indeed, the choice of the person from whom looking for advice in a firm can affect the advisee's performance. Literature has provided evidences that in general informal networks are connected to performances and this holds true also for the network on which we have focused our attention. Hence, it should be important for the firm to make sure that people who have the right expertise and knowledge

to help others are effectively accessible and that everybody in the firm is aware of who retains the specific and valuable knowledge.

LIMITS & FUTURE RESEARCH

The limitations we had to face encompass these categories: i) data gathering and response rate; ii) privacy concerns; iii) questionnaire design (further questions could have been included); iv) Tools used for the analysis; v) non-generalizability of results (the study has encompassed one firm only); vi) observer biases.

As regards future researches, we think it would be significant to address the impact on the creation of ties in the advice network of other personal characteristics with respect to the ones included in this work; for instance, education and age. Secondly, it would be interesting to furtherly develop analysis on the effect of networks configurations have on individuals' performances. Thirdly, it would be also interesting to expand this kind of analysis in non-industrial networks, for example co-authorship ones and assess if the same results are obtained.

0. INTRODUCTION

“If the formal organization is the skeleton of a company, the informal is the central nervous system driving the collective thought processes, actions, and reactions of its business units”.
Krackhardt & Hanson, 2000.

0.1 MOTIVATIONS BEHIND THE ANALYSIS

A network is not just an idea. On the contrary, it represents an extraordinary detailed picture of the reality, which surround us. Networks depict the system in which countries, organization, people are embedded; and have the power to determine the success or the failure of individuals and firms.

We are all familiar with the truism “It is not what you know, it is who you know”. Managers invariably use their personal relations when they need to meet impossible deadlines or get advice on a strategic decisions. It is through these informal networks, not only through traditional organizational hierarchies, that information is found, and work is done. Unfortunately, many firms treat informal networks as an invisible enemy, which keeps decisions from being made (Cross and Prusak, 2002). There is the widespread belief that informal networks are unobservable and ungovernable and, therefore, not a valuable tool for effective management.

Almost 90 years of research on social networks, from the seminal work of Jacob Moreno (1934) and through the primary research conducted at Harvard University, have yielded remarkable results. The development of network theory in the field of social and economic research has been exceptional. Example theories include the theory of six degrees of separation by Milgram (1967) and theories of the strength of weak ties and embeddedness by Granovetter (1973 and 1985), as well as the contributions of Freeman (1979) and – among Network Theory of Organizations – the works of Brass (1984), Burt (1992) and Krackhardt (1992, 1999).

Although both the role of formal and informal elements is recognized by foundational organization theory (Simon, 1947; Barnard, 1938), it seemed that the evolution of the literature shifted like a pendulum from one pole to the other. During 1960s and 1970s the

focus was mostly oriented on formal organizational hierarchies and mechanisms (Galbraith 1974, 1971; Mintzberg 1979), while for the past two decades, scholarship focused on the role of informal elements explaining the organizations' functioning

0.2 THE OBJECTIVES

This thesis aims at combining qualitative and quantitative research methods to study social networks in an organizational context and their interplay with the formal structure. We mix the theories of formal and informal organization to provide a comprehensive explanation of firm's inner dynamics. In particular, we adopt as main approach the Social Network Analysis (SNA).

The context of our research is the Italian division of Novelis, a multinational company, leading producer of flat-rolled aluminium products and the world's largest recycler of aluminium⁸.

From one side, the scope of this work is to provide Novelis with a series of feedbacks about the informal structure of the company. In particular, highlighting how informal networks work and providing the management with meaningful and valuable insights about this theme. To achieve this objective, we run a series of interviews with company's managers and we administered a survey to Novelis' employees. This permitted us to carry out a critical analysis of the different networks that co-exist inside the firm and identify key people and criticalities.

On the other side, we aimed at enhancing the understanding about informal networks. Specifically, we studied the determinants, which lead individuals to choose a specific person when looking for advice inside the organization. In order to accomplish this, we formulated several hypotheses based on the analyzed literature and applied innovative statistical techniques typical of SNA – namely the QAP analysis - which allowed us testing determinants individuals positions in a certain social network. We theoretically discuss and empirically document that relational characteristics, elements of the formal structures and personal features play a crucial role in the formation of ties on the advice network.

⁸ <http://novelis.com>

0.3 THE FRAMEWORK

The thesis consists of the following Chapters

1. Literature Review. We performed an in-depth analysis of the literature. We initially focus on the key elements and definitions of the formal structure of the organizations; then, we explore the main findings on informal networks inside the organization. Finally, we provide some backgrounds on role and differences of gender in these informal networks and a preliminary overview of the importance of SNA for this field of research.
2. Hypotheses. We formulate several hypotheses based on key findings already illustrated in the first chapter and additional arguments. For sake of relevance, the hypotheses focus on one particular type of informal network, namely the advice network, and are aimed at improving our understanding of the determinants behind the creation of a tie in this network.
3. Methodology. We explain the methodology implemented for the study. We also offer some crucial definition of the measures adopted by SNA and discuss the tools on which we relied for the analyses.
4. Case Study: results and discussion. In this section, we firstly examine the firm on which we performed the entire study and the design of the questionnaire. We then illustrate the main results of the SNA applied on the firm and the managerial implications.
5. Hypotheses testing and discussion. We present and describe the models used to test the hypotheses and the main findings.
6. Conclusions.
7. Limitations and future research.

CHAPTER 1

1. LITERATURE REVIEW

This first chapter aims to provide an overview of the most important findings on formal and informal organizations.

Firstly, we report formal organization's theories and key concepts; then, we shift our focus on the informal organization, i.e. how individuals relate, despite what prescribed by the formal organization. We explore the theoretical backgrounds on this topic, encompassing the findings of the studies on social capital in organizations, the rationales behind the emergence of informal networks and the different types of network, which may arise. In addition, we examine literature's findings on the impacts of informal networks on firms and on performances.

Since one of the purposes of our research is also to investigate the role of gender disparities inside organizations, we focus our attention on those papers that investigate this topic from a viewpoint of the informal networks.

Finally, we include a brief section dedicated to the most diffused approach to study informal networks, namely the Social Network Analysis (hereafter: SNA).

1.1 SYSTEMATIC APPROACH FOR LITERATURE REVIEW

To perform the literature review we adopted a systematic approach, which allowed us to cover a wide range of topics in a coherent way.

The first brief we started with was to study how the formal and informal organization differ and how they impact on organizations and on organizational members. We started with two papers proposed by our thesis supervisor Cristina Rossi Lamastra (Gulati and Puranam, 2009;

and Guimera, 2006) and then we performed an analysis on back and forward citations using the Scopus database.⁹

From this analysis, we understood which were the primary tools used in this field. For example, we discovered the existence of SNA and of tools created to perform this type of analysis. Also, we familiarized with terms like social capital, graphs, modes network and prominent authors like Moreno, Tuchy, Krackhardt.

Anyway, since with this type of analysis did not cover a sufficient amount of literature we performed some additional research.

Still using Scopus database, we used the keywords “Social Network Analysis” with Subject Area “Comportamental Science or Social Science or Social Networking or Data Mining or Behavioural research” with results filtered for Italian and English papers. The final list consisted of 1,139 papers. We exported them in an Excel file in which the major information such as paper name, authors, publication date, journal, abstract were automatically collected. We excluded some papers because the title clearly indicated they were not fitted for our analysis and remained with a list of 621 papers. The next step consisted in reading the abstract of these papers and selecting the most relevant for this thesis.

Finally, we went through most interesting papers and books of the list and performed a citations review in order to find other useful sources of information for our analysis.

1.2 THE FORMAL ORGANIZATION

The formal organization (or organizational structure) has been defined as “the skeleton of a company” (Krackhardt & Hanson, 1993), which provides the base upon which the firm is built and can properly function. One of the definitions is provided by Daft, Murphy, and Willmott, (2010), it is that it consists of three main elements. Namely:

- Formal reporting relationships: levels of hierarchy and span of control;
- Department definition (as grouping of individuals);
- Cross department alignment: coordination, communication and integration effectiveness.

⁹ Scopus is the largest abstract and citation database of peer-reviewed literature: scientific journals, books and conference proceedings. <https://www.scopus.com/home.uri>

From what reported above, it is straightforward to conclude that the formal organization defines reporting relationships and job titles, departmental and divisional memberships, which are all encouraged by the management.

One of the main purpose of the formal organization is to define procedures which allows to "easily anticipated problems" and to set "standard modes of production" (Krackhardt and Hanson, 1993). The organization chart (see for instance the one reported in Figure 1) is the most established tool to represent formal organizations. It allows visualizing and capturing in a glance: the previously mentioned key elements reporting relationships, grouping, and cross department integration. The organization chart provides the reader the "structure of control" (see again Daft et al., 2010)

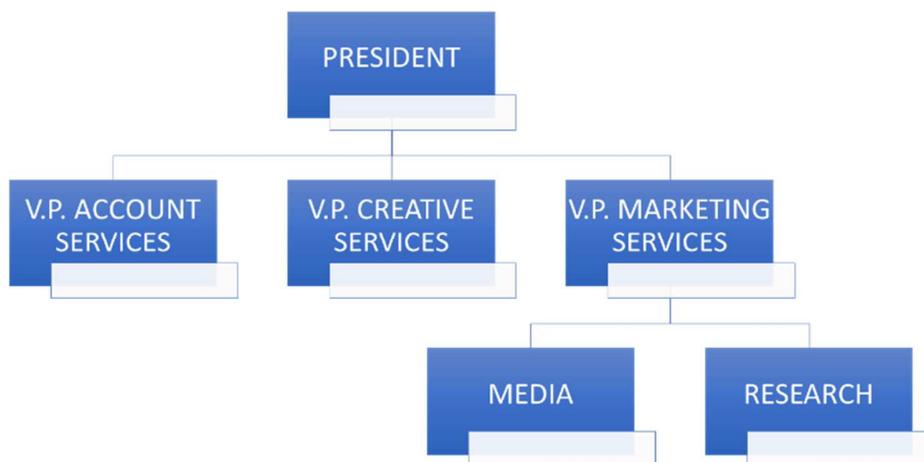


Figure 1.2-1 - Example of organizational chart

The aim of the organization structure is to provide a framework of responsibilities, reporting relationships and grouping, and to set mechanisms for linking and coordinating organizational elements into a coherent system.

1.2.1 Organization Design Theories

Organizational structure is the formalization of the system of tasks and relationships that permits to coordinate actions and to reach defined objectives. The firm's management has to

match the organizational structure and the organizational culture (norms and values) through organizational design so that the achievement of goals is assured.

In order to examine firm's organizational design, i.e., its antecedents and performance consequences, researchers have developed several theories. The most important ones include the *information processing perspective* (Burton and Obel, 1998; Galbraith, 1974) the *contingency theory* (Donaldson, 2001), the *complementarity theory* (Milgrom & Roberts, 1995), the *configuration theory* (Doty, Glick and Huber, 1993; Ketchen et al., 1997), the *resource-based view of the firm* (Markides and Williamson, 1996), *decision theory* (Huber and McDaniel, 1986), and *managerial and organizational cognition* (Bandura & Wood, 1989).

Information processing is the most diffused among the cited theories (Hunter III, 2015). Its aim is to give an answer to the complexity, ambiguity and uncertainty coming both from external and internal environments of firms. Indeed, organizations must often find a solution for problems that result ill-defined with a small amount of unclear information (Weick and Daft, 1982).

1.2.2 The Formal Organization: Elements and Perspectives

The following section is aimed at exploring some of the most important theories developed around organizational design and formal structures.

The information-processing theory deals with uncertainty: the greater its level, the higher the quantity of information that has to be processed by decision makers to reach target level of performance (Galbraith, 1971).

If the structure does not fit the information requirements of the organization, organizational members either have too little information or spend time processing information that is not vital to their task, thus reducing efficiency (Nadler and Tushman, 1988).

At the two poles of how the organization can be designed, there are (Daft et al., 2010):

1. Traditional control centralized organization
2. Contemporary learning de-centralized organization

The first model emphasizes the role of hierarchy, rules, control and centralized decision making; individuals' roles and responsibilities are well-defined and the communication follows a formal reporting system. The latter on the contrary presents less rules and hierarchy, a decentralized decision making and a more informal communication pattern. In the recent years, firms are raising their efforts to flatten their organizations, though, it mostly results in a reduction of the number of hierarchical levels rather than in a lack of hierarchy.

Anyway, what presented above are ideal structures. In reality, firms position themselves in the spectrum encompassed by the two extremes (i.e. the traditional and the contemporary configurations) depending on the level of information asymmetry that characterizes the industry, the environment and other endogenous and exogenous factors.

The relationships in terms of communication among organizational elements (i.e. linkages) can be of two types: vertical and horizontal. As regards vertical linkages, they serve the purpose to enhance the control and the coordination among different levels. Galbraith (1973) identifies several structural devices, which help the proper functioning of vertical linkages: hierarchical referral, rules and plans, vertical information systems. As concerns horizontal communication, its objective is to overcome communication issues within the same hierarchical level. As before, Galbraith suggests several structural alternatives to improve them: information systems, direct contact, task forces, full time integrator, teams.

Following contingency theory (Daft et al., 2010) the company has to design the structure that better responds to the context in which it operates depending on external environmental conditions, industry-related factors, and uncertainty level. The literature has identified different types of departmental grouping:

- Functional Structure: the departments are grouped according to the activities they perform. For example, there is the marketing unit, R&D unit, Manufacturing unit, and so on.
- Divisional structure (also called product structure or strategic business units) where departments are grouped depending on their objectives: products, services, geographical area, customers.
- Matrix structure: it combines the previous models since it gives equal importance to divisions and function.

- Virtual network structure: most of the activities are outsourced to third parties and coordination is performed by organization's headquarters.

These types of structures are ideal, while, in reality, firms apply hybrid solutions.

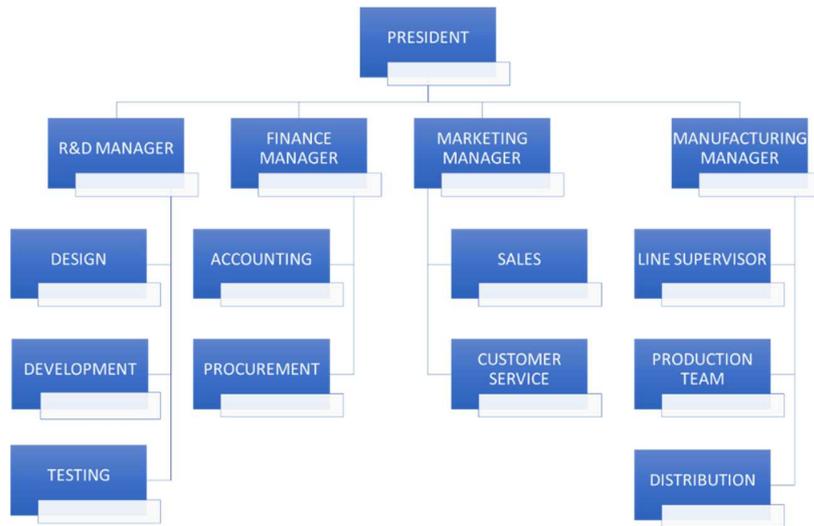


Figure 1.2.2-1- Functional structure

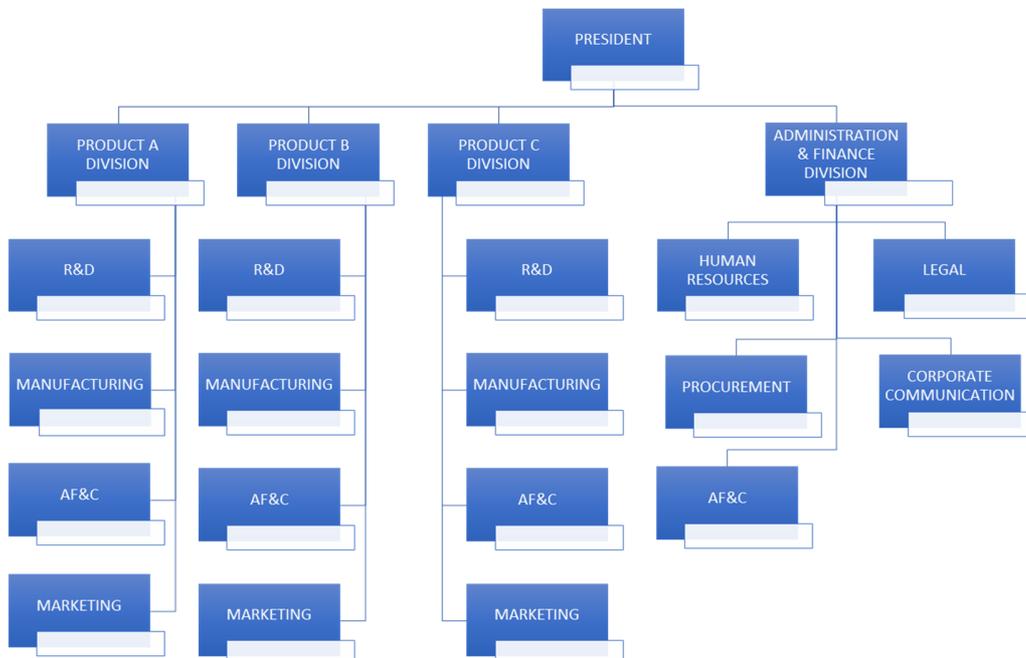


Figure 1.2.2-2- Divisional structure

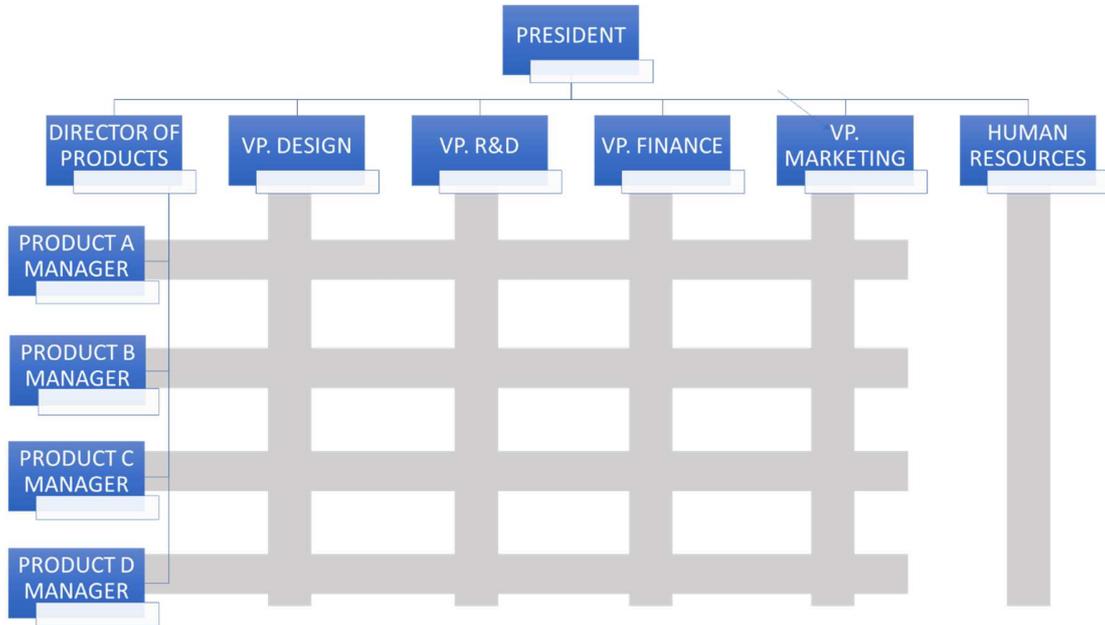


Figure 1.2.2-3 Matrix structure

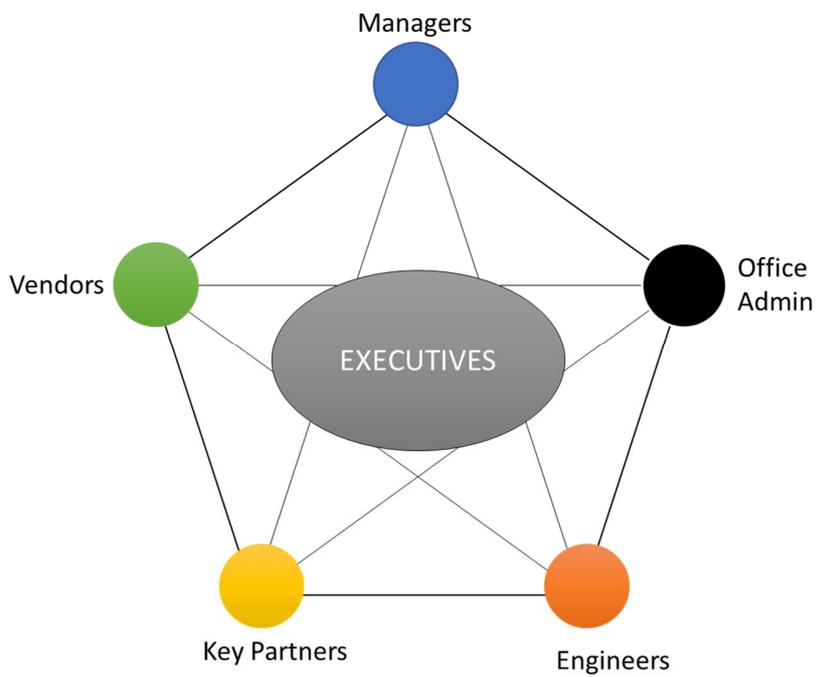


Figure 1.2.2-4 Virtual network structure

Another approach for grouping is proposed by Mintzberg (1979) who emphasizes the role of grouping as “a mean of coordination”. In his view, grouping should be based on:

- Knowledge and Skills: Positions may be grouped according to the specialized knowledge and skills that members bring to the job (Hospitals for instance group surgeons in one departments, anesthetists in another and orthopedic in a third).
- Work process and function: Units may be based on the process or activity used by the workers (For example, manufacturing firms may distinguish casting, welding and turning).
- Time: Groups may also be formed according to when the work is done. (as in the case of different shifts in factories).
- Output: in this case units are formed on the basis of the products it is made or the service provided. (A large manufacturing division may have separate divisions for each of its product lines)
- Client: Another source of grouping may be the need to deal with different clients (for example insurance firm may have separate departments for individual and group policies)
- Place: Group may be formed according to the geographical regions in which the firm operates.

In addition, Galbraith (1971) links task uncertainty with the design of the organization structure. The author provides a framework with four design strategies that allow coping with task uncertainty:

- Slack resources
- Creation of self-contained tasks
- Investment in vertical information systems
- Creation of lateral relationships (direct contact, liaison roles, task forces, teams, integrating roles, managerial linking roles, matrix organization).

Basically, firms should choose among these strategies the ones that allow reducing both information problems and uncertainty level and meet the environmental challenges at the lowest cost. Galbraith dwells on the mechanistic approach to the design problem, which suggest the use of mechanisms in order to coordinate actions performed by interdependent

roles. In his view, the coordination is achieved through rules and programs, hierarchy, targets or goals.

Burton and Obel (2004) offer a similar approach. They list six sets of main elements of the organizational design, which can also refer to the information-processing framework:

- Configuration (functional, divisional, matrix): it represents the form of the organizational structure. It specifies the principle for dividing work, breaking tasks into sub tasks and coordination activities (Burton and Obel, 1995)
- Complexity: vertical differentiation (it relates to the levels of hierarchy), horizontal differentiation (it refers to the degree of specialization within the organization), spatial differentiation (it relates to the geographical dispersion of the activities in the organization)
- Centralization: it refers to decision-making process. A firm is highly centralized if the formal authority in the decision-making process is concentrated in few people at the vertex of the organization.
- Formalization: It represents the guidance in the organization. It is aimed to obtain a standardized behavior. It increases the capacity to process information while reducing the resources needed to process information (Galbraith, 1974)
- Incentives: They support the firm's infrastructure and coordination, control, and information systems, and thus, help to increase the chances that tasks are completed and the goals of the organization are achieved.

Mintzberg (1979) suggests that organizations can be classified according to three basic dimensions: (1) the key part of the organization: the part of the organization that mostly affects the rate of success or failure of the organization; (2) the prime coordinating mechanism: the principal mean to coordinate activities; (3) the type of decentralization: the degree of involvement of subordinates in the decision-making process.

For each of the dimensions, Mintzberg identifies five basic configurations that we reported in the figure below: for each structural configuration, a different coordination mechanism is dominant, and a different part of the organization play the most important role, and finally, a

different type of decentralization is used), which are combined in order to define five different structures.

Structural configuration	Coordination mechanism	Key part of organization	Type of decentralization
Simple structure	Direct supervision	Strategic apex	Vertical and horizontal centralization
Machine bureaucracy	Standardization of work processes	Technostructure	Limited horizontal decentralization
Professional bureaucracy	Standardization of skills	Operating core	Vertical and horizontal decentralization
Divisionalized form	Standardization of outputs	Middle line	Limited vertical decentralization
Adhocracy	Mutual adjustment	Support staff	Selective decentralization

Table 1.2.2-1 - Mintzberg's (1979) five basic configurations for organizations

Mintzberg, who mainly focused his work on the study of the formal organization, also concluded that "most work just cannot get done without some informal communication. Life is simply too complicated to regulate everything" and so organization entities regulate their behaviors through "mutual adjustment". This concept is even more emphasized by Krackhardt and Hanson (1993, pag 104), "Informal is the central nervous system driving the collective thought processes, actions, and reactions of its business units. Designed to facilitate standard modes of production, the formal organization is set up to handle easily anticipated problems. But when unexpected problems arise, the informal organization kicks in."

One of the first who emphasized the importance of human relations was Mayo (1933) and his Human Relations School: according to his view, in order to enhance the productivity level, it is necessary to take into account personal and social characteristics of workers, not only those aspects related to the task or to the control of the activity. The pillars of this perspective were then defined by the experimental work of Hawthorne, which proved how

individual, psychological and social factors (such as teamwork, communication, working environment, teams) and not only economic reasons affect productivity of employees¹⁰.

Whoever works in or studies organization can easily see how the **formal** (or *de jure*) structure differ from the **informal** (or *de facto*) network, revealing some important differences (Han, 1983).

Farris (1979) proposes the classification below, which is quite useful to grasp in a nutshell the differences in Table 1.2.2 2

Elements	Formal	Informal
Salient goals	Organization's	Individuals'
Structural units	Departments/positions	Individual roles
Basis of communication	Offices formally related	Proximity: Physical, professional task, social
Basis of power	Legitimate authority	Capacity to satisfy individuals' needs
Control mechanisms	Rules	Norms
Type of hierarchy	Vertical	Lateral
Belonging of individuals	Specific	Ambiguous
Communication	Structured	Unstructured
Origin	Planned	Spontaneous
Changes over time	Shifts	Incremental
Group leadership	Explicit	Implicit

Table 1.2.2-2 - Farris's (1979) classification of formal and informal structure

It is now important to shift the focus on the informal organization to understand why it emerges and the consequences it has on the firms.

¹⁰ Other important theories related to the motivation have been following developed: theory of X and theory of Y (McGregor, 1966) which can be linked to the contingency theory; hierarchy of needs (Maslow, 1954); dual factors related to the satisfaction at work (Herzberg, 1982).

1.3 THE INFORMAL ORGANIZATION

The raising attention on informal structure of organization is driven by two major trends. The first one is the result of formal organization change. Indeed, a growing number of firms is shifting towards decentralized, flat and post-bureaucratic structures (Rajan and Wulf, 2006). Because of this phenomenon, the importance of less "structured" forms of communication has increased. Secondly, the development of network analysis methodologies (Wasserman & Faust, 1994) has allowed the detection of informal paths of communication that in past was not possible to recognize and measure.

Theories of social network started with the study of Moreno (1934) who introduced the fundamental concept of sociogram, the diagram representing structural patterns of group interactions. Other important findings in this field of research have been the ones of Milgram (1967) and theory of embeddedness of Granovetter (1985). More recently, important contributions to the Network Theory of Organizations have come from Brass (1984), Burt (1992) and Krackhardt (1992, 1999).

An informal network organization is created by the set of relations not explicitly designed as the organizational chart, but emergent and "lived" by organizational members in almost all types of organizations (Allen, James, and Gamlen, 2007; Rank, 2008). These informal ties can also lead to the creation of an informal hierarchy that encompasses different organizational levels (Diefenbach and Sillince, 2011: pag. 1521). It is shown by Simon (1969) that also informal networks develop a hierarchy structure, however, unlike formal structure, in the informal one the most important individuals are not at the top of the hierarchy, rather they are at the center of dense cluster of interaction (Krackhardt, 1994).

1.3.1 Reasons for the emergence of the informal organization

Informal networks arise in many ways. They often emerge from the context of formal departments, but can also arise cross-departmentally, as short circuits in intra-organizational communications (Ibarra 1993, Krackhardt and Hanson 1993). Informal ties can be the result of the effort of the organization to promote social activities or the unintended result of

physical colocation and homophily¹¹ (McFarland 2005). In some cases, the informal organization can resist managerial efforts to guide or mandate its form (Blau 1955). Knowing why informal networks arise can be useful both from a practical point of view (actions of managers) and from an academic one.

Baker (1981) and Han (1983) have identified several reasons driving the formation of informal organizations:

- Affiliation needs: to satisfy the need for belonging to a group, individuals tend to join network of friendship.
- Identity and self-esteem: belonging to a group can develop, enhance and confirm an individual sense of identity.
- Social reality: informal network serves as an agent for structuring and supporting a shared social reality.
- Defense mechanism: group cohesion can act as a defense mechanism to reduce (perceived) risk and strengthen individual's ability to respond to that threat.

Anyway, scholars have demonstrated that informal networks are heavily influenced by the formal structure, and that the dynamics of the organization is dependent on the informal networks (Reif and Monczka, 1973; Simon, 1976). Diefenbach and Sillince (2011) also found that the defined formal principles tend to be replicated in the informal network. Thus, hierarchical structure is not smoothed, but it similarly persists in individuals' social ties since organizational members shape their relationships according to the prescribed hierarchy. There is, in fact, consensus in the literature about how informal and formal network coexist and supplement each other (Monge and Eisenberg, 1987; Groat, 1997) or even are so intertwined that they are hardly distinguishable (Mintzberg, 1983). Recent trends towards de-hierarchization of organizations' structure and less defined channels of communication lead the informal networks to be an essential and necessary mean of communication within the organization (Scott 2017, Borgatti et al. 2018; Mintzberg, 1983; Farris, 1979).

¹¹ Homophily is defined as the tendency of individuals to associate and bond with similar others (Lazersfles and Merton, 1964).

1.3.2 The social capital

The researches about informal organization and informal network ground on the key notion of social capital. There are many similarities between these two concepts and they are often used as synonymous in the literature.

The term "Social capital" was introduced for the first time by Hanifan in 1916, but it became common thanks to James Coleman who studied how social capital leads to human capital (Coleman, 1988). A widespread definition of social capital is the one of Nahapiet and Ghoshal (1998) who define it as "the sum of actual and potential resources embedded within, available through and derived from the network of relationships possessed by an individual or social unit". Another definition of Social Capital is the one given by Leana and Van Buren (1999, pag: 540): "a resource reflecting the character of social relations within the firm [...] realized through members' levels of collective goal orientation and shared trust, which create value by facilitating successful collective action". The latter focuses more on the organizational dimension of social capital, which is realized through an alignment of objectives and directions. However, both definitions describe social capital as a network of relations created by a set of connections, a network that springs from the intrinsic nature of human being, who is to be a *zoon politikon*¹².

Scholars have furthermore looked at social capital in reference to the embeddedness theory (Granovetter, 1985) according to which it can lead to a competitive advantage (or disadvantage) depending on the specific individual's position inside the network and the structure of the network (Granovetter, 1973; Burt, 2001).

1.3.3 Types of informal networks

Unlike the formal structure that is fixed and represented by lines of subordination, the informal structure changes its shape by shifting the researches' focus on the *types* of relationship between two (or more) individuals.

¹² *Zoon Politikon* is a termed which refers to the atavic tendency of humans to be social animals: crucial for them are the interactions with others individuals and society as a whole.

Literature proposes different kinds of classification of informal networks. We reported the main ones in chronological order in Table 1.3.3-1.

Authors	Classification
Tichy and Tushman (1979)	<ul style="list-style-type: none"> • Technical approach: deals with work related issues • Political approach: related to individual and group goals • Cultural approach: related to the tacit and deep meanings and shared value in the organization
Monge and Eisenberg (1987)	<ul style="list-style-type: none"> • Expression of affect • Influence attempt • Exchange of information • Exchange of goods and services
Krackhardt and Hanson (1993)	<ul style="list-style-type: none"> • Advice network: used to determine who has the technical and professional knowledge in the organization • Trust network: shows tie of friendship and affection • Communication network: reveals employees who talk about work related matters on a regular basis
Torenvlied (1998) and Ibarra (1992)	<ul style="list-style-type: none"> • Instrumental relations: refer to daily interactions based on short term goals • Authority relations: based on power and influence • Intimate relations

Authors	Classification
Cross and Parker (2004)	<ul style="list-style-type: none"> • Communication network: it reveals individuals who talk about generic or specific topics (it depends on the question's formulations) • Information network: it is an indicator of current or recent collaboration within the network. It reveals the people who provide the network with information • Problem-solving or advice network: it reveals to whom individuals turn when they need an advice for a challenging problem • Accessibility network: it reveals the individuals who are accessible and reachable by others when they need information or advice.

Table 1.3.3-1 - Informal networks' proposed frameworks

1.3.4 Missing link between informal and formal organization

Many authors have denoted the lack of a stream of researches about the interplay of formal and informal organization and its effect on performances. The literatures on formal organization and informal social structure are largely disconnected, independent, and rarely integrated with each other. An integration between these two streams of research can be of crucial importance in the field of organizational design. This link can be brought to light by "empirically evaluating the consistency of formal and informal networks and the conditions under which such consistency benefits the performance of individual organizational actors" (Soda & Zaheer, 2012: pag: 754). The authors' results have confirmed that organizational performance is positively correlated with the consistency of these two networks¹³.

¹³ Consistency reflect the extent to which a node A s replicating or differentiating its contacts and ties across the formal and informal networks. If the nodes of the focal ego A are exactly replicated in the two different networks - so A shows the identical patterns and the same alters in the two networks - the overlap of A's ego networks shows its maximum consistency (1.0; and minimum inconsistency). For a clarification see Soda and Zaheer, 2012, pag: 753.

1.3.5 Consequences of informal network

Informal networks attracted scholarly attention also because of the impact that they have on organizational performances. A well-structured network is more efficient, faster in solving unexpected problems and more effective. Many researchers detected how key interpersonal processes such as interpersonal trust within and among organizational contexts (Zaheer, McEvily, and Perrone, 1998), knowledge transfer and exchange (Hansen, 1999), team dynamics (Reagans, Zuckerman, and McEvily, 2004), social influence (Sparrowe & Liden, 2005), affect performances at both individual and organizations.

At the firm level, it has been demonstrated how the social capital has a discriminant role in enhancing knowledge creation while reducing sacking (Nahapiet and Ghoshal, 1998), in knowledge transfer (DeToni, Nonino and Pivetta 2010; Maurer, Bartsch and Ebers, 2011), and on growth (Prashantham and Dhanaraj, 2010). The presence of informal ties across teams can lead to the creation of relevant resources such as knowledge and personnel exchange (Kilduff and Tsai, 2003).

As Burt (2000) highlights, scholars agree to attribute a fundamental role to social capital in organization, which benefit from it in:

- Improved knowledge-sharing caused by a strong trust in relationship, shared frame of references and goals.
- Diminished transaction costs due to the high level of trust and the cooperative spirit.
- Greater coherence of action due to organizational stability and shared understanding (Cohen and Prusak, 2001)
- Low turnover of employees that in turn reflects in a lower overall cost for hiring and training personnel.

As concerns the last point, it is important to stress how people become loyal to groups even more than to the firm itself. Hence, stronger cooperation among and within groups makes easier to avoid turnover. This has even more important consequences in knowledge-intensive firms, where the asset side of the balance sheet is quite poor, and the real competitive advantage lies on the knowledge of their employees. A survey conducted by Michaels, Handfield-Jones and Axelrod (2001) on a sample of more than 13,000 managers shows how 80% of them have worked for a boss who felt inadequate during their work career. This kind

of situation creates an incentive for employees to leave the firms, reducing their propensity to learn and to develop the business inside the organization.

Studies found that networked organizations have advantages over markets because they can mobilize not only the traditional financial and human capital controlled by the firm but also social capital (Burt, 2005; Nahapiet and Ghoshal, 1998).

Social relationships, represented as network structures, are the key to understand cooperation in knowledge creation and knowledge transfer (Nahapiet & Ghoshal, 1998). Hansen, Mors, and Lovas (2005) study the product development phase of a company and how social network impacts on knowledge sharing process, intended as the decision of information seeking, search costs and the cost of transferring the information. It emerges that it is fundamental to assess the problem through the simultaneous analysis of multiple networks (within-team, inter-subsiary, and transfer).

Numerous problems can occur when formal and informal structures are misaligned and push the organization in different directions. The creation of informal social groupings can influence work relations, norming work output to be equal within peer groups rather than optimal (Blau and Scott 1962; Roethlisberger and Dickson 1964). Sometimes it can happen that the social capital is so strong that "might also limit [the employee] ability to change the composition of her network as required by his tasks" (Gargiulo and Benassi, 1999: 299). Despite what above, some authors found a temporary positive effect of the misalignment between formal and informal organizations (Gulati, 2009). In fact, the mismatching can cause a compensation effect ("compensatory fit"), which in turn leads to ambidexterity. However, the extent of the positive consequences depends on the strength of the informal ties and on benefits that can be exerted by ambidexterity¹⁴.

Having a developed informal network can lead managers to overcome the trade-off between exploration and exploitation. Network can be an important lever of their ability to behave ambidextrously and offer insights into the micro-foundations of organizational ambidexterity (Rogan and Mors, 2014). An established informal network can also enhance managers'

¹⁴ Gulati and Puranam (2009) refer to ambidexterity as that specific characteristics which allow a company to successfully pursuit at the same tie exploration and exploitation techniques. Others examples of dualities are: cost vs differentiation and differentiation vs integration.

influence on the opinion dynamics in a group: a formal network that is well supported by an informal one can reduce opinion clustering (Song, Shi, Ma, and Yang, 2015). Moreover, managers who have a high awareness of the strength of informal ties in the work setting are more likely to achieve formal goals (Hollingsworth, 1974) and to obtain better results (Steiny and Kukkonen, 2007)

It is straightforward understanding that managers can leverage on the informal network and this becomes even more crucial going up in the hierarchical structure of a firms. The extent of the impact of informal network on performances is even stronger if referred to top managers mostly because of the importance of knowledge sharing (Burton, Wu, Prybutok, 2010). A central position in the advice network (assisting and helping co-workers) corresponds to a positive rating of performances not only by the co-workers but also by team leaders; on the contrary central positions in the hindering network¹⁵ badly affect and slower the work of their coworkers (Sparrowe, Linden, Wayne, Kraimer, 2001)

The structure of interpersonal network leads to a strengthening or limitation of valued resources (Brass, 1984; Ibarra, 1993), thus affecting performances. It is important to stress that through informal networks there is a flow of relevant resources (for instance task advice and strategic formation), which show a positive correlation with job performance (Sparrowe, 2001). Finally, it has been demonstrated that people with more different, entrepreneurial networks have the tendency to be more successful (Cross et al. 2004). In essence, a strong social capital leads to early promotion, career mobility, and managerial effectiveness (Burt, 1992; Burt, Hogarth, Michaud, 2000; Gargiulio and Benassi, 1999)

Finally, the role of leaders and the position in the network is another key aspect. In particular, the embeddedness of leaders in subordinates, peers, and supervisors' informal networks is fundamental to reach a certain group performance, but it also affects leader's reputation. Balkundi and Harrison (2006) proved that the density of the teams' relationships in the network positively correlates to improvements both in performance and in viability¹⁶. In addition, leader's centrality within the team and team's centrality in the inter-group network

¹⁵ The hindrance network is composed by relations tending to thwart task competition.

¹⁶ Team viability is defined as a group's potential to retain its members – a condition necessary for proper group functioning over time. (Hackman, 1987)

enhance the performance of the whole team especially in the first periods of the leaders nomination. However, the effect is less visible overtime when there is more familiarity between members. Related to this issue, the study of Mehra, Dixon, Brass, Robertson (2006) shows how the centrality of leaders is linked to their personal reputation among peers, superiors, and subordinates network and to the group performances.

1.3.6 Company performances and informal networks

The informal network can be used as a way to access critical information. Researches have consistently shown that the network has a significant impact on what actors come to know: specifically, the types and amount of information a certain actor acquire over time. Thus, there are many actions undertaken by managers who understand this potential such the use of collaborative technologies like virtual problem-solving spaces and online resumes (Cross and Parker, 2004). Unfortunately, a common spread belief among managers is that there is limited room to modify this network. As shown by Cross, Nohria and Parker (2002), this is not always the case, and we will address later how managers can influence this network. However, unless the management put in place specific actions in order to shape the informal network, it will be pulled by homophily (Lazersfles and Merton, 1964). Companies that will be able to identify, leverage, and remap informal networks will obtain a competitive advantage. This will be enhanced by less hierarchical structures, where managers will have to leverage on the ties they have to solve complex problems. Understanding the relationships will be the key to managerial success (Krackhardt and Hanson, 1993). Managers tend to disregard these ties, while it is important that they understand how to exploit and transform them into a tool to exert benefits in terms of performance improvement: indeed, informal ties are closely related to performance and job satisfaction, thus increasing the commitment towards the entire organization.

The collaboration that happens thanks to informal relationships is even more relevant in an economy characterized by high knowledge-intensity and rapid changes (Cross et al., 2002). Of course, the study of the exchange of information is not always a trivial task. For example, Bouty (2000) focused information change between researchers across boundaries. The monitoring of this flow is clearly hard, because of the number of real and virtual occasions

they have to interact with each other. Because of the complexity, there is a cost associated to the leak of information that has managers must control to avoid dispersion of "secret" information, especially by youngest researchers.

To understand the validity of what said until now, the behavior and the effect of informal network during critical times can be studied. The importance of informal network during crises periods has been investigated by several authors. For example, Diesner, Frantz, Carley (2005) analyzed the Enron's email corpus to represent and study the real organizational network. They found out that interpersonal communication intensified during the crisis period "bypassing formal chains of communication". In particular, lawyers and executives increased the communication within their rank and diminished the upward reporting, while the board reduced the lateral communication. The overall effect during the infamous period was a communication flow different from what prescribed by the formal structure.

Krackhardt and Kilduff (1990) show how during periods of change or crisis, the informal organization (in particular friendship ties) proves to be a relevant tool: the ties do not refer only to relationships within the same unit but especially to linkages across units. Indeed, they may have a crucial role in the solution of complex situations that can emerge, making the organization more flexible. The authors also stress the need of a proper design to help the development and the monitoring of friendship ties.

An appropriate design is even more effective in facing crises according to Krackhardt and Stern (1988): personal ties bring benefits to the organization by reducing the magnitude of the impact and increasing the response rapidity.

1.3.7 Implications

The first part of this review has shown the importance of informal network, especially for knowledge-intensive firms where people use personal relationships to find critical information for the accomplishment of their tasks. It is now time to introduce how the management of an organization can leverage on the informal network in order to solve/avoid common problems that can arise. Most problems can be detected only if management undertakes a series of analyses aimed to detect critical disconnections (Cross and Parker,

2004). The work of Cross, Nohria and Parker (2002) identifies several **myths** spread in the management about informal network and the related solutions:

➤ *To build a better network we have to communicate more.*

The quantity of communication is for sure an important indicator about a network. However, it is not enough, and managers should pay special attention to the quality of information. By subtracting the advice network¹⁷ (information seekers) to the communication network a set of people emerges who say they communicate, but are not actually exchange useful information. A solution for managers in this area could be focusing on potential performance of the network. That is to say shifting the focus from "who is currently obtaining information from whom" to "who knows what". For example, by implementing a database with skills profiling, record of experience, and expertise of employees. In fact, by working on networks that start from what people know, the management can act to sustain informal groups without adding the burden of more and potentially useless communication. Recent studies on organization have found plenty of example in which the organization failed to seize opportunities because workers were not aware of their colleagues' expertise (Cross and Parker, 2004).

➤ *Everyone should be connected with everyone else.*

The density (i.e. number of actual ties on number of possible ties) is an important structural parameter that characterizes a network. However, having a network in which everyone is connected with everyone else is neither feasible nor desirable. The solution is to connect people in case a strategic payoff is likely to arise from that connection. For instance, by promoting cross-boundary collaborations that can be critical to capture market opportunities.

➤ *It cannot be done too much to aid informal network*

Managers can aid the informal network in several ways. The first area of context is the formal structure: managers should understand how the formal structure may obstacle group effectiveness. For example, in organizations with a strong top-down culture, the informal network tends to closely mirror the prevailing pattern of hierarchy, and this results in a lack

¹⁷ In the advice network people are the nodes and tie represent a request for advice.

of flexibility (or ambidexterity, Gulati and Puranam, 2009) required to effectively respond to new opportunities. By bringing together different expertise of people in different divisions, the organization can become more efficient and exploit new market opportunities. Others contexts for possible management actions are linked to work management practices, employee management practices, and cultural context of the organization (for example, promoting group collaboration over individual performance).

➤ *How people fit into networks is a matter of personality (which cannot be changed).*

Scholars have found just a slight correlation between personality characteristics and network position (Mehra, Kilduff and Brass, 2001). Anyway, managers can make some steps towards leveraging on the expertise of peripheral members, for instance, having them working with more centered people and to let them answer directly to requests for information (so that others will recognize their expertise for future issues).

➤ *Central people who have become bottlenecks should make them more accessible.*

People often become central in informal networks because they know things that connect different part of the organization. However, this can make them so overwhelmed by colleagues' questions that they cannot accomplish the normal duties their job requires. Managers can intervene to solve this problem by reorganizing information domains and changing decision rights. This action not only frees the central actors but also includes peripheral people in the center of the network.

In the following table (source: “The hidden power of social network”, Cross and Parker, 2004), we present a summary of the main strategic areas that can benefit from an intervention on the informal network.

Supporting partnership and alliances	Executives are increasingly employing cross-organizational initiatives such as alliances or other form of strategic partnership to leverage their organizations' unique capabilities.
Assessing strategy execution	Core competencies or capabilities in knowledge-intensive work are usually a product of collaboration across functional or divisional boundaries. Social network analysis allows executives to determine whether the appropriate cross-functional or departmental collaborations are occurring to support strategic objectives.
Improving strategic decision making in top leadership network	A core function of top executive teams is to acquire information, make sound decisions, and convey those decisions effectively to the broader organization. Social network analysis, when done with both the top leadership team and the next layer down, can provide valuable diagnostic information to leadership. Not only can it help assess connections within a top leadership team, but it can also reveal how information is entering and leaving this group.
Promoting innovation	Most innovation of importance is a collaborative endeavor. Whether concerned with new-product development or process improvement initiatives, social network analysis can be particularly insightful in assessing how a team is integrating its expertise and the effectiveness with which it is drawing on the expertise of others within the organization.
Ensuring integration post-merger or large-scale change	Particularly in knowledge-intensive settings, large-scale change is fundamentally an issue of network integration. Social network analysis, done before a change initiative, can help inform the change process as well as identify central people within the network whom a sponsor might want to engage in design because of their ability to convey information to others. Social network analysis can also be done as a follow-up six to nine months after implementation. Quite often these assessments reveal significant issues that leaders need to address for the initiative to be successful.

Developing communities of practice	Communities of practice are usually not formally recognized within an organization but can be critical to an organization's ability to leverage expertise distributed by virtue of physical location or organizational design. Social network analysis can be used to uncover the key members of the community as well as assess overall health in terms of connectivity.
Integrating networks across core processes	Informal networks across core processes are often fragmented by functional boundaries. Both cognitive and organizational barriers often keep groups from effectively integrating unique expertise, which can damage quality, efficiency, and innovation. As the process map did for reengineering, social network analysis provides a diagnostic assessment of information and knowledge flow both within and across functions critical to a core process.

Table 1.3.7-1 - Benefits of Informal Networks' assessment

(Source: "The hidden power of social networks, Cross and Parker, 2004)

1.4 GENDER AND INFORMAL NETWORKS

Current data about women and organization show several problems, such as difference in salary, lower number of women reaching top positions, lack of trust towards their competences and work¹⁸.

Researches about gender inequalities inside organizations cover a wide set of themes, but we decided to focus our attention on the those studies that encompass the interplay between gender and informal networks

The importance of homophily in the creation of long lasting ties has been stressed in several studies, as already mentioned in the previous sections.

Gender is reported as one of the main rationales to create homophile relations in our society along with age, religion, education and occupation (Mcpherson, 2001).

¹⁸ Please see: <https://www.bloomberg.com/quicktake/why-women-earn-less-than-men>; https://gem-report-2017.unesco.org/en/chapter/gender_monitoring_leadership/ ; <https://www.economist.com/the-economist-explains/2017/10/20/why-do-women-still-earn-a-lot-less-than-men> ; <https://quifinanza.it/finanza/donne-lavoro-e-discriminazione-limpatto-negativo-della-disuguaglianza-di-genere-sulla-crescita-globale/187739/> .

A major problem pointed out is the exclusion or restricted accessibility for women to the informal interaction network, which contribute to the “glass ceiling” phenomenon, according to which women can hardly reach positions beyond the middle management (Kanter, 1977; Lincoln & Miller, 1979; Miller, Labovitz, & Fry, 1975; Morrison & Von Glinow, 1990; O’Leary & Ickovics, 1992). Durbin’s analysis (2011) shows that female senior managers have limited accessibility to (or are even excluded from) the strategic informal network, which is fundamental for the creation knowledge and the access to power and resources.

Other studies have examined career advancement, comparing the gain male and female employees obtain with respect to the “costs” they face. Indeed, evidences showed that being equal the level of education, training and working experience, functional areas, overall men were able to get higher benefits form the network compared to women in terms of career enhancing (Brett & Stroh, 1997; Dreher & Cox, 2000; Kirchmeyer, 1998; Landau, 1995; Morrison & Von Glinow, 1990; Schneer & Reitman, 1994; Stroh, Brett, & Reilly, 1992). According to the research of Heilman (2002), gender biases and their influence on the evaluation of women’s work create a mechanism for which it is not sufficient for women to demonstrate a certain level of competence to achieve the same organizational position of men, skills being equal.

Lyness and Thompson (2000), studied factors that are perceived as hampering or easing the career advancement for both men and women. Again, it emerged that women perceived as more difficult to have access to the informal network but felt as crucial for them to show a good track-record and a good network of relationships more than it is for men, who instead stressed the role of mentoring as key element for career advancement.

Forret and Dougherty (2001) define five types of networking behavior: maintaining contacts, socializing, engaging in professional activities, participating in community, and increasing internal visibility. They found significance in gender as a predictor of networking behavior, but even if in the past men seemed much more inclined in establishing social relationships, women are becoming more conscious of the great importance these have in terms of career outcomes. However, authors point out that the larger commitment of men in socialization may find an explanation in the greater amount of after-hours they generally have, while women would spend this time dealing with family caring issues. In a subsequent paper, the

authors used interviews and questionnaires to study how networking behavior can be a means to enhance career outcomes (in terms of number of promotions, total compensation, perceived career success) both for managerial and professional employees, with a particular attention for the differences between men and women. The latter study revealed how gender affects the benefits that can be exerted from networking, with better outcomes for men in terms of career-enhancing.

McGuire study (2002) demonstrates that women's network is as large as men's, but with fewer powerful people. Because of this, it is more difficult for them to exploit the network to achieve organizational benefits. The author identified this structural exclusion as main cause of the lower organizational status achieved.

Brass (1985), relies on social network analysis to study the impact of interaction patterns on the perceptions of influence and on promotions. Analyzing three types of networks (workflow, communication, friendship), it emerged that women were rated as less influential than men, though the two genders did not show particular differences on several measures. Women proved to be aware of the existence of the informal network and developed informal ties in the workplace, but gender homophily prevailed as well as for men. The research focuses on two particular aspects: influence exercised and promotion obtained. The first appeared to be related to the position both in the workflow and in the interaction network (in which women showed strong centrality), while the promotions showed positive correlation with centrality in departmental, in men's and in dominant coalition interaction networks, in which women appeared not very integrated.

One of the key research is the one of Ibarra (1992), who studied five types of networks: interaction work advice, support, influence, communications and friendship. She distinguishes two networks mechanisms that impede gender equality in the distribution of power across the organization: the first is homophily, the second relates to the exploitation of individual attributes and positional resources to obtain network advantages. As regards the first issue, the SNA performed in an advertising firm showed how men create stronger homophilous ties also across different networks. Instead, women tend to build two distinct networks, one with other women for support and friendship and the other instrumental (exchange of job-related resources, including information, expertise, professional advice,

political access, and material resources) with men. It is confirmed by the results of Brass's research (1985), according to which women tend to form informal ties with men for what concerns power and promotion. As regards the second issue (individual attributes and positional resources), it is worth to note that the percentage of women occupying high management roles in the analyzed company was lower compared to men's and so was their presence in the most relevant departments. Hence, the centrality level of the two genders was affected: men's centrality displayed higher values and depended mainly on work experience and personal activities, while for women it was related to resources' control.

The study of van Emmerik (2006) shows how men and women differ in terms of social capital creation. She distinguishes in hard social capital (development of task-oriented resources that can be used to achieve valued career outcomes) and soft social capital (development of emotional support with high level of closeness and trust). The research finds out that high organizational level of both categories of gender develop more the hard social capital, with men showing better results and better exploitation of both types of social capitals.

An interesting analysis of Powell (2002) describes how the tendency of managerial stereotypes to emphasize the importance of "masculine characteristics" was still present up to the date of the research, despite in the increasing proportion of women occupying top management positions and the increasing appreciation of feminine type of leadership. Moreover, the study of Hiellman and Okimoto (2007) states that female managers success in those managerial areas that are typically considered for men is prevented when stereotypes are violated (for instance, in terms of behavior with other members, family caring issues).

1.5 SOCIAL NETWORK ANALYSIS

The most affirmed tool to study social networks is the Social Network Analysis (hereafter SNA). Several books have been written on this topic (e.g. Wasserman et al. 1994; Scott, 2017; Knoke, 1984) and it has been widely applied by researchers to study informal networks (e.g. Krachardt et al 1994; Cross et al. 2004; Ibarra, 1993; Soda and Zaheerr 2014; Brass et al. 2004; Hansen and Scott 2008; Kleinbaum 2013) to cite few among the others.

SNA adopts a different research perspective compared to social and behavioural science: indeed, it is based on the assumption of the relationship's importance among interacting units

(or social entities). As Wellman (1988) reports “Structured social relationships are a more powerful source of sociological explanation than personal attributes of system members”. This because aggregating single individuals independently as done in attribute analysis overfly members’ patterned connection (Berkowitz, chapter 18, 1982). But using Coleman’s (1964) words “individuals do not act randomly with respect one another. They form attachments to certain person, they group together in cliques, they establish institutions”. So, treating each social system as a structural independent unit can be fundamentally wrong.

Basically, in SNA:

- Actors and their actions are interpreted as **interdependent** autonomous units.
- Relational ties between actors are channels for resources’ transfer or “flow”.

The fundamental difference between a social network explanation and a non-network explanation of a process is the inclusion of concepts and information on relationship among units in a study. This is a quite useful insight: think for example about how in real life the behaviour of humans, corporations or states is influenced by the behaviour of other actors who play a role in the context of interest. This is one of the concepts on which SNA is grounded.

SNA is particularly effective in (Cross, Borgatti, Parker 2002):

- Promote effective collaboration within strategically important group: When through SNA are detected structural problems or disconnections many solutions can be undertaken such as joint groups internal projects, change of the revenues goals, new communication forums like weekly status calls, short update e-mail and project tracking database.
- Support critical junctures in networks cross functional, hierarchical, or geographic boundaries.
- Ensure integration within groups following strategic restructuring initiatives.

Evidences from an analysis of 60 companies performed by Cross and Parker (2004) proved that SNA is an effective method to improve company’s connectivity and by-product its performances, learning and innovation. This is achieved thanks to the discovering and understanding of disconnections and rigidities in the network and the development of

targeted actions rather than general ones, given that the improvement of collaboration is costly (Hansen, 1999)

CHAPTER 2

2. HYPOTHESES

In this chapter, we base on literature to propose several hypotheses, which relate the probability of the formation of a tie in the advice network to several dimensions. These dimensions deal with: i) the presence of a tie in other networks (H1-H3); ii) some prominent characteristics of the structure of the firm (H4-H7); iii) two key individual characteristics, which prior contributions have considered as important antecedents of tie formation: gender and tenure (H9-H10).

The aim is to gain insights on why and how individuals tend to ask for advice to others in an organization. According to Krachardt (1993), the advice network is a particular type of informal network and it “shows the prominent players in an organization on whom others depend to solve problems and provide technical information”.

In our literature review, we did not find many papers investigating the determinants of the creation of advice ties. Indeed, social network researchers have widely demonstrated the importance of personal ties in the construction and acquisition of information (Granovetter, 1973; Burt, 1992; Rogers, 1995; Hansen, 1999; Borgatti and Cross 2003). Nevertheless, there has been little exploration of the rationales behind the fact that organizational members go to specific others for work-related advice and help (Nebus 2006; Cross, Borgatti, Parker, 2001). In particular, Nebus (2006) found that accessibility and perceived willingness to share the advice are predictors of advice tie creation, while Cross et al. (2001) remarked the importance of homophily. Others argue that status consideration play a determinant role in advice relations (Blau 1955, Montgomery 1996, Flynn, 2003).

Additionally, we know from past researches the transfer of work related advice in organizations is usually characterized by strong tendencies toward reciprocity (e.g. Agneessens and Wittek 2012, Rank et al. 2010). In other words, this means that the willingness of an employee to provide resources to a colleague is directly proportional to the resources the other party returns. The rationale behind this can be explained by social exchange theory (Blau 1964) proposing that individuals maintain ties to others in a self-

serving, opportunistic way, aiming to exploit the benefits and reduce the costs of their relations.

The advisor-advisee relation has also been addressed by researchers as fundamental since it is closely linked to organizational power (Brass, 1992; Ibarra et al. 1993), job performance (Sparrowe et al. 2001), self-efficacy and attitude towards technology (Burkhardt, 1994). Moreover, it is extremely connected to the transfer of work-related information, strengthening the coordination of existing activities and reinforcing organizational standards. (Gibbons, 2004). Owing to all these consequences that the advice network exerts on the organization, we think it may be of great interest to furtherly explore the determinants behind the choice to seek advice from a specific person.

2.1 ADVICE NETWORK AND PRESENCE OF TIES IN OTHER NETWORKS

In this first section of our hypotheses, we aim at understanding how the presence of a tie between two actors in utility, accessibility, and friendship networks fosters the creation of a relation advisor-advisee. We provide the rationale behind the formulation of these hypotheses based on the reference literature.

For what concerns the utility network, it is fundamental to cite Zmud (1978), who studied information quality. He found that it is reflected in messages that are relevant and useful to the problem being addressed. A source that shows quality in the message delivering, it is clearly likely to be used more frequently than sources providing information of lower quality. Hence, we expect that the sources that are perceived more useful will be more addressed also for seeking advice.

The quality of information is also a crucial factor for a decision maker to justify the basis of a decision taken with respect to other people in the organization. Thus, for decision taking and problem solving, the information (and its source) has to be conceived valuable, useful, and reliable (Goldstein, Marcus and Rausch 1978; Staw 1980; Borgatti and Cross 2003). This is remarked also by O'Reilly (1982), who found that the utility and quality of the source is crucial in choosing among co-workers to whom address.

For all the above, we conclude that an individual that perceives another as source of useful and reliable information would turn to her also for advice and problem solving.

H1: all else being equal, the presence of a tie between two individuals in the utility network predicts the formation of a tie between the same pair in the advice network.

It is well established in literature the concept that individuals are limited in cognitive energy and time constrained¹⁹ (Benson & Beach 1996, Rastegary & Landy, 1993). Consequently, time and effort they invest in building relations with others are quite limited. Since people are bounded in their rationality, they often may be comfortable with a solution that is satisfying rather than optimal (Simon, 1957). Thus, also in social relations people may tend not to seek for the optimal²⁰ source but for a one that, in a fast-tracking world (Brehmer 1990), is satisfying for them.

Owing to this, we argue that accessibility is a sufficient condition in the determination of a satisfying source of advice.

This insight is also reinforced by March and Simon (1958) according to whom the choice to exploit a specific communication channel can be self-reinforcing, leading to a reiteration of its use whether or not the information is not the optimal one. In a study of research and development, Gerstberger and Allen (1968) found that channel accessibility is a crucial determinant of the use of a specific channel.

For these reasons, accessibility can be seen as a crucial factor for the selection of the person to whom asking for advice.

H2: all else being equal, the presence of a tie between two individuals in the accessibility network predicts the formation of a tie between the same pair in the advice network.

Communication network has been associated several times with friendship network by researchers (e.g. Cross and Parker 2004; Krachardt 1993). This type of tie covers an important role in organizations: as demonstrated by Sias and Cahill (1998) friendship ties

¹⁹ Time constrain has been defined as the difference between the amount of available time and the amount of time required to resolve a decision task.

²⁰ In this case optimal is intended as a source that would provide the information of the highest quality possible.

foster the discussion of issues that people would not share with others directly or within groups. Moreover, individuals are often afraid of asking for advice to others because it can signal incompetence and may lead to a loss of professional prestige (Goffman, 1961). This should be moderated if the other is considered as a “friend”.

We suggest that if a person has a friendship relation with another in a working context, she would turn to this person for help in problem solving or advice.

H3: all else being equal, the presence of a tie between two individuals in the friendship network predicts the formation of a tie between the same pair in the advice network.

2.2 ADVICE NETWORK AND FORMAL STRUCTURE

In this second part, we study the relation between the formal structure of an organization and the creation of ties in the advice network. In particular, as to the characteristics of the formal structure, we examine the formalized communication considering the reporting relationship highlighted by the organigram and the meetings at which specific individuals must take part; the co-location of individuals (i.e. working in the same plant); belonging to the same unit; the hierarchical level to which actors belong.

Starting from contingency theory, organization architectures are considered as adaptations appropriate to technological and environmental requirements (Child 1977; Lawrence & Lorsch 1969; Mintzberg 1979; Mahoney 1992). Organization design represents a deliberated and intended approach to build rational devices to pursue specific organizational goals (Dow, 1988). Anyway, always following Dow, this is an incomplete view as it disregards all the counterstrategies that actors put in place to question the formal objectives. These counterstrategies are the results of a continued exchange of resources and information. According to Selznick (1948), members of an organization are inclined to deviate from what is formally prescribed, because they tend to fight the depersonalization inherent in the formal structure.

However, actors may choose informal relationships, even if sanctions exist for their preserving formal procedures (Blau, 1954; Noorderhaven, 1992).

Many authors remarked the importance of the formal structure even in forming informal ties (Reif & Monczka, 1973; Simon, 1976; Diefenbach and Sillince, 2011, Monge & Eisenberg 1987; Groat, 1997; Mintzberg, 1983). In fact, following Brass et al. (2004), the formal structure of an organization is an antecedent of interpersonal network within it and that “the opportunities to interact with some others” are subject to individual positions and physical space. Moreover, behavioural interactions are influenced by formal factors such as power and hierarchy. (Baker et al 1999, Brass 1984, Bobb, 1980; Dow, 1988; Hertman & Johnson 1990; Mintzberg 1983; Minge & Contractor, 2003; Ouchi, 1979; Scott, 1998; Stevenson, 2001; Watson & Weaver, 2003). Other authors have advanced the understanding on the *formally induced* homophily (Kleinbaum et al. 2013), which refers to the tendency to establish informal interactions between people who are formally similar.²¹ It has been demonstrated that actors have the underlying psychological preference to interact with others who are like themselves. There is proof of such choice homophily in friendship networks among children (Shrum et al, 1988) adults (Lazarsfeld and Merton 1954), social support network (South et al 1982) to cite few among the others. There has been of course influential research on homophily in corporate environment (Ibarra 1993, Ibarra and Smith-Lovin 1997). Moreover, homophile ties happen in several types of interactions. For example, in age, gender, class and organizational role (Aaron, 2006). Given the fact that people turn to similar ones for social interactions, this might also be true for advice network.

H4: all else being equal, the presence of a tie between two individuals in the formal network predicts the formation of a tie between the same pair in the advice network.

Another prominent organization factor, which may predict the likelihood of the formation of a tie in the advice network is the fact that two individuals belong to the same production plant. Several researchers found evidences according to which collocation and geographical proximity increase the communication chances and in general the ties' formation among people (Allen 1977; Monge et al. 1985; Blau and Schwartz 1984; Sorenson and Stuart 2001; Marmaros and Sacerdote 2006).

²¹ Kleinbaum Stuart and Tushman inted *formally induced* homphily as an emergent pattern of reciprocate interactions which occur within defined organizational structures (job functions, business units, offices).

H5: all else being equal, the fact that two individuals are in the same venue predicts the formation of a tie between the same pair in the advice network.

Kleinbaum et al. (2013) have studied how business units and job functions foster the tie creation. Across types of relationships (Lazarsfeld and Merton 1954, Fisher 1982, Marsden 1988, Reuf et al. 2003, Goodreau et al 2009) and diverse empirical context (South et al 1982, Shrum et al. 1988, Reagans 2005, Marmaros and Sacerdote, 2006), scientists have demonstrated that people associate and interact more frequently (Regans 2011) with others who are similar themselves. Hence, we argue that (in a work domain) similarities can be given by the belonging to the same unit. Han (1996) reports that in large and multi-business firms, functional and office boundaries that most strongly influence the opportunity set of potential interaction partners for organizational actors (see also Kleinbaum et al. 2009).

We expect that interactions especially for what concerns advice are fostered by belonging to the same boundaries, prescribed by the formal organization (Galbraith 1973).

H6: all else being equal, the fact that two individual belong to the same BU predicts the formation of a tie between the same pair in the advice network.

According to *formally* induced homophily, individuals should see similarities also in the hierarchical level, and hence turn to individuals having a similar hierarchical level for advices. As said above, individuals may be afraid of asking for advice since they can be perceived as poorly competent (Goffman, 1961), and this effect may be magnified as differences in hierarchical levels increases. Another interesting viewpoint is that individuals relate for information and problem solving (Borgatti et al. 2003) to their peers or to members belonging to proximate layers. For all what above, we posit that difference in the hierarchical level should decrease the chance an individual looks for advice from another.

H7: all else being equal, the fact that two individuals belong to different hierarchical levels predicts the formation of a tie between the same pair in the advice network.

2.3 ADVICE NETWORK AND INDIVIDUAL CHARACTERISTICS

In this last section, we try to understand the relation between two fundamental personal characteristics of individuals that can affect the tie formation in the network of interest. Specifically, we aim at studying how gender similarity and job tenure affect the decision of whom having as advisor.

Plenty of papers confirm the importance of individual characteristics and similarities in individual characteristics in the formation of relationships among individuals (e.g., Lazarsfeld and Merton, 1964, McPherson 2001, Rivera et al. 2010). In particular, in line with prior contributions, we focus on the role of gender and tenure.

Given the fact people tend to establish informal relations with similar, we expect this also will be true for the gender dichotomy; hence that man will tend to ask for advice to other men and woman will tend to ask for advice to others women.

H8: all else being equal, the fact that two actors have the same gender predicts the formation of a tie between the same pair in the advice network.

Sparrow and Davies (1988) demonstrated that as age increases, workers are lower rated considering overall efficiency, but when length of service is controlled, age difference in performance may sometimes disappear entirely (Giniger, Dispenzier, & Eisenberg, 1983; Schwab and Heneman, 1977) suggesting the effect of experience – which is reflected in tenure length – may be a valuable resource in colleagues' eyes.

This is also remarked by Lave and Wenger (1991) and Wenger (1998) who found that people that have spent more time in the organization are perceived as having more knowledge. As a consequence, they should be more sought for information or advice by other members. Moreover, it has been demonstrated by (Kleinbaum and Stuart, 2004) that centrality and structural autonomy²² increases with tenure.

²² As defined by Burt (1992) actors are structurally autonomous when they are “free of structural holes on their own and rich in structural holes at the other hand. This era the players best positioned for the information and control benefits that a network can provide.”

Hence, we argue that the higher the tenure of a person, the higher the probability she will be sought for advice from those who have spent a lower number of years in the organization.

H9: all else being equal, a positive difference in tenure between two actors predicts the creation of a tie in the advice network

The last hypothesis we wanted to test is exploratory and looks at the joint effect of having a higher tenure and belonging to the same BU.

Zenger and Lawrence (1989) found that the more the time individuals spend in a firm, the more they tend to develop “familiarity” with technical topics and language used inside the organization and to be sought by the others for technical help. We argue that individuals will tend to create ties in the advice network with those that have spent more time in the firms (and so are perceived as having more “familiarity” with firm-related topics) and that belong to their same BU (which means they have the specific “technical familiarity” with the topics that the advisee deals the most with).

H10: all else being equal, the fact that the two individuals belong to the same BU and that there is a positive difference in tenure predicts the tie formation between the same pair in the advice network

We provide a testing of these hypotheses in Chapter 7.

CHAPTER 3

3. METHODOLOGY

We resort to a **mixed method** approach. This approach is very common in literature and organizational studies (Johnson and Onwuegbuzie 2004; Brewer and Hunter 1989; Creswell 2003; Johnson and Christensen 2004) and allows combining qualitative and quantitative research techniques and methods. Accordingly, we decided to both conduct interviews with key informants and apply SNA methods.

In this chapter, firstly we describe the rationales proposed by literature to select the individuals to include in the group of interest and to perform the collection of the information necessary to the study. Then, we illustrate the main concepts of SNA that we have used in our analysis and the description of the tools applied in the hypotheses testing. Finally, we address the problem of data privacy, which we had to deal with.

3.1 IDENTIFICATION OF THE GROUP OF INTEREST

The first issue to address is the identification of the group of individuals, who fit with the aim of the analysis and (in our case) that allows to produce an interesting output on the social mechanisms inside the firms. For these purposes, it is crucial to understand who are the individuals whose relations and mutual interdependence contribute to the proper functioning of the organization (Cross et al. 2004). This phase is usually carried out with a preliminary meeting with the firm's management, who are asked to describe to the researchers how the firm runs and to help in the selection of the employees that comply with the characteristics above mentioned. The management should also provide information about the firm's formal structure (e.g. job functions, reporting lines, hierarchical levels) and formalized communication mechanisms (Wasserman and Faust, 1994; Scott, 2012). This constitutes a first but extremely important step for the assessment of the company.

3.2 DATA GATHERING

Social network data that can be collected consist of at least one structural variable measured on a set of actors. The theoretical motivation for the research usually determines which structural variable to be measured and which techniques to be used. For example, friendship among people are most likely studied using questionnaires or interviews.

In a network data set there are two types of variables: structural and composition.

Structural data are measured on pairs of actors and measure ties of a specific kind (e.g., business transactions among firms, friendship among people, or trade among nations).

Composition variables (or actor attribute variables) are measurement of actors' attributes and so are measured at level of individual actors. For example, researchers might record gender, race, social status, ethnicity for people, or geographical location, after-tax profits or number of employees for a firm.

In order to extract relational data²³ from the selected group of interest, several techniques have been developed (Wasserman et al. 1994)

- Observation
- Interviews
- Questionnaires
- Archival records
- Experiments
- Other techniques, including ego-centred small world, and diaries
- Most recent approaches are based on technology: for instance, use of event-log, GPS, e-mail log

Questionnaire is the collecting method most used and most established in literature so far (Wasserman et al., 1994; Krackhardt et al., 1993; Cross et al., 2002) and it is the technique we selected for this thesis project together with interviews. It usually encompasses questions

²³ Relational data can be of any type depending on the research interests. In essence, they form the tie in the 2D representation (graph representation) of the network. See structural data.

about the respondent's ties to other individuals and proves to be particularly valuable if the relations that are being studied are those ones that respondent can report on.

The validity of the questionnaire methodology was proved by Romney and Freeman (1987), who state that verbal reports (recall of interactions) should be properly assessed using principles of memory and cognition. Indeed, they found that what people report about their interactions is related to the long-range social structure (that is what a researcher should be interested in) rather than to particular interactions. For what concerns validity, we can recall Mouton, Blake, and Fruchter (1955) who found that sociometric measures (like the number of choices received) were related to a number of individuals' characteristics, such as leadership and effectiveness.

Clearly, the formulation of questions must align to the purposes of the research and specifically designed for the extraction of the networks that researchers consider key for their analysis (Cross et al. 2004; Scott, 2012). Literature provides some interesting examples of questions already tested and meaningful attributes that give insights about the individuals characteristics (Ibarra 1993, 1994).

Generally, together with the questionnaire the researcher makes a series of interviews with the individuals involved in the study (Mckether, Gluesing and Riopelle, 2009). These are aimed to gain more information about the network, which will be studied and to prepare an ad-hoc questionnaire, or to verify that the information collected through the questionnaire are reliable.

Other approaches have been developed in recent years, for example Fischbach, Kai Gloor, Peter A. Schoder, Detlef in 2009 use a prototype of an IT supported instrument ("social badges") to support automatic collection of informal, personal interaction among workers within a firm. Anyway, this methodology is not sufficiently developed yet to give reliable results, and often deals with problems related to privacy.

Other examples in which the technology helped the researches offering new ways to collect social network data is offered by Christopher C. Liu, Sameer B. Srivastava and Toby E. Stuart, who used the census of membership in electronic mailing list to reconstruct the

informal network or by Wil P. Van Der Aalst, Hajo A. Reijers and Minseok Song, who used the event log to unearth the social network.

3.3 RESULTS' VISUALIZATION AND ANALYSIS

In order to visualize and analyse the network, we combined UCINET²⁴, NetDraw and Pajek (Borgatti, 2002).

Each question of the survey administrated gave us the information needed to build the related network (information, communication, utility, etc...). Data were then organized in Excel spreadsheet in order to be processable for network software like Ucinet, NetDraw and Pajek.

The process followed is quite straightforward. For each network all the actors involved in the survey where reported (name were substituted with alphanumeric numbers) in the same order on the row (x axis) and columns (y axis) of an excel spreadsheet. Then, each cell was filled with 1 if actor on the x axis reported to have a connection with actor on the y axis. Hence, the final matrix is a square matrix (there is the same number of actors in each axis) and with the main diagonal filled with 0 (actors were reported in the same order, and given the type of questions we did not allowed for self-choices). These matrices are called in SNA "sociomatrix".

These sociomatrices are then uploaded on Ucinet for the format conversion (Ucinet DL Editor), which allows to perform the analysis on Ucinet itself and to upload the file on Netdraw for the displaying of the graph theoretic (e.g., the network diagram with nodes representing individuals in the organization and arcs connecting them).

Ucinet, which is the most used software to perform SNA, provides researchers and managers with key networks metrics and allows to test hypotheses both at dyadic level (that is to say the relations among members) and at the nodal level (that is to say the determinants who caused a given node to have a certain position in a given network).

²⁴ <https://sites.google.com/site/ucinetsoftware/home>

3.4 NOTATION FOR SNA DATA

A set of data regarding a network can be viewed, represented and analysed in several ways. Basically, three types of notations can be used to describe information contained in a data set. These notations are (Wasserman et al. 1994):

- Graph theoretic
- Sociometric
- Algebraic²⁵

In this thesis, we take advantage just of the first two types.

The **graph theoretic** can be seen as the elementary way to represent actors and relations. Mathematically a graph consists in two sets (N, L) . A set N includes g actors in number, $N = \{n_1, n_2, \dots, n_g\}$. It is recorded whether each actor in N relates to every other actor on this relation. Consider a dichotomous and directional relation, n_i either relates to n_j or does not. If the pair of actors n_i and n_j is different from the pair n_j and n_i the relation is directional. If a tie is present, then we say that the ordered pair is an element of a special collection of pairs, L . With L entries in L , we have that $L = \{l_1, l_2, \dots, l_L\}$. All the elements in L can be represented graphically by drawing a line from the first actor in the element to the second. Since the lines have a direction, we refer to this graph as a direct graph. Directed lines are referred to as *arcs*. Hence, we use the symbol L to refer to the set of directed lines and the symbol l to refer to the individual directed lines in the set.

Of course, there can be as many as $g*(g-1)$ elements (the total number of ordered pairs in L), and as few as 0. Moreover, if the relation is non-directional, it means we cannot distinguish the line from n_i and n_j and the line from n_j to n_i . As a consequence, the set L comprises $g*(g-1)/2$ pairs.

For this work, given the type of relations studied, we will not deal with self-choices. Hence, an actor does not relate to itself.

²⁵ Algebraic Notation is most useful for multirelational networks, since it easily denotes the “combinations of relations in these networks. The main differences with previous notations consist in the use of capital letters to denote types of relations (for example F for “is friend of”) and the framework used to report relations (for example if there is a tie from actor I to actor j on relation F it becomes iFj).

The main advantage of graph theoretic notation is that data set can be easily represented in a two-dimensional space with arcs as directed arrows between points indicating actors.

With **Sociometric notation**, relational data are often presented in a two-way matrix termed *sociomatrix*. It is often a complementary notation used beside the graph theoretic one. The sociomatrix reports on the rows the sending entity/actor and on the columns the receiving entity/actor. Thus, if we have a one-mode network (all actors coming from the same set) we will have a square matrix.

Sociograms and sociomatrices were first used by Moreno (1934) and Northway (1940). Other authors that contributed to the growth of this notation were Lindzey and Byrne (1968), who proposed measurement of relations and Klovdahl (1986).

A sociomatrix for a dichotomous relation is exactly the adjacency matrix for the graph (or sociogram) quantifying the ties between the actors for the relation in question. Row and columns correspond to the individual actors, ranked in identical order. Since the total number of actors is g , the size of the matrix will be $g * g$.

Differently from graph theoretic notation, self-choices lie along the main diagonal of the sociomatrix, therefore, the main diagonal of a sociomatrix is usually full of undefined entries.

For the relation X , we define X as the associated sociomatrix. This sociomatrix has g rows and g columns. The value of the tie from n_i to n_j is placed into the (i,j) th element of X . The entries are defined as:

$$x_{ij} = \text{The value of the tie from } n_i \text{ to } n_j \text{ on relation } X.$$

where i and j ($i \neq j$) range over all integers from 1 to g . If the relations under examination is dichotomous, then the values for the tie are simply 0 or 1. That is:

$$x_{ij} \in (0,1)$$

3.5 SNA PROPERTIES

We now introduce some important SNA properties and advanced measures that we used for the selected network assessment (Wasserman and Faust, 1994).

3.5.1 Density

The *density* (Δ) of a graph is the proportion between lines which are actually present (L) in the graph and all possible lines.

$$\Delta = \frac{L}{g(g-1)/2} = \frac{2L}{g(g-1)}.$$

The maximum value of density corresponds to 1 if all possible lines are present ($L = g(g - 1)/2$). In the latter case, the graph is said to be *complete*. A complete graph contains all $g(g - 1)/2$ possible lines, the density equals to 1, and all nodal degrees are equal to $g-1$. The minimum value is 0, which corresponds to an empty graph.

We can also represent the density for a subgraph, which is used to evaluate the cohesiveness of subgroups and to construct blockmodels²⁶ and the related and simplified representation of networks.

3.5.2 Connected graphs and components

A graph is **connected** if there is a path between every pair of nodes in the graph. Which means that all pairs of nodes are reachable. Otherwise, the graph is **disconnected**.

If a graph is disconnected, it means there will be some subsets of nodes in which there are no paths²⁷ with nodes belonging to a different subset. The connected subgraphs in a graph are called **components**. A component of a graph is a maximal connected subgraph (a maximal entity is one that cannot be made larger and still retain its property).

²⁶ Blockmodels are advanced SNA techniques used to group individuals based on similarity in their relations (one similarity measure is the Structural Equivalence), in order to represent a simplified version of the network. See Wasserman and Faust, 1992.

²⁷ Paths are one of the most used metrics for connection in SNA. A path is a walk (that is a sequence of actors and relations that begins and ends with actors) between two actor in which each other actor and each other relation in the graph may be used at most one time.

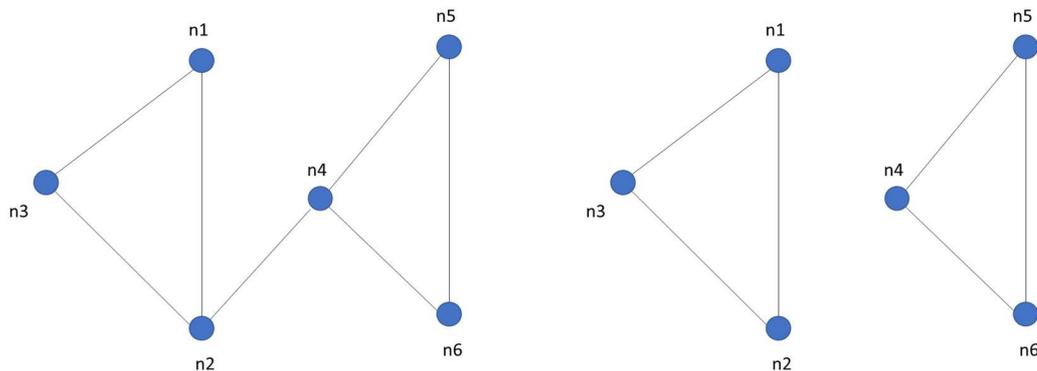


Figure 3.5.2-1 – A connected graph and a graph with components.

3.5.3 Geodesic

A **geodesic** is the shortest path between two nodes. The geodesic distance between two nodes is equal to the length of the geodesic between them. The **eccentricity** of a node is computed considering all geodesic distances that there are between a specific node and the other nodes in the graph. Considering each pair of nodes in the network and calculating the geodesic distance among them, the **diameter** of a graph is equal to the largest geodesic distance between all pair of nodes.

3.5.4 Cohesive subgroups

It is not easy to give a definition of cohesive subgroups. Many authors in the past attempted to do so, but a widely accepted definition is still missing. According to some authors like Foster, Seidman and Freeman, the concept of social group can be studied by looking at the properties of a subset of actors within a network. In SNA, we refer to this property with the word **cohesion** among subgroup members based on certain properties of the relations among the actors. To assess the cohesion of the analysed networks, we base on density and geodesic distance measures (Borgatti et al. 2002).

3.5.5 Clique

A clique is a maximal complete subgraph of three or more nodes. Basically, it consists in a subset of nodes all of which are adjacent to each other, and do not exist other nodes that are also adjacent to all the members of the clique.

We can use the definition of clique to define a subgroup. Anyhow, this would be a very strict definition of cohesive subgroup. In fact, the absence of a single line – that is the absence of choice – will prevent a subgraph from being a clique.

An evolution of this concept consists in the creation of subgroups based on the **geodesic distance** between nodes. That is: we define cohesive subgroups based on reachability, which require geodesic distances among members of a subgroup to be small. From this concept born the notation **n-cliques**: a n-clique of an undirected graph is a maximal subgraph in which every pair of actors is connected by a path of length n or less.

Another way to look at cohesive subgroups is through **nodal degree**. Subgroups based on nodal degree require actors to be adjacent to relatively numerous other subgroup members. Again, this concept is the starting point for the definitions of **k-plaxes** and **k-cores**.

Also, Seidman defines an **LS set** as a “set of node S in which each of its proper subsets has more ties to its complement within S than to the outside of S.”

What said above can be adjusted to take into account directional relations instead of dichotomous relations.

3.5.6 Connectivity

The concepts of reachability, connected graph and components can be used to define nodes and lines, which are critical for the connectivity of a graph. The connectivity of a graph is a function of whether a graph remains connected when nodes and/or lines are deleted.

A node, n_i , is a **cut point** if the number of components in the graph that contains n_i is lower than the number of components in the subgraph that result from deleting n_i from the graph. An example is shown in the figure below.

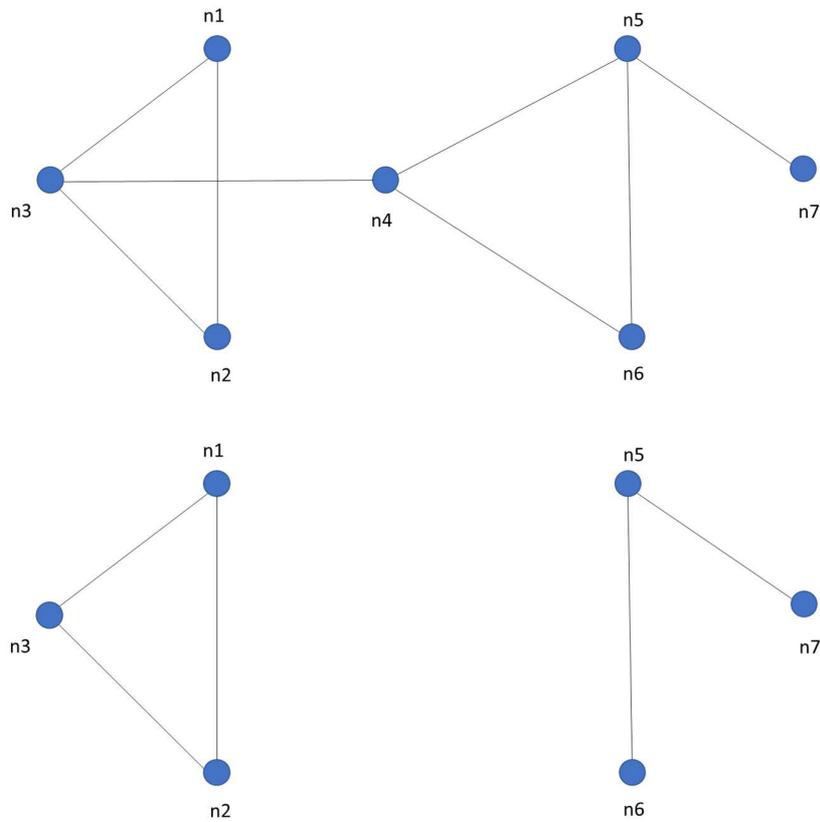


Figure 3.5.6-1– Example of a cutpoint in a graph

Similarly of what said for nodes, also for lines a similar concept exists. A bridge is a line that is critical to the connectedness of the graph, it means that a graph containing such line has fewer components than the subgraph that is obtained removing the line. The removal of a bridge leaves more components that when the bridge is included. Again, an l-line cut is a set of l lines that, if deleted, disconnects the graph. A bridge is therefore a 1-line cut.

3.5.7 Centrality measures

Network analysis is effective in the identification of the most prominent individuals or groups inside the organization. Several measures of centrality have been developed and they provide different insights.

3.5.7.1 Degree centrality

Degree centrality corresponds to the simplest expression of centrality.

The *degree* of a node, denoted as $d(n_i)$, equals the number of lines which are incident with it, or, equivalently, equals the number of nodes adjacent to it. It ranges from 0 (if the node is not adjacent with any other node, and it is called *isolate*) to $g - 1$ if the node is adjacent to all other nodes in the graph.

Following Proctor and Loomis (1951), we have:

$$C_D(n_i) = d(n_i) = x_{i+} = \sum_j x_{ij} = \sum_j x_{ji}$$

A problem of this measure is its dependence on the number of actors, g . To account for this problem, a proposed standardization of the measure, which can be used to compare networks of different sizes is the following:

$$C'_D(n_i) = \frac{d(n_i)}{g - 1}$$

A related index, called “**ego density**”, proposed by Burt (1982) and by Knoke and Kulinski (1982). An ego density for a non-directional relation is simply the ratio of the degree of an actor to the maximum number of ties that could occur.

For what concern **group centralization**, Freeman (1979) proposes the following formula:

$$C_D = \frac{\sum_{i=1}^g [C_A(n^*) - C_A(n_i)]}{[(g - 1)(g - 2)]}$$

This index determines how centralized the degree of the set of actors is. This index is also a measure of the dispersion or spread of the actor indices, since it compares each actor index to the maximum attained value.

There are also simpler group-level degree indices. In fact, recognizing that the simplest actor-level index is the degree of the actor, one can take the average of the degrees to get the mean degree, $\bar{C}_D = C_D(n_i)/g$.

In case of digraph, we can talk about indegree and outdegree.

The **indegree** of a node, $d_I(n_i)$ is the number of nodes, which are adjacent to n_i . The indegree of a n_i is equal to the number of arcs of the form $l_k = \langle n_i, n_j \rangle$, for all $l_k \in L$, and all $n_i \in N$. Indegree is thus the number of arcs terminating at n_i . This measure in SNA quantifies the receptivity or popularity of an actor.

The **outdegree** of a node $d_O(n_i)$, is the number of nodes adjacent from n_i . The outdegree of a node n_i is equal to the number of arcs of the form $l_k = \langle n_j, n_i \rangle$, for all $l_k \in L$, and all $n_i \in N$. Outdegree is thus the number of arcs origination with node n_i . This measure quantifies the expansiveness of an actor.

We denote the mean indegree as \bar{d}_I , and the mean outdegree as \bar{d}_O . These are calculated as:

$$\bar{d}_I = \frac{\sum_{i=1}^g \bar{d}_I(n_i)}{g}$$

$$\bar{d}_O = \frac{\sum_{i=1}^g \bar{d}_O(n_i)}{g}$$

We will also be interested in the variability of the nodal indegrees and outdegrees. In fact, the variance of indegrees and outdegrees, unlike the mean, can be different.

Thanks to the indegree and outdegree in a diagraph, we can distinguish between four types of nodes depending on the possible ways the arc can be incident with the node. Following Haray, Norman, and Cartwright (1965) and Hage and Haray (1983), a node is a:

- Isolate if $d_I(n_i) = d_O(n_i) = 0$,
- Transmitter if $d_I(n_i) = 0$ and $d_O(n_i) > 0$,
- Receiver if $d_I(n_i) > 0$ and $d_O(n_i) = 0$,
- Carrier or ordinary if $d_I(n_i) > 0$ and $d_O(n_i) > 0$

Carrier has both indegree and outdegree equal to 1, whereas an ordinary node has both greater than 1 (Burt 1976, Marsden 1989, Rhicards 1989a).

3.5.7.2 *Betweenness centrality*

Betweenness centrality focuses on the actors in between a network. The concept grounds on the fact that an actor, who is in the middle of the network has more influence than others or, following Freedman (1979), that actors in the center have more “interpersonal influence”.

If we consider the communication network, then the probability of the communication using any one of them is $1/g_{jk}$. Where g_{jk} is the number of geodesics. If we let $g_{jk}(n_i)$ be the number of geodesics linking the two actors that contain n_i we can calculate an actor’s betweenness as,

$$C_B(n_i) = \frac{\sum_{i < k} g_{jk}(n_i)}{g_{j \square}}$$

With i different from k and j . Basically, this index counts how “between” each of the actors is, as a sum of probabilities. The lower bound is 0, when n_i is not included in any geodesic. And the maximum is given by the number of pairs of actors not including n_i , that is $[(g - 1)(g - 2)]/2$.

The crucial idea is that an actor is central if it lies between other actors on their geodesic.

Considering two actors in the network we want to consider the geodesics between them. If there is more than one geodesic, all geodesics are equally probable.

3.5.7.3 *Closeness centrality*

The second perspective on actor centrality bases on the distance between actors. This measure focalizes on how distant an actor is to all others in the set. The basic principle is that if an actor is central then s/he will be able to easily interact with others (Bavelas 1950, Leavitt 1951). As reported by Beauchamp (1965), actors occupying central position could be highly productive in communicating information to others. Starting from the work of Hakimi (1965) and Sabidussi (1966) researches began relating closeness with **minimum distance**.

Actor level centrality measures for closeness are obtained by taking the sum of row i of the distance matrix to obtain the total distance n_i is from all others nodes, and the dividing by $g - 1$ (i.e. the minimum possible total distance).

The reciprocal of this value give us an actor-level index for closeness. The formula is exactly the same for non-directional relations. In detail, is:

$$\square'_c(n_i) = \frac{(g - 1)}{\sum_{j=1}^g d(n_i, n_j)}$$

The founding and straightforward principle is that centrality has a negative correlation with distance, and the reader can understand how much it is connected with the previous mentioned concept of geodesic distance.

It represents the extent to which a person lies at short distances to many other people in the network.

3.5.8 Brokerage measures

Starting from the assumption that the mix of different information, ideas, know-how creates values (Dsi, 1988), it is enough straightforward why brokerage is an important phenomenon. Brokers mediate interactions between a pair of unconnected actors (Burt, 1992, 2007). Hence, they are facilitator of the flow of information and resources across pairs of actors.

There is a rich body of literature about the role of knowledge brokers in the technology transformation process (Lind and Persborn, 2009; Dobbins et. al, 2009; Meyer, 2010). In general, brokering is described as “moving knowledge around and creating connections” across the boundaries (Meyer, 2010).

Following Howells (2006), we apply the term “intermediaries”. Intermediaries improve connectedness and create innovative possibilities of dynamics within network. We decided to adopt the vision of Gould and Fernandez (1989) who described the brokerage as the role played by a social actor, who mediates contact between two actors.

In the figure below, we offer a representation of brokerage roles according to Gould and Fernandez:

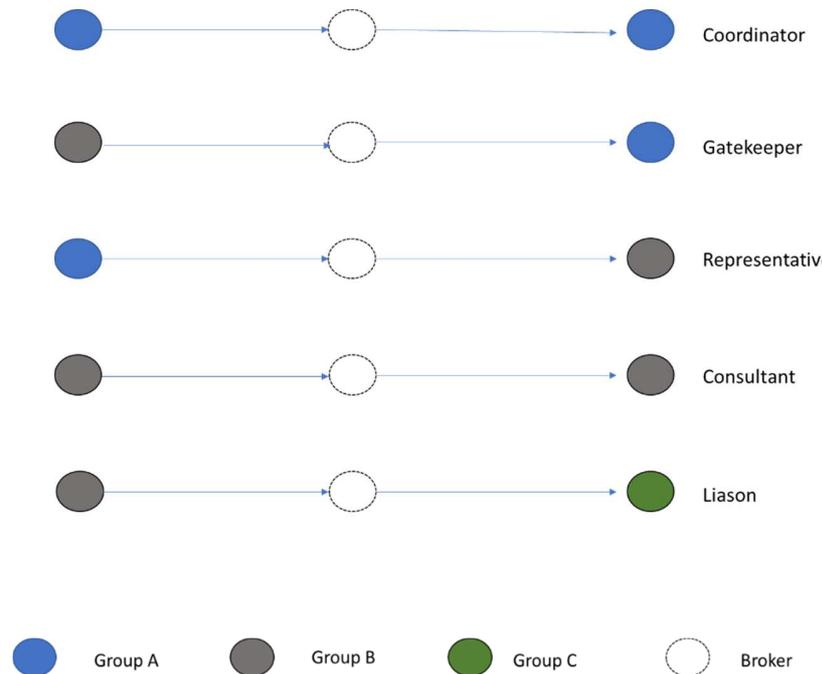


Figure 3.5.8-1 - Brokerage roles

The level of brokerage is an important information in a social network because it gives an indication on how easily information pass through a network. Basically, given a graph and a partition of nodes, the procedure proposed by Gould and Fernandez calculates measures of five types of brokerage. Each type is defined on from who and to whom the information flow is passed.

Brokerage can occur only when we consider a triad: Imagine that there are nodes A, B, C. Node B has a link with the other two, but A and C have no link between them. In this case, node B is playing a role of broker. The kinds of nodes from whom and to whom information arrive define the type of brokerage. For example, we have:

- **Coordinator:** counts the number of times b is a broker and $G(a)=G(b)=G(c)$, that is, all three nodes belong to the same group.
- **Consultant:** counts the number of times b is a broker and $G(a) = G(c)$, but $G(b) \neq G(a,c)$. That is the broker belong to one group and the other two belong to a different group. In this case the broker acts as a consultant for the other two counterparts. Hence, this helps

in the identification of the key players who provide information valuable belonging to different functions, or players to who people in the same function turn to in order to resolve a problem which cannot be addressed internally.

- **Gatekeeper:** counts the number of times b is a broker and $G(a) \neq G(b)$ and $G(b) = G(c)$, that is, the source node belongs to a different group.
- **Representative:** counts the number of times b is a broker and $G(a) = G(b)$ and $G(c) \neq G(b)$. That is the destination node belong to a different group.

3.6 HYPOTHESES TEST: QAP ANALYSIS

To test our hypotheses, we relied on two fundamental tools provided by Ucinet: the QAP correlation and the LR-QAP regression.

Their adoption is common in SNA and they have been implemented by those paper that have dealt with social network studies (e.g., Krackhardt et al., 1990; Kilduff, 1992; Burkhardt, 1994; Labianca, Brass and Gray, 1998; Shah, 2000; Labianca et al., 2001; Tsai, 2002; Borgatti & Cross, 2003; Moody and White, 2003; Ho & Levesque, 2005; Grandori and Soda, 2006).

As stated by Krackhardt (1987, 172), “one of the most serious problems of the statistical analysis of networks is that the unit of analysis is the dyad and dyads, as it has been reasonably argued, cannot be considered independent of one another”. Indeed, the observations cannot be defined as independent and the classical statistical regressions, such as OLS, do not fit our case. Observations in individual rows or in individual columns do not represent independent data, but instead show a certain degree of dependence in relation to the column or row to which they belong (i.e. structural autocorrelation).

Therefore, studies on SNA often require techniques different from those applied on dataset of independent observations. Thanks to the Quadratic Assignment Procedure (QAP), we can overcome this key problem of this analysis. QAP uses a randomization/permutation technique (Edgington 1969, Noreen 1989) to build the significance tests. Basically, the QAP scrambles the dependent variable data through several permutations and this allow overcoming the problem of the dependence of data. Krackhardt (1987) has proved through

Monte Carlo simulations that statistical bias and efficiency characteristics are very reasonable.

The MR-QAP consists in a non-parametric statistical algorithm and occurs in two steps (Kilduff et al. 1994): the first is based on a multiple regression that compares the cells of the dependent matrix with the respective one in the independent matrix; in the second phase the permutation of rows and columns occurs and the regression is computed again. Through this procedure, we can overcome the structural autocorrelation (Krachardt 1987) and the seriousness related to multicollinearity of data (Dekker, Krachardt and Snijders, 2003). QAP analysis allows performing a study on these matrices, which can refer both to relations or attributes, correctly transformed. The procedure to generate the matrices is the one suggested by Borgatti et al. (2013). It is necessary to convert non-dyadic data (the non-relational) into dyadic ones by building a matrix $N \times N$ (given the number of actors equal to N).

Given a specific cell of the matrix referred to the individual i (row) and individual j (column), we would have:

- either the difference between the values of the data associated to i and j (which is the case of job tenure, for instance)
- or 1 or 0 in case i and j belong to the same category (for example, if individuals belong to the same business unit, we would have a 1).

If the variable is already dyadic, the transformation is not needed.

All the examined data are cross-sectional, i.e. collected in a specific unit of time.

Since the dependent variable of our model is represented by a binary matrix, we have implemented the LR-QAP (Logistic Regression Quadratic Assignment Procedure) for the regression, which gives an estimation more consistent with respect to the MR-QAP²⁸ technique for the underlying case (Borgatti, Everett, Johnson, 2013).

²⁸ LR-QAP is more consistent compared to MR-QAP in case the dependent variable is a binary matrix.

3.7 DATA PRIVACY MANAGEMENT

Social network questions often deal with sensitive or threatening to be disclosed information. Thus, one of our biggest concern was the data privacy protection, which was also stressed by the analysed company's management. This is a crucial aspect that has to be crystal-clear to the respondents to gain their trust and hence to obtain a good response rate. For these reasons, we decided to: i) sign a non-disclosure agreement with the company; ii) make a presentation to the company's personnel to describe our research objectives, explain how we would have managed their data and answer to their questions; iii) replace names and surnames with alphanumeric codes.

Moreover, Novelis's directors wrote an email of invitation to the presentations in which they also stated us and our thesis supervisor would have used data just for research aims, that the firm would have viewd just the general output and that there would be neither particular reference to specific individuals nor to their answers.

CHAPTER 4

4 DATA COLLECTION

In this chapter, we provide the reader with several key elements that were crucial for the development of the case study and for the testing of the hypotheses formulated in the previous chapter. First, we describe the firm on which we have performed the analysis and provide insights on its formal structure and the prescribed mechanisms of communication. Second, we give some general evidence on the selected group of people. Third, we describe both the rationale behind the designed questionnaire and its administration to the actors. Fourth, we explain how we transformed the questionnaires' answers into raw material for the analysis. Finally, provide the main findings we obtain through SNA.

Nevertheless, before going through these topics, we mention one problem that we faced since the beginning, that is the difficulties in finding a firm available in disclosing all the necessary material and information to accomplish the analysis.

4.1 OBSTACLES IN THE DATA COLLECTION

The process of data collection has been tough, and it took quite a long time.

Indeed, the data required to perform SNA imply high level of trust and privacy concerns. Another critical issue related to time pressure to get results within a reasonable date.

At the beginning, we were supposed to collaborate with a defined company and the analysis would have been based on the flow of emails and internal communication tracked with the software MyAnalytics. However, we had to pivot, because of changes in the management structure and the increase in time to receive an answer. Another company seemed interested in our research, but we have never received a formal commitment.

Even though the study of emails applied in the SNA would be extremely interesting, it clearly appeared to us that it was easier for firms to agree in administering questionnaires and/or interviews, which are more traditional and less constrained by privacy problems (though, some measures to protect the participants' data must be addressed).

At the end, three different options seemed to be the most valuable:

- 1) Look for already available datasets on the internet or in the software that we wanted to use
- 2) Resort to Survey Monkey or similar tools, which might allow us to gather participants in our study
- 3) Ask to further companies with which we had personal contacts

Of course, all the option above displayed weaknesses and threats.

Available datasets are a fast solution, but we could not customize to make them more meaningful and they often did not have all the information for the analysis (for instance, lack of information on the formal organization, missing attributes...)

Survey monkey (or similar tools) is also a rapid way to gather data. However, even inserting constraints to attract meaningful respondents, we would have missed the chance to study a particular formal structure with its reporting and communication mechanisms and the emergent informal networks, since with this approach can provide only actors belonging to different organizations.

The third solution seemed the best for what concerns completeness and reliability of information, though the level of uncertainty and the time required were big threats.

Eventually, we managed to find a company, Novelis Italia Spa, which proved to be concretely committed and interested in the research and provided us all the data and instruments to perform it, within a reasonable time span.

4.2 THE COMPANY

In this section, we provide the reader with general information about the company. After a brief presentation, we illustrate the formal structure in terms of the reporting relationships prescribed by the organigram and the adopted mechanisms of communication.

Novelis is an industrial firms in the aluminium sector, subsidiary of the Hindalco Industries Limited which is part of the Adytia Birla Group, a multinational conglomerate based in Mumbai. The company is leading in the production of flat-rolled aluminium (it accounts for

nearly 12% of the global supply) and in the recycling of aluminium. Its customers belong to several industries, such as automotive, beverage can, consumer electronics, construction and packaging.

Born from the spinoff of Alcan in 2005, Novelis leverages on an integrated network of rolling and recycling advanced facilities in North America, South America, Europe and Asia.

It accounts for nearly 16,000 employees worldwide, 5,000 of whom come from the recent downstream acquisition of Aleris Corporation (a global supplier of rolled aluminium products) – in July 2018.

We had the opportunity to get in touch with the firms thanks to personal and trustworthy relations and it showed interest in our research.

4.3 MEETINGS WITH THE COMPANY AND PRELIMINARY INTERVIEW

We scheduled a first meeting with the head of the Human Resource department, Dr R. Cavanna, and the Operations Director, Dr M. Marcassa, in order to describe the objectives of the research, to gather general information about the formal structure of the company and to plan the following steps for the processes of data collection and analysis.

Because of the strong ties and relations between the two plants of the Milanese area, precisely in Bresso and in Pieve Emanuele, we agreed that the study would have encompassed both.

Overall, we had two meetings with the company's Operation Director and with the HR Manager and with them we schedule a presentation of the project to the employees (see the specific section below)

4.4 THE FORMAL STRUCTURE

As it emerges from the organigram, Novelis (which includes Bresso and Pieve Emanuele's plants) formal structure is functional. Each function's head (level N) directly reports to the respective vice-president located in the headquarter of Zurich. There is one main function – Operations - which is split into six sub-functions. The others are: Human resources, Finance, Sales, IT, Procurement and Supply chain.

We report the organigram of the seven functions below.

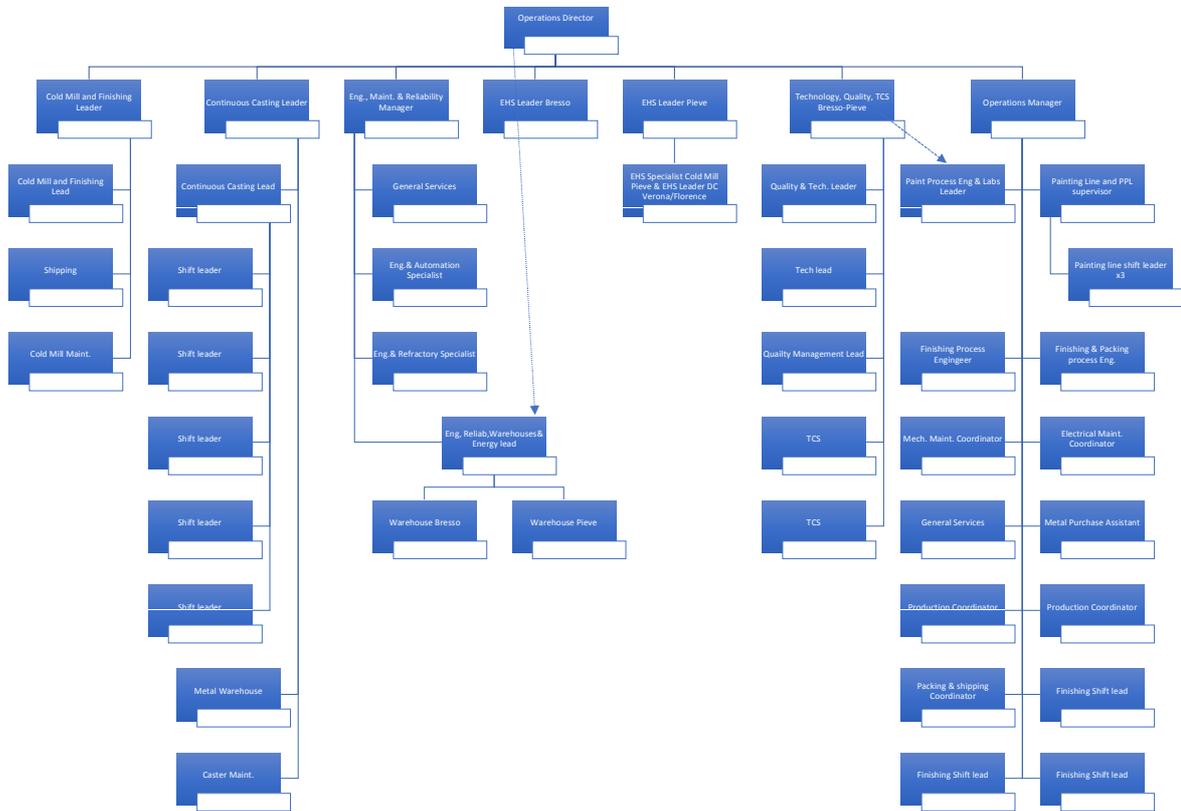


Figure 4.4-1 - Operations

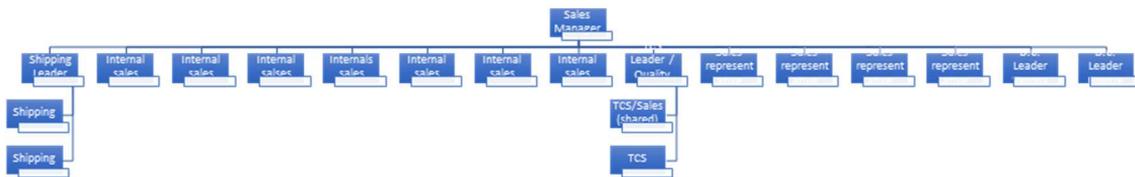


Figure 4.4-2 - Sales

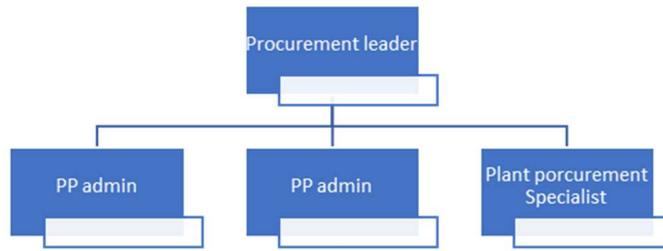


Figure 4.4-3 – Procurement

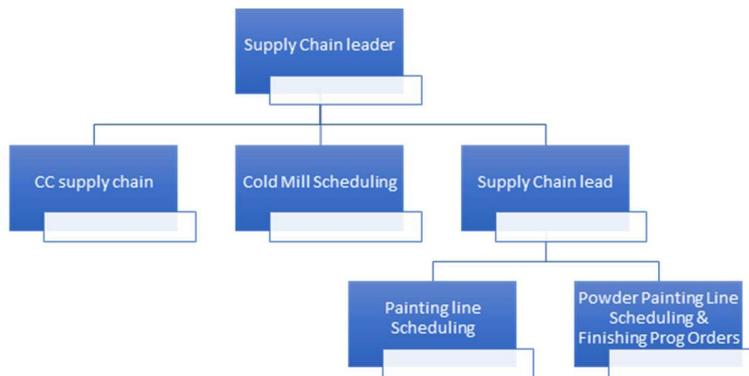


Figure 4.4-4 – Supply chain

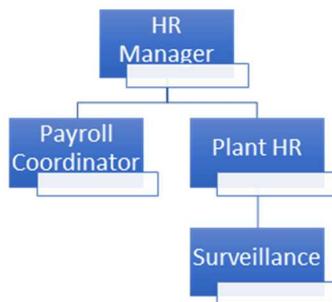


Figure 4.4-5 – Human resources

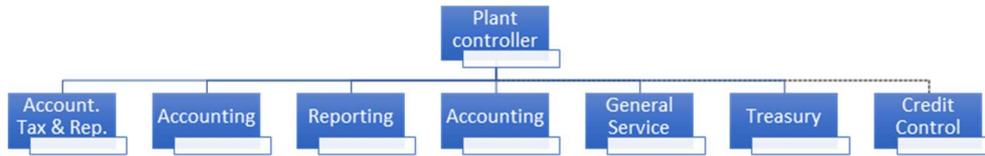


Figure 4.4-6 – Finance

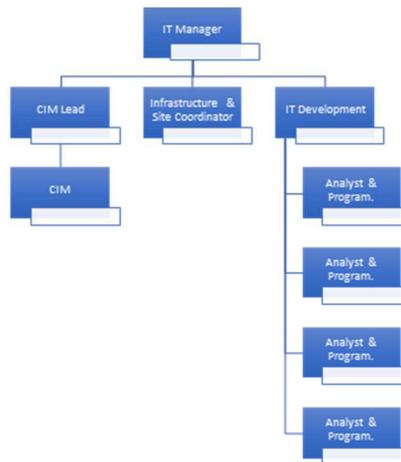


Figure 4.4-7 - IT

We will refer to the first level of the hierarchy (head of the functions) as N, to the second levels as N-1 and so on.

4.5 COMMUNICATION AND COORDINATION MECHANISMS

To make the firm work properly, it is fundamental that functions (and individuals) communicate and make and evaluate plans together. Indeed, they are strongly intertwined and problem solving involves the collaborative cooperation among them.

The firms have put in place several communications and coordination mechanisms. We report them in the following.

1) MEETINGS

They are mainly direct forms of communication, represented by meetings and committees. They are formalized and give the chance of exchanging information.

The following table summarizes the characteristics of the meetings, describing who participates, their frequency and the objectives.

Meeting	Participants	Frequency	Main objective
Steering Committee	All the functions' leader at level N (most senior managers)	Twice a month	Production and financial forecasts Past performance analysis
Operations meeting	Operations: N and N-1	Monthly	Report about previous month results Potential criticalities of the following month
Quality meeting	Operations: N N-1 (except from the two in charge of Safety) N-2 most significant from Production and Technology functions Sales: One representative	Monthly	Discuss about previous month and criticalities for future
Human Resource meeting	Operations: N HR: N and N-1	Monthly	Systematic identification and discussion of topics that involve the relation among HR and Operations. The aim is not to disregard some important issues such as recruiting, training, relation with trade unions, payrolls, and so on
Safety	Operations: N N-1 N-2 most significant from Production and Maintenance HR: N Representative of Human Safety and Health	Once every two months	Discuss about safety issues. (though safety topics are discussed in all the daily meetings)

Meeting	Participants	Frequency	Main objective
SIF (Serious Injuries and Fatalities)	Operations: N HR: N Two Human Safety mangers Guests depending on the need and the topic to discuss		Analyse probability of occurrence and impact (risk) of serious injuries and mortal accidents
Daily meeting (joint meeting between the two plants)	Operations: N N-1 Some N-2 Sales: One representative (N-1), also called product manager, rotation HR: rotation Procurement: One representative Supply chain: One representative IT: one representative	Every day at 9:30 am	Discuss about previous and same day issues. It follows a fixed agenda: - Safety - Metal flow between the two plants - Quality - Production
Call to safety (extraordinary meeting)	Everyone		This is an extraordinary meeting. For example, when a mortal accident occurred in a plant in the US, all the activities stopped and they had this meeting
Call to quality (extraordinary meeting)	Performed during the shift with the required people		Discuss about quality topics of the moment and possible development projects. For instance, the ones related to the development of automotive in the plants
Result update (still has to take off)	Voluntary base	Monthly	Inform about the result of the previous month in terms of safety, production and quality.
Meeting with trade unions	HR and trade unions' representative	Twice a week	Fundamental mean to convey information between official and informal

Table 4.5-1 - Novelis's meetings

2) INTRANET, NEWSLETTERS and BULLETIN BOARD

They play a significant role for the communication also at corporate level and for the sharing of information. For instance the company relies on AS/400 to communicate and share data across BU.

As regard newsletters employees receive newsletter from the corporate in order to keep them updated about organizational changes and important facts regarding Novelis.

On the other hand, bulletin board allows communicating to all the employees, also to the ones who are not provided electronic devices, general information related to for instance vacations, shifts, change in mansions and similar.

3) COMMUNICATION WITH THE HEADQUARTER

The communication system is quite complex. It must be taken into account that not only internal communication occurs, but also the communication with the headquarter plays a significant role for the right execution of the activities and for decision-making processes. Indeed, Novelis, as we already mentioned has a structure according to which each N level in Italy directly reports to her director in the European Headquarter located in Zurich.

4) MEETING TO BE SETTLED IN FUTURE

Novelis management is currently trying to formalize a procedure to share expectations on quality and time between the different functions whose relation can be represented as supplier-customer. This system will be much more structured and a trial has been launched between two units.

Other meetings that will be settled are the following: Operation and controller meeting and a Reliability meeting

5) DISCLOSURE OF NOVELIS CULTURAL CONTENTS THROUGH INFORMAL TOOLS

Novelis has been working on this project for the past three years because the company is striving for a cultural change. They have developed informal communication instruments which, despite their informality, have the formal purpose of sharing the cultural values of the company and make people motivated and aligned with them.

The selected tools are: recognition cards, storytelling, and focus conversation.

Recognition cards allows organizational members to give and receive feedbacks among the and represent a way to show appreciation for the work done by a specific person. They base on performance and cultural indicators (e.g.,: “winning together”). For instance, lately the company has managed to reach the target EBITDA and the president of the European area has sent a card to each of the employee as a recognition of the efforts put to achieve the common objective. This is informal an informal tool whose purpose is to reinforce organization increasing people’s accountability and spreading cultural values.

Story telling refers to the practice of letting the meeting begin with a member telling a story that has occurred inside the organization or that more generally involves the positive behaviour of somebody towards the organization. Basically, it represents a way to convey constructive messages and to spread best practices in line with the cultural values of the company.

With the last one, **focus conversation**, Novelis aims to build a more positive working environment. Indeed, according to this “program”, the employees and, in particular, the opinion leaders should drive their conversations towards valuable and stimulating topics for the company, for instance when they meet at the coffee machine or during lunch. This would allow creating positive connections among people and remove barriers.

The results of the use of these tools are hardly measurable, at least in the short term. Tough, the achievement of long-term business targets can be associated with the implementation of these practices.

There are not particular **horizontal ties** that regulate the communication among people belonging to the same level. For what concerns **vertical ties**, the employees tend not to disregard them to avoid the occurrence of inefficiencies and of short-circuits that can hamper the proper functioning of the organization. For instance, if the N-2 of the operations has to communicate to its N, she should pass from its N-1 and vice versa.

4.6 DESCRIPTION OF THE SAMPLE

It is important in this step to identify a sample of people that has a significant impact on the organization's operations or strategy and on the effective knowledge sharing and on collaboration (Cross, Borgatti, Parker 2002).

Owing to the characteristics of the company, the mutual independence of members across different functions, and the limited number of employees working in the two plants, we aimed at analysing the network as a whole, in order to extract the effective collaboration in place. Moreover, we wanted to find out whether and how groups are built, despite functional, hierarchical or physical boundaries that may lead to a fragmented landscape.

Overall, there are 308 employees in the company. The selected sample, which includes also white collars, is supposed to account for those individuals, who contribute to the integration across departments and whose expertise and information are vital for the organization's processes. The decision on the sample was agreed with the management of the company.

We decided to exclude from our analysis the blue collars for the following reasons: i) They do not have access to computer or mobile devices for communication; ii) They give to and gather from their supervisors (*Capiturno*) the required information to accomplish their tasks, hence they are not directly key for information exchange at higher level iii) they perform repetitive tasks and have no managerial decision.

We submitted the questionnaire to the selected 101 employees because they represent those more suited for SNA study²⁹. In the end, 79 employees responded to the survey, bringing the rate of responses at a 78%. This level of respond rate is significant for SNA studies (Borgatti et al. 2008) and represents also a good rate given the fact people in organization are most of the times little prone to invest their energies and time in such activities.

The final sample includes 107 individuals, since we added the most cited 6 actors who were not initially part of the sample.

²⁹ The suitability is given by a combination of factors such as hierarchical level, level of freedom in the decision-making process, role and others shortly explained in detail.

The following analysis is aimed at providing the reader with a general overview of the population and of the respondents.

The figure below refers to the distribution of respondents and of the population in the different plants of the company. As can be seen for population, 58% of them reported to work in the Bresso plant, 34% reported to work in the Pieve plant and 8% reported to indistinctly work in both.

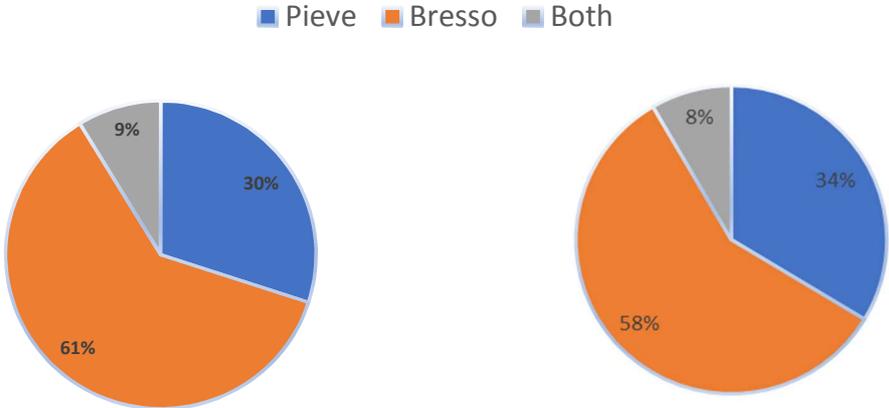


Figure 4.6-1 – Respondents’ distribution across plants

Figure 4.6-2 – Population’s distribution across plants

For what concern BU, most of the individuals belongs to the Operations unit, which is in line with the nature of the company that has in the productive area the core of its activities. 56% of employees of the population are reported to work in this function. The second largest function is Sales in which 15% of people work, then Finance (8%), IT and Supply Chain (7% and 6%) and finally HR and Procurement with 4%.

■ Operations
 ■ Finance
 ■ IT
 ■ Supply Chain
 ■ Procurement
 ■ Sales
 ■ HR

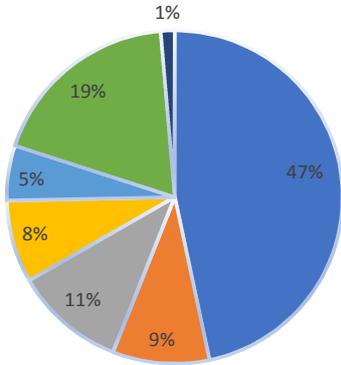


Figure 4.6-3 – Respondents' distribution across BUs

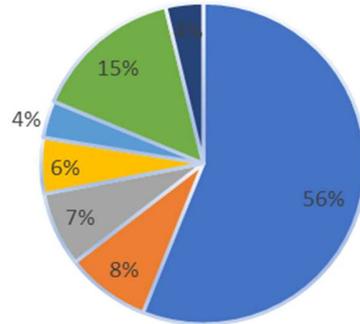


Figure 4.6-4- Population's distribution across BUs

Since operations function is at the core of the activities performed by Novelis, it is due to present an overview of this important part of the company. Crossing the data of business units belonging with the ones of plant membership it is possible to draw the picture below. As can be seen, operations' members are split almost evenly between the Bresso and Pieve plants.

■ Pieve
 ■ Bresso
 ■ Both

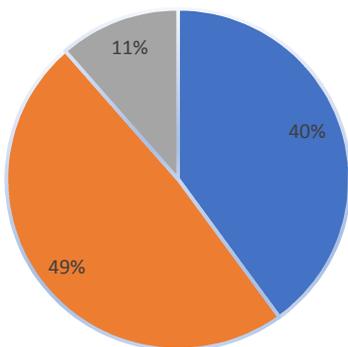


Figure 4.6-5 – Operations' respondents across plants

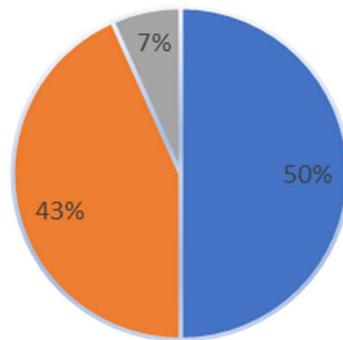


Figure 4.6-6- Operations' population across plants

4.6.1 GENDER IN THE ORGANIZATION

Since one of the reason this study was born was to study the role of women in the organization and given the fact that gender issues are gaining much attention among the scholars, we report below data on gender distribution.

Specifically, the selected population accounts for 22 women. Overall, women accounts for the 21% of the total sample. 81.8% of them responded to the survey.

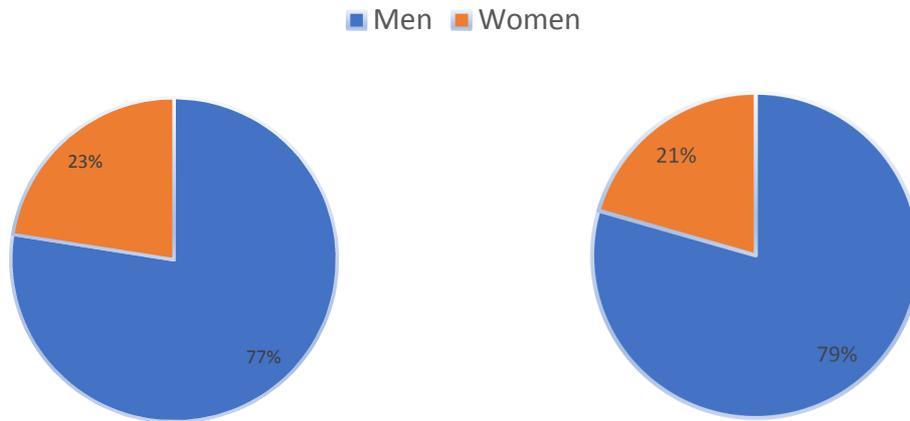


Figure 4.6-7 – Respondents’ gender distribution Figure 4.6-8- Population’s gender distribution

We also analyse how women and men distribute across BUs. For what concern male, the majority of them is allocated to Operations, while women are mainly present in the Sales function and secondly to Operations. See figures below:

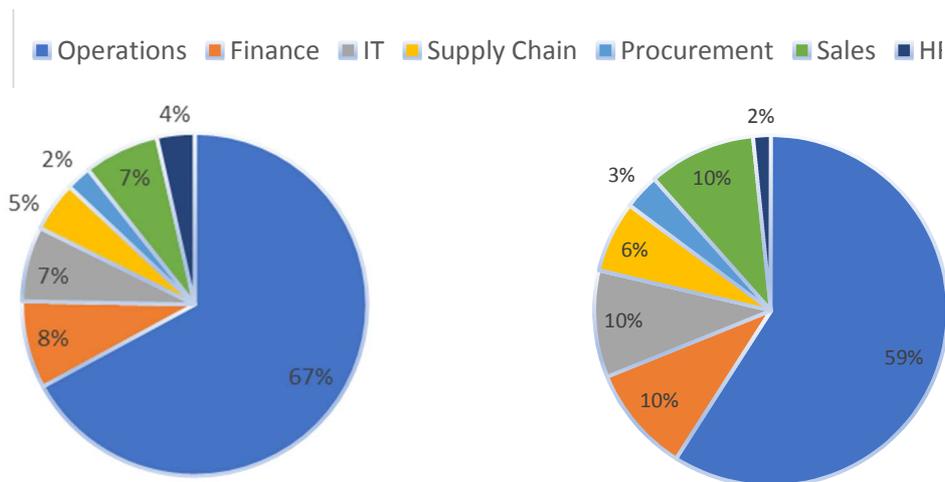


Figure 4.6-9 – Men respondents across BUs

Figure 4.6-10- Men population across BUs

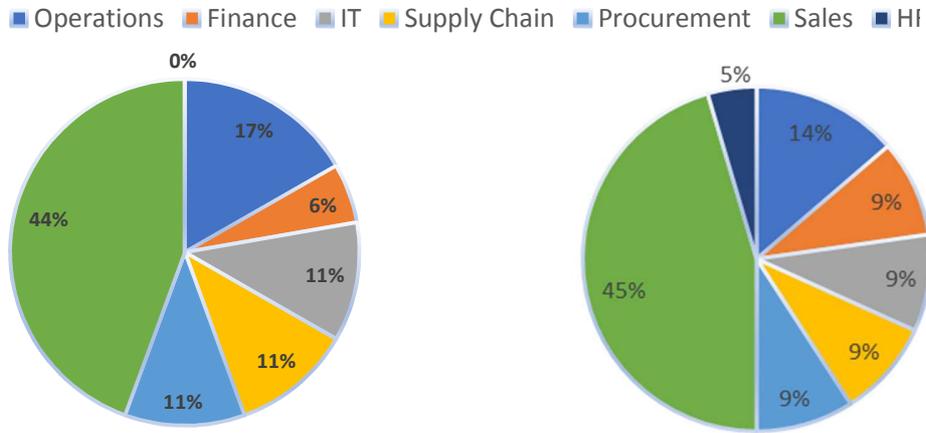


Figure 4.6-11 - Women respondents across BUs Figure 4.6-12- Women population across BUs

If we look at the distribution of women across the different levels and across units, we can see that the majority occupies the position N-1 and that most of them belong to the Sales function.

Three women hold the N position for the functions of IT, Finance and Supply Chain. The graph below depicts the situation:

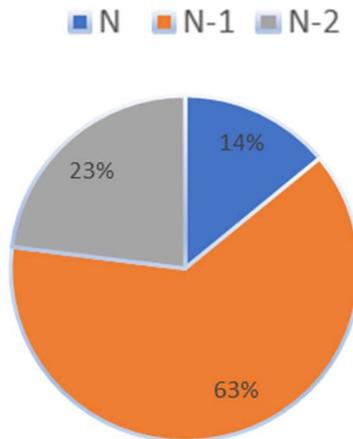


Figure 4.6-13 - Women's population across hierarchical levels

4.7 THE QUESTIONNAIRE

In this section, we illustrate how we designed the questionnaire we administered to the employees of the firm, the way it was delivered and how we generated the dataset to perform the subsequent analyses. It would have been of great interest to collect also other types of data through our questionnaire. Anyway, the fact our analysis is run in an organizational context led us to compromise for increasing the response rate. It is obvious that in organization people first may not be willing to respond to a questionnaire (especially if proposed by external entities) and second they generally do not have so much time to dedicate to non-working related topics. For these reasons, we believed that a too detailed survey would have significantly decreased the response rate.

4.7.1 Questionnaire design

In order to collect information to perform the analysis and to suggest some best practices to adopt, we developed a questionnaire, which was designed to include two different categories of questions:

- I. The first regards generic information that we could not derive from the formal chart or from previously given information. Following main studies on SNA, we asked:
 - a. Colocation: in which of the two plants they spend most of their time. Indeed, some of them are generally located in just one of the two (Bresso or Pieve), but others share their time in both.
 - b. Job satisfaction

The answers to these questions, together with other data such as hierarchical layer, department and gender are included in the following analysis as the elements that affect the creation of ties. In particular, the information on the gender would be useful to study the real impact of this characteristic on behaviour and the position in the informal organization.

- II. The second category deals with the extraction of the informal organization. Questions are described below. For each of them, employees had to identify the group of colleagues (with Names and Surnames) that fit to the characteristics of the demand according to their

personal judgement/experience. As is typical in network research, each independent variable was measured by using a single network question (e.g., Ibarra 1992, 1995).

1. *“think now of the people you talk the most about issues related to your work (directly, via telephone or via email):to whom do daily require information necessary to accomplish your activities?”*

The question deals with the communication relationship among people and should identify the so-called “friends” (Cross and Parker, 2004). It represents the informal structure of an organization as represented on ongoing patterns of interaction. It can be especially useful to detect sub-groups or cliques which can be the effect of political problems or complementary can let emerge people who play a particular role such as central parties, isolates and bottlenecks (Cross, Borgatti, Parker 2002).

2. *“think of the people you talk the most about issues related to your work (directly, via telephone or via email): who do daily require information necessary to accomplish your activities?”*

This question spots whether the network is rigid, in other words if constraints in the information network exist but also patterns of collaboration in the organization (Cross and Parker, 2004) and Brass, 1984). For instance, the dependence over specific people that creates bottlenecks in the information flow. Through this question we reflect exchange of information important to do one’s work. (Cross, Borgatti, Parker 2002)

3. *“identify the people inside the company that give you the most useful and valuable information (directly, via telephone or via email)”*

This question should provide us with the set of people who possess the most useful information. We decided to ask this question because in our opinion it is a step ahead the previous one. We believe there will be a correlation between the two questions and a comparison between them and the others could give us very meaningful insight. In terms of centrality this measure gives a clue on who are the potentially most helpful people.

4. *“identify the people you seek the most the most for advice when you have to face a problem or to carry out a task. For example, who do you ask for help at least once a week or who does help you to better understand the problem?”*

This question is meant to reveal who support the others for problem solving (Cross and Parker, 2004). It detects the advice network (Krackhardt and Hanson, 1993), which stands for the people with the expertise and technical skills and the awareness of others' skills and knowledge. Moreover, measuring “seek advice from” provides significant benefits in organizational context and are particularly informative. (Rizova, 2006) The relationships spot with this question imply a higher level of trust and selectivity respect previous questions and it is particularly informative because a strong problem solving networks often ensure that people are solving the right issue, hence, improving both individual and network performance (Cross, Borgatti, Parker 2002).

Questions 2, 3 and 4 together are key to assess who collaborates and interacts. For what concerns the analysed firms and its processes, we would expect to discover high level of interconnectedness between different layers and different departments, despite what predicted looking at the formal organigram and the planned mechanisms of communication.

5. *“when you need information or help, who are the people you find accessible inside the organization? For example, who are those who are available in sharing with you a sufficient amount of time to help?”*

By asking this question we want to understand who is perceived as most accessible inside the company and shows engagement towards colleagues' problems (Cross and Parker, 2004). In fact, just knowing someone knowledge and skills does not guarantee they will share with other colleagues insightful information. A dense access network is often critical to ensure effective information sharing. (Cross, Borgatti, Parker 2002)

4.7.2 Questionnaire administration

We sent the questionnaire to the identified group of interest as a link to Survey monkey via mail. We chose to do so instead of administering it on paper format, because it allows people to fill it on their own device without worries of disclosing sensitive information in front of their colleagues.

We performed two follow-ups to those who had not answered yet.

4.7.3 From questionnaire to dataset

In order to build the sociomatrices and the graph using Ucinet and Netdraw, we created one matrix for each question on EXCEL where we put 1 when the relation was in place, 0 otherwise. These matrices were subsequently converted in Ucinet to obtain a dataset easily accessible by the software.

Therefore, we obtained different datasets corresponding to the networks we wanted to study:

- friendship network
- information network
- utility network
- advice network
- accessibility network
- formal network

In particular, for what concerns the formal network, we based its creation on the links displayed by the organigrams and on the participation at the various meetings.

We also created an excel spreadsheet in which we put all the collected actors' attributes: tenure, gender, business unit, hierarchical level, job satisfaction.

4.8 PROJECT PRESENTATION

Before administering the survey, we agreed with the Human Resource Manager and with the Operations General Manager to settle a presentation in order to clarify the goals of our thesis and to present the project to the Novelis's personnel. This decision was key to involve them all and to stress the data privacy protection, since it was immediately clear that it would have

been a great threat, as it always happens in Social network Analysis. Indeed, questions regarding relationships inside the organization make often respondents not comfortable in answering, thus giving misleading results or no results at all (given that they are not obliged to answer, just kindly invited).

We planned two meetings to present the project at Bresso's plant and one in Pieve Emanuele. Just after, we sent the invitation to the questionnaire.

CHAPTER 5

5 RESULTS OF THE CASE STUDY: SOCIAL NETWORKS AT NOVELIS

This chapter presents the results of SNA based on structured data both given by the company itself and collected through questionnaire administration via Survey Monkey.

The structure given to the description of the results is aimed at emphasizing the key findings that have permitted us to perform a critical examination and provide some hints for what concern managerial implications. We can distinguish three broad categories of results: the first relates with general consideration of key aspects of informal networks, namely the cohesion of the company and the accessibility issue; the second deals with the distinction among actors who belong to different company's informal subunits (i.e. the core and periphery – which are extensively explained in this chapter) of the information network; the last is aimed at identifying those actors that play significant roles in the organization.

Hence, we firstly address the connectivity inside Novelis through the examination of the information and the communication networks; we then move to the consideration of the accessibility between the two core units (Operations and Sales). As regards the second part of this section, related to the roles, we describe the approaches and the results that lead us identify the leaders, the brokers, the bottlenecks and, finally, a new character, the Lochagos.

To pursue our objectives, we relied on the both the analysis of key SNA measures and graphical considerations.

5.1 CONNECTIVITY IN NOVELIS

In order to study the level of connectivity of the organization, we resort several measures of cohesion in two fundamental networks: the information network and communication network (which can be intended as a general communication network that displays who people talk to for both private³⁰ and working related topics). In this specific case we used the information

³⁰ The formulation of the questionnaire allowed us to detect informal communication ties which can be intended as vehicle of private information. Based on Krackhardt (1994) this can also be seen as friendship network.

network and the communication one because i) are the most used in literature for these kind of analysis and ii) it would not make sense to use utility network or accessibility to calculate measures of connectivity.

5.1.1 The information network

The information network shows how people inside the organization look for information to accomplish their daily activities. For the proper functioning of the organization, this network should not show disconnections because it is vital for the right running of the company.

In the figure 5.1.1-1 it is represented the entire information network. Node's label represents the gender of the individual (light blue for man and pink for women), node's colour represents the BU to which she belongs – a legend is reported below the graph – and node's shape represents the plant in which the actor is located (Bresso -square, Pieve -circle, or both – triangle).

Firstly, we analysed the network as a whole; after, we critically examined the main results. The format used is coherent with the one chosen for the rests of the network representations.

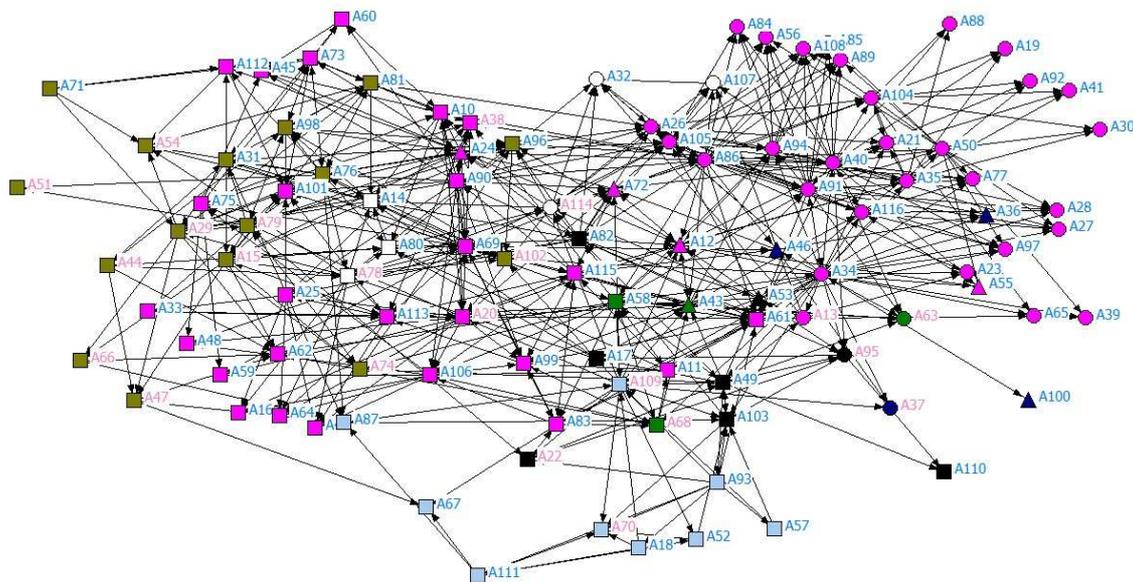


Figure 5.1.1-1 - Information network's graph

- OPERATION
- FINANCE
- IT
- SUPPLY CHAIN
- PROCUREMENT
- SALES
- HR

As can be understood, the network is quite complex and dense. It is not easily understandable just looking at whole picture. For that reason, firstly, we have used some tools and metrics to highlight important elements and then we focused on subsectors (subgraphs³¹) of the whole network.

This network displays a density of 0.055 with a standard deviation of 0.228. The average degree is equal to 5.822. It is a much easier measure to be interpreted since it is literally the average number of ties that each node has.

We now look at the density between BU³² and plant.

DENSITY	BU 1	BU 2	BU 3	BU 4	BU 5	BU 6	BU 7
BU 1	0.082	0.002	0.019	0.05	0.063	0.016	0.033
BU 2	0.009	0.278	0.125	0.019	0.056	0.007	0.028
BU 3	0.027	0.056	0.375	0.188	0.094	0.023	0
BU 4	0.039	0	0	0.433	0	0.135	0
BU 5	0.108	0.028	0.031	0	0.75	0.016	0
BU 6	0.024	0.035	0.008	0.125	0	0.213	0
BU 7	0.004	0	0	0	0	0	0.167

Table 5.1.1-1- Information network's densities according to BUs

³¹ See methodological approach chapter for a clarification.

³² BU will be used for the rest of the network to identify the world Business Unit.

The density of ties is maximum within each BU and it emerges that the density of connections of the unit HR with the other BU is null. Anyway, it should be taken into account the low rate of answer from this BU.

If we focus on the others BU, we can see that Outdegree density of Supply chain is 0 with Finance, IT and Procurement, meaning that no information is asked. Moreover, reinforcing the lack of information transfer between BUs 4 and 5 also outdegree density of BU 5 towards BU 4 is 0.

The outdegree density between BU 6 and 5 is also 0, meaning that BU 6 (sales) does not ask for information on a daily basis to BU 5 (procurement).

DENSITY	PLANT 1	PLANT 2
PLANT 1	0,121	0,014
PLANT 2	0,011	0,082

Table 5.1.1-2 - Information network's densities according to production plants

If we look at density on a partition based on **plant**, we can see that there is higher cohesion within the same plant. This means that to run daily activities, actors generally ask for information to people that work in their same plant. It can be noticed that the cohesion in the first plant is higher than in the second.

As another measure of cohesion, we compute the geodesic distance. For this network, the average value is 3 with a standard deviation of 1.1.

The connectedness³³ is equal to 0.664, meaning that almost 67% of pairs of node can reach the rest of the network. In fact, connectedness is defined as the proportion of pairs of nodes which can reach other by a path of any length. (Krackhardt, 1994). Compactness in our network is equal to 0.264. The lower value is as consequences that compactness weight the paths connecting nodes inversely by their length.

5.1.2 The communication network

Below, we report a representation of the **communication network**. The format is the same as the information network:

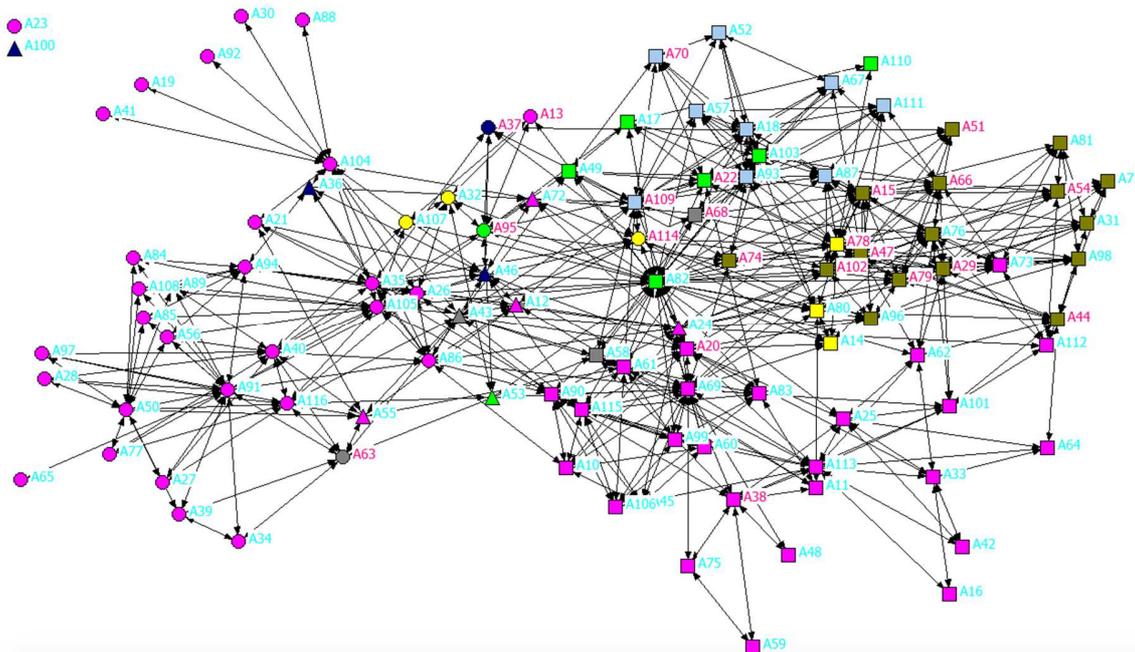


Figure 5.1.2-1- Communication network's subgraph

In order to analyse this network, we performed a symmetrisation of the matrix, based on the maximization (union). This is a typical routine in SNA and allows the researcher to obtain a symmetric matrix starting from a non-symmetric one. Basically, a tie is recorded if at least one of the two actors reports to have a friendship relation with the other. This operation allows having a unidirectional network, an essential feature, which allowed as to perform sophisticated analysis.

The **average density** recorded in this network is equal to **0.087** with a standard deviation of 0.2817. The average degree – i.e. the number of ties arriving to and coming from each node – is 9.215. A density of 0.087 means that only 8.7% of all the possible linkages are effectively

in place. The high level of standard deviation is explained by the dichotomy of the adjacency matrix related to this network.

It is interesting to look at **density within each group of interest and between different groups**. For this reason, we created homogeneous groups, partitioning them according to BU, plant, gender, and tenure, and then, we calculated the density inside each group and among different groups.

Density	BU1	BU2	BU3	BU4	BU5	BU6	BU7
BU1	0,101						
BU2	0,011	0,694					
BU3	0,044	0,278	0,643				
BU4	0,044	0,13	0,208	0,467			
BU5	0,075	0,139	0,125	0	0,833		
BU6	0,03	0,104	0,102	0,135	0,047	0,475	
BU7	0,067	0,056	0,063	0,042	0	0	0,333

Table 5.1.2-1- Communication network's densities according to BUs

Particularly, table 5.1.2-1 shows the partition according to **BU**. It emerges that the cohesion is higher within the same unit, and this is valid for all the seven BU of the firm. BUs that show a high level of cohesion are Finance, IT and Procurement, while Operation is the least cohesive, owing also to the higher number of actors (and hence the higher number of possible ties). It is worth to notice that the density between BU Supply Chain and Procurement; Sales and Procurement and Sales and HR is equal to 0, meaning that no tie is in place between them.

Density	PLANT 1	PLANT 2
PLANT 1	0.148	
PLANT 2	0.012	0.159

Table 5.1.2-2 - Communication network's densities according to production plants

If we look at density based on the **plant** (Table 5.1.2-2³⁴), it appears that cohesion within the same plant is higher than between different plants. The level of cohesion within each plant is comparable. This result is in line with researches about geographical colocation, that is that proximity has a positive effect on the creation of ties.

If we look at the other measure of cohesiveness of the network, we can say that communication network is quite cohesive since 77.9% of the actors have a **geodesic distance** between each other equal or lower than 3, and that the average distance is equal to 2.667. It means that all actors are reachable on average in less than 3 steps.

If we compute the average geodesic distance for each individual, we can see that it ranges from 1.74 and 3.59. Both the distance-weighted fragmentation index and the distance-based cohesion provide a clue on the compactness of the network, which appears to be averagely good, but not too strong.

As can be seen from figure 5.1.2-1 there are two actors who are disconnected from the rest of the network. Hence, forming a network with 3 components.

5.2 THE ACCESSIBILITY ISSUE

The purpose of this section is to study the Accessibility with respect to the two most important functions of the organization (namely, the Sales function and the Operations one) looking at the accessibility network's subgraph³⁵ that encompasses this two units only.

We chose to analyse this network since from preliminary interview Sales members reported difficulties to reach Operations members during daily activities.

Graphically, the network of accessibility between these two functions appears as in Figure 5.2-1.

³⁴ In this case the data are symmetrical since we are dealing with communication network. Hence, the Plant 1 to Plant 2 value of density is equal to Plant 2 to Plant 1.

³⁵ Subgraphs were obtained using the specific procedure proposed by Netdraw. This technique consists in the extraction of nodes which possess a given attribute (in this case the belonging to Operation BU or Sales BU) and the reporting of all the ties which are present within the nodes generated.

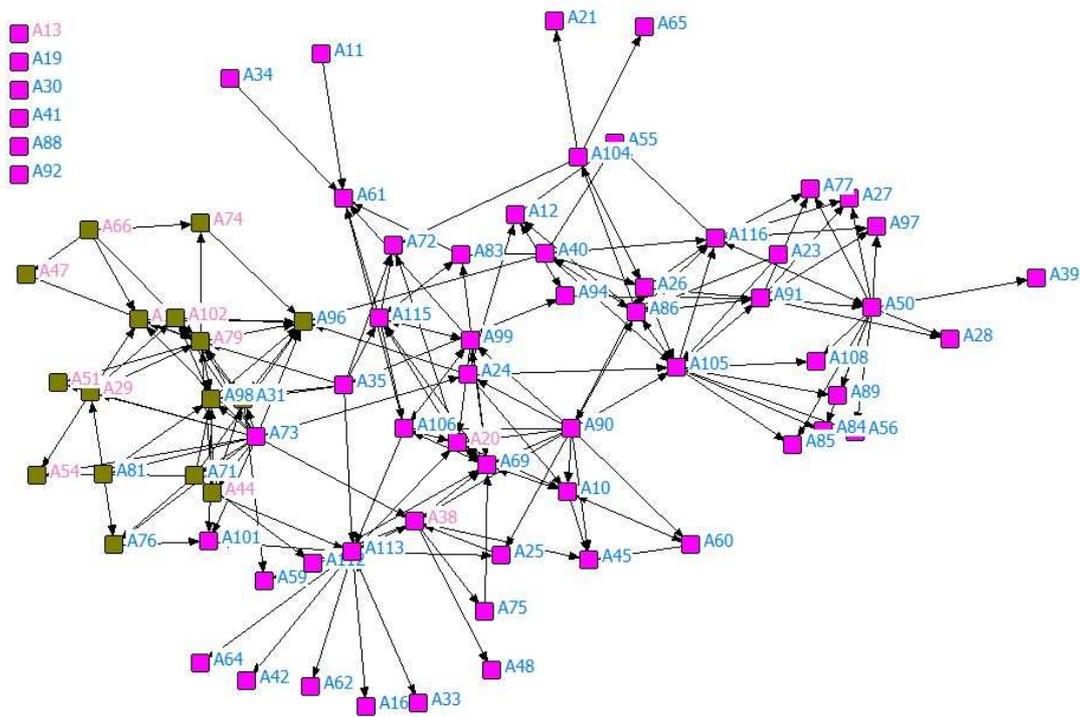


Figure 5.2-1- Subgraph of Operations and Sales' Accessibility networks

The graph confirms what was understood from preliminary interviews³⁶: while the Operations network is quite accessible for members belonging to this unit (145 ties), there are only 5 ties going from Sales department to Operations department in the accessibility subgraph.

³⁶ Sales BU members reported to have difficulties to reach Operation BU members.

5.3 CORE-PERIPHERY IN THE INFORMATION EXCHANGE

Core – Periphery procedures aims at differentiating actors of a given dataset into two categories: the core and the periphery. The notion is quite prevalent in such diverse fields of inquiry as world political systems (Snyder and Kick, 1979), economics (Krugman, 1996) and organizational studies (Fualkner, 1987).

In our work, we used a procedure that uses a hill climbing³⁷ algorithm to fit a core/periphery model to the data. In essence, it identifies what individuals belong in the core and what belong in the periphery.

The algorithm uses the in-degree centrality for binary data as a starting point and then the hill climbing techniques is used to improve the initial partitions and the best fit is reported. The fit function is the Pearson correlation between the permuted data matrix and an ideal structure matrix consisting of ones in the core block interactions and zeros in the peripheral block interactions. (Borgatti and Everett, 1999).

Intuitively, the results of this procedure will be the creation of two blocks: the core – dense and cohesive – and the periphery – sparse and unconnected.

³⁷ Hill climbing is a mathematical optimization technique, which belongs to the family of local search. It is an iterative algorithm that starts with an arbitrary solution to a problem, then attempts to find a better solution by making an incremental change to the solution. If the change produces a better solution, another incremental change is made to the new solution, and so on until no further improvements can be found.

The figure 5.3-1 below shows the classification in core and periphery groups of the whole information network. Label colour indicates the gender (blue for men and pink for women), the nodes' colour indicates the membership to core or periphery group (red for core and light blue for periphery) and node's shape represents the BU of the node.

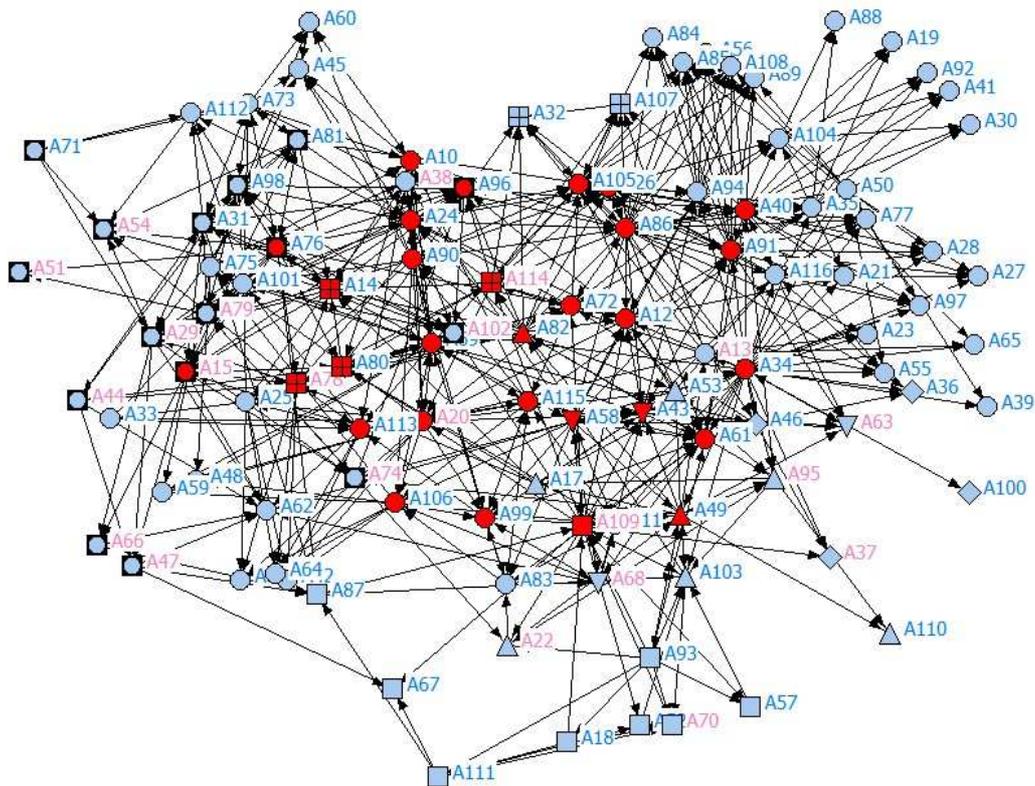


Figure 5.3-1- The Core (red) and the Periphery (light blue) in the Information network

At a first glance, the difference may not appear clear, but if we compare the dense subgroup (the core) with the non-dense subgroup (the periphery) we can immediately spot the difference (Figure 5.3-1).

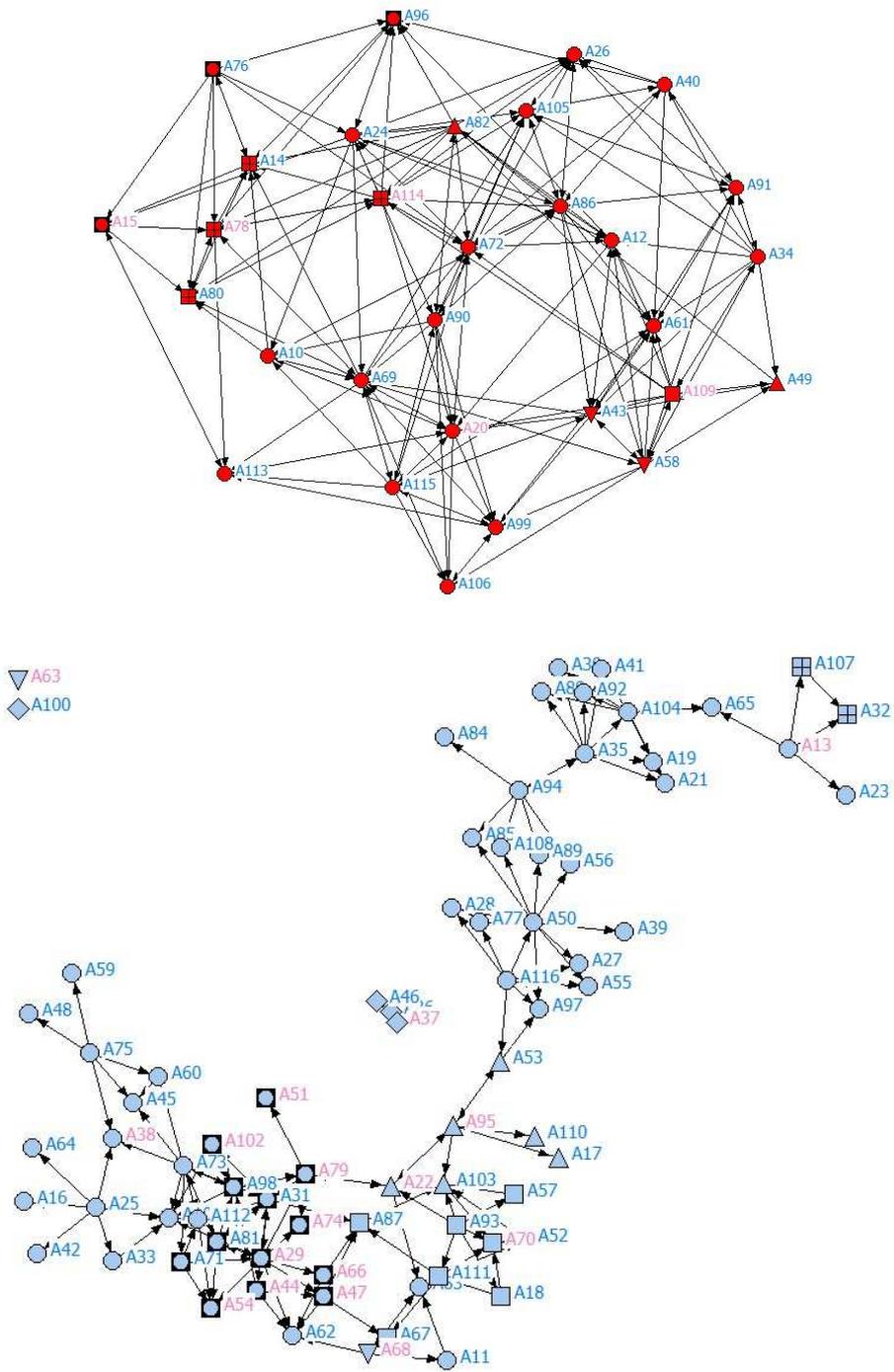


Figure 5.3-2 The Core (above) and the Periphery (below) in the Information network

As can be seen, the core network results in a much denser network compared to periphery where individuals are just partially connected. In fact, performing a density analysis and distinguishing between core and periphery, we obtain data reported in table 5.3-1.

Table 5.3-1 demonstrates how core subgraph is much denser than periphery one: meaning that core actors rely on each other heavily to obtain information.

	CORE	PERIPHERY
DENSITY	0.221	0.025

Table 5.3-1- Densities in the Core and in the Periphery

5.4 THE BROKERS IN THE INFORMATION NETWORK

As already mentioned in the Methodology Chapter, four possible brokerage roles can be identified in a network: coordinator, representative, gatekeeper and liaison. In order to find the actors that play these roles, we performed an analysis on the information network, since it would have provided us with the most significant results: since brokerage measures deal with the brokerage of information flows. These roles can be spotted on Ucinet, relying on the procedures “G&F brokerage roles”

We identified four actors who play the role of **coordinator**. For every actor and for every role, we report the ego networks below. (Figure 5.4-1)

All coordinators belong to the Operation function. This seems positive, since it is the most crowded one and represents the core of the organization. Indeed, if some actors act as coordinators, this should decrease the level of complexity.

Among identified coordinators, we can see how A104 and A35 play a central role. A104 connects an otherwise disconnected dense cluster, while A35 functions as a bridge with the rest of the unit. The situation can be visualized even graphically (Figure 5.4-1, top right).

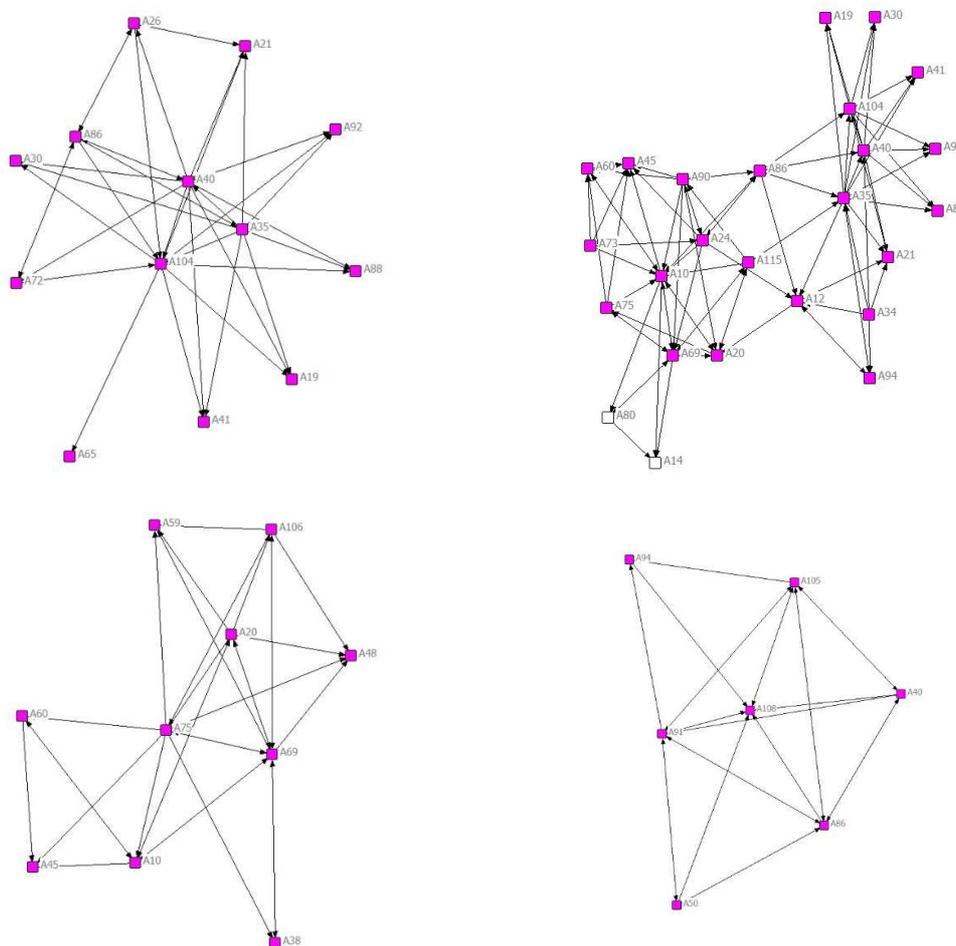


Figure 5.4-1- Coordinators' ego networks

Then, we identified three actors who play the role of **consultant** (Figure 5.4-2). A58 and A68 belong to the function Procurement, and as can be understood from the colours of the figures below they act as consultant for the Operation function.

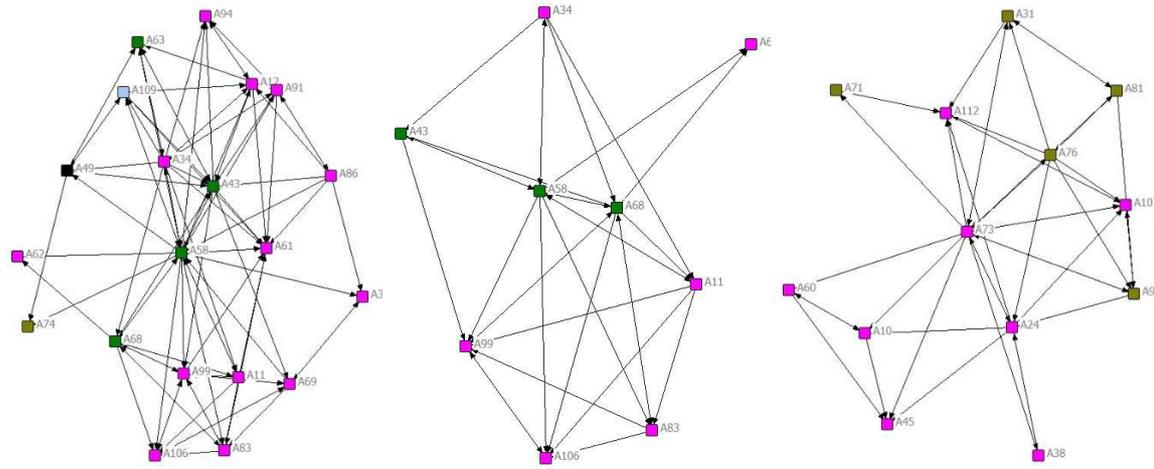


Figure 5.4-2- Consultants' ego networks

The opposite happens for A73 (Operation), who acts a consultant for the Sales function. The result fits the reality, because the individual (who is n-2 in Operation) and the actor to whom he reports are shared between Operations and Sales. Through this analysis, we identified the three key players on which the information flow between the Operation, Procurement and Sales functions relies.

Actors identified as **gatekeepers** (Figure 5.4-3) permit the information transfer from the external environment (which in this case is referred as another BU with respect to the one of the actor) to their BU. For example, A46 (HR) probably informs about the need of additional shifts to accomplish the activities (information, which emerges from Operation) and transmits this information to the rest of his BU. A80 (Supply chain) is a fundamental bridge between his function and Operations, Sales and IT, while actor A93 (Finance) is crucial for the Finance function to receive support from the IT function.

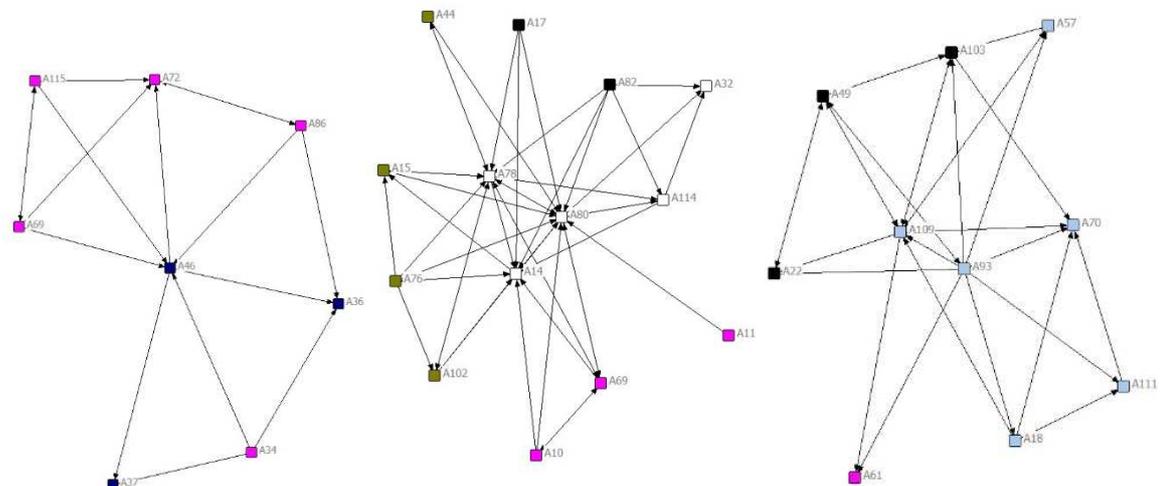


Figure 5.4-3- Gatekeepers' ego networks

These **representative** actors are important because allow the transferral of the output (in terms of information) of their BU to other BU in the organization (see Figure 5.4-4). For example, A47 (Sales) brings the results of the Sales BU to Finance, which is critical to record economical result and balance the cash flow in the short and medium term. A53 (IT) acts in the same way but between the IT and the Operations BUs. A82 (IT) plays a more general role than A53, connecting the IT BU to Operations and Supply chain. Finally, A73 connects Operations with the Sales BU.

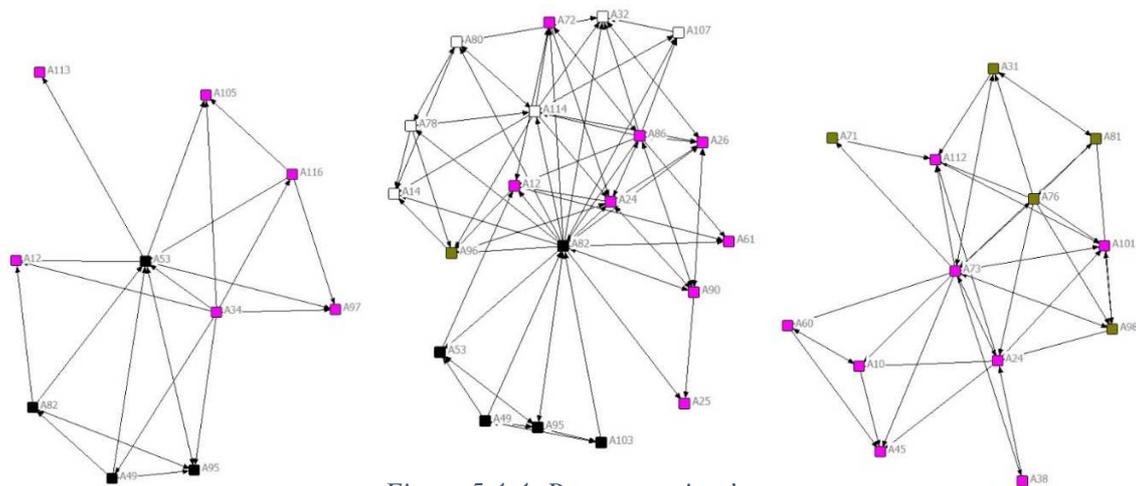


Figure 5.4-4- Representatives' ego networks

Finally, we identified actors who play the role of **liaison** (Figure 5.4-5) in Novelis. As said, liaison has a bridge function between two three different groups and we expect the existence of bridges between strategically important BUs (i.e. Operations and Sales). The results give credit to what we expected. In fact, the actors identified are A14 and A78. A14 (Supply chain) is positioned in between Sales and Operation. As we can see, he is actually very well connected with a big share of sales function, but the information owned comes from only two actors of operations and two actors of IT. The same happens for actors A78 (Supply chain).

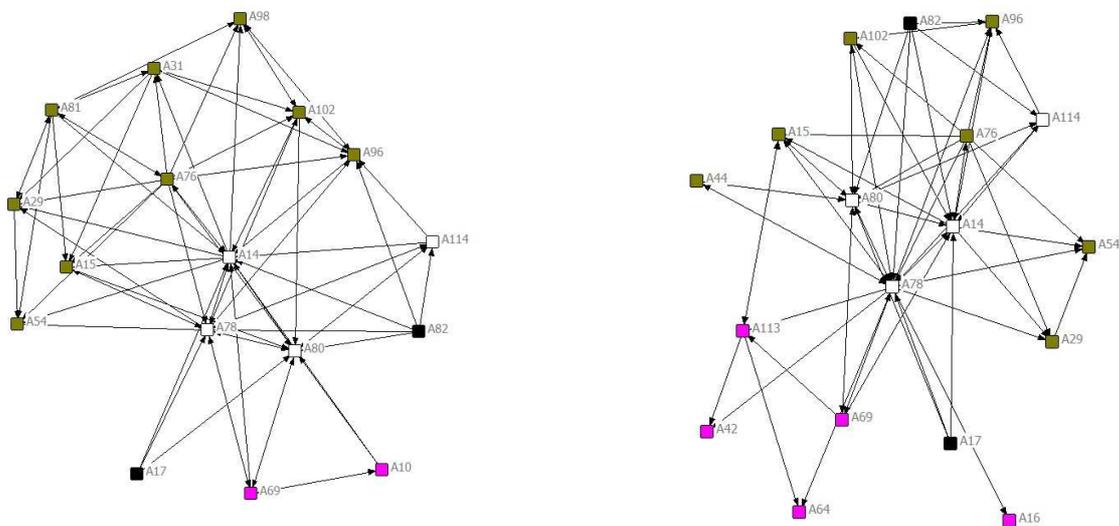


Figure 5.4-5 – Liaisons' ego networks

5.5 THE BOTTLENECKS IN THE INFORMATION TRANSFER

Individuals with central positions in the information network play surely an important role, as they act as connector of the working flows. However, as it often happens, they could also become bottlenecks of the system, slowing down and reducing the efficiency of the information flow.

To detect the bottlenecks, we compared the actual status in terms of density and centralization of the information network and the what-if status if we remove the information network's crucial actors. (De Toni et al. 2010)

In the as-is status, the actual density of the network is 0.055. The average degree is 5.822 and the InDegree Centralization is equal to 0.087.

The ego's centrality analysis shows that some actors dominate others if we compare their centralization measures. The actors who display the higher level of Indegree are the following:

- **A20: Operations, n-1, female**
- **A61: Operations, n-2, male**
- **A105: Operations, n-1, male**

Once identified most central actors, we proceeded to the creation of a subgraph through the use of Netdraw. The subgraph was composed by all the actors in the network except these 3 key actors. We then calculated multiple networks measures on these actors. The table below shows the result of the centrality measures after these actors were removed:

BASIC NETWORK MEASURES	
AVERAGE DEGREE	5.533
INDEGREE H-Index	10
DEGREE CENTRALIZATION	0.279
OUT-CENTRALITY	0.276
IN-CENTRALITY	0.072
DENSITY	0.053

Table 5.5-1 - Basic Information networks' measures after removing the bottlenecks

The Average degree decreases to 5.533, by just a 5%. The same happens for the density (4%) and – unsurprisingly³⁸ – the outdegree centralization. Anyway, the Indegree centralization falls of 17%, indicating that the Indegree network is the 17% more sparse (or less centralized) compared to the previous situation.

Below we graphically show the situation by comparing the two ego networks:

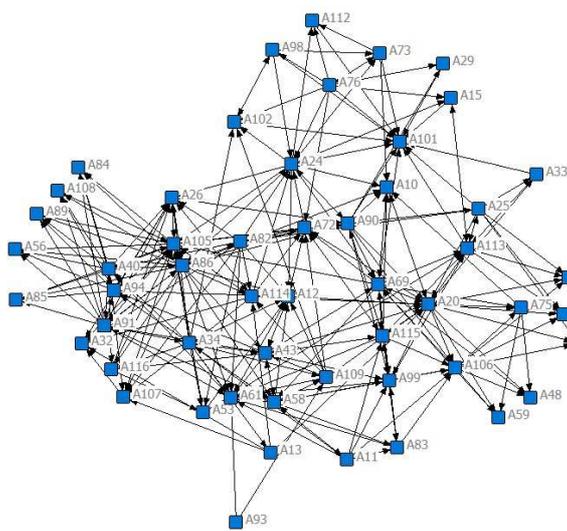


Figure 5.5-1- Information network before removing the bottlenecks

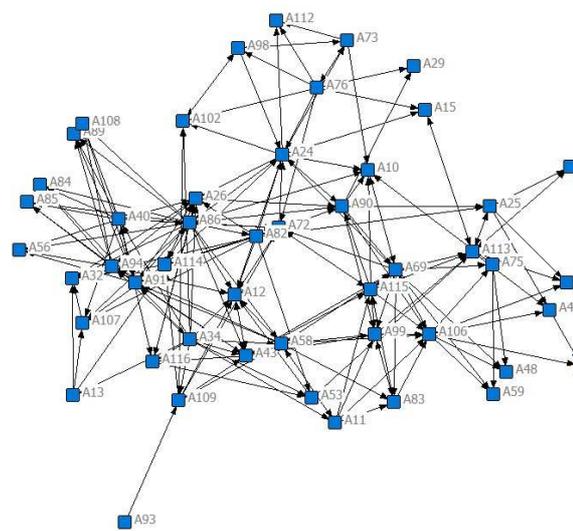


Figure 5.5-2- Information network after removing the bottlenecks

5.6 THE LEADERS

Following Cross et al. (2004) we tried to identify the leaders in the organization. Basically, these individuals are actors who display simultaneously **high levels of degree both in the communication and in the information networks**. Since these networks can be considered one at a time or jointly, we decided to walk the two different routes and then compare the results.

³⁸ Unsurprisingly refers to the fact that the actors removed did not display high level of Outdegree (i.e. ties going from them to others), but instead they were chosen for their high level of Indegree.

Firstly, in order to spot the so-called leaders inside the organization, we have compared the individuals who display the **highest Indegree** coefficients in both networks and highlighted the ones that appear in both lists.

Among the highlighted actors, five out of six belong all to the Operation function, one to Supply chain. Considering the first five, they are all male and n-2 except for one, who is a woman and n-1.

The list of leaders according to this first assessment is reported in the table:

Actor	BU	Level	Plant	Gender	Communication Indegree	Information Indegree
A105	Operations	n-1	1	M	0.142	0.104
A61	Operations	n-2	2	M	0.132	0.113
A20	Operations	n-1	2	F	0.123	0.142
A12	Operations	n-1	Both	M	0.113	0.094
A69	Operations	n-2	2	M	0.113	0.113
A80	Supply chain	n-2	2	M	0.104	0.094

Table 5.6-1- Assessment of leaders through Communication and Information's Indegree measures

To cross check our results we decided also to **analyse together** the two networks. This is somehow different from the previous method because we are now computing metrics based on the coexistence of the two networks.

The image below displays the friendship and the information network together. The level of complexity increases disproportionately with respect to other figures presented in this work, since two very dense networks are displayed at the same time.

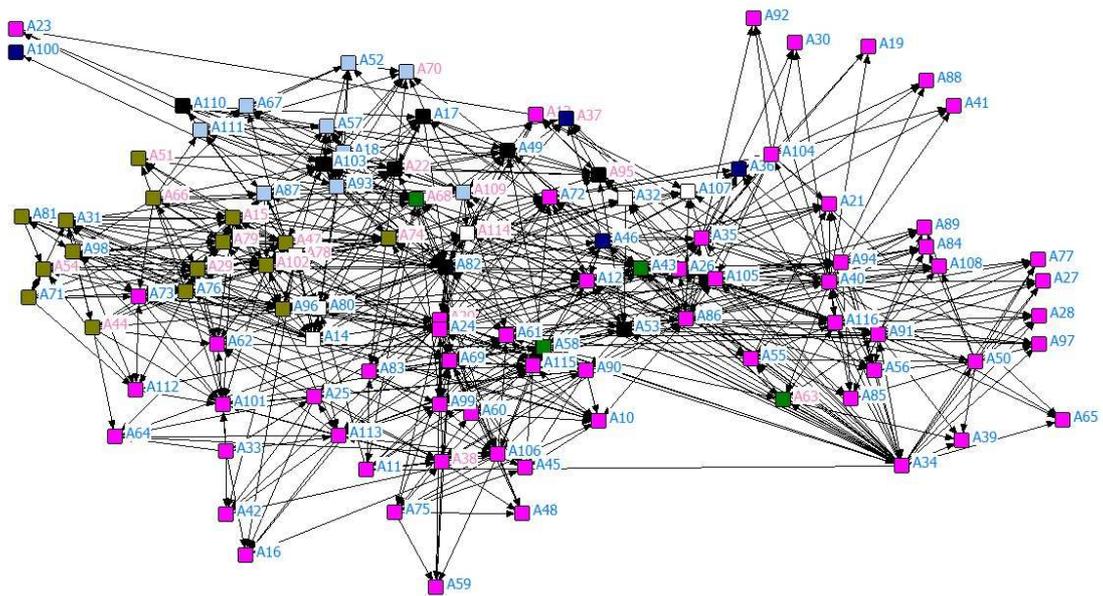


Figure 5.6-1 Joint representation of Information and communication networks

We then calculated the *Indegree centrality* for the advice network and best ones are reported below:

Actor	Unit	Level	Plant	Gender	Indegree Centrality
A15	Sales	n-1	2	F	0.16
A20	Operations	n-1	2	F	0.17
A61	Operations	n-2	2	M	0.16
A69	Operations	n-2	2	M	0.14
A101	Operations	n-2	2	M	0.14
A103	IT	n-2	2	M	0.15
A105	Operations	n-1	1	M	0.17

Table 5.6-2 - Top performer on Indegree centrality computed on the joint network Information-Communication

As can be seen, four actors are common with the previous analysis. This means that these actors displayed a high centrality both in the separate consideration of the two networks and in case of a 2-mode network.

Another important measure we should take into account when analysing information-communication network is the betweenness centrality, since it gives a measure of the position of the actor in the whole network.

Best *betweenness centrality* scores are reported below:

Actor	Unit	Level	Plant	Gender	Betweenness Centrality
A20	Operations	n-1	2	F	0.04
A58	Procurement	n-2	2	M	0.04
A69	Operations	n-2	2	M	0.06
A78	Supply Chain	n-1	2	F	0.04
A82	IT	n-2	2	M	0.07
A105	Operations	n-1	1	M	0.06
A86	Operations	n-1	1	M	0.05

Table 5.6-3 - Actors with highest betweenness centrality in the Communication-Information network

Actors **A20** (Operation, n-1, female), **A69** (Operation, n-2, male) and **A105** (Operations, n-1, male) are reported to belong simultaneously in the top performer of all the measures calculated since now. We can then conclude that **these actors act as leaders for the whole network.**

It can be noticed that two of them are located in the Plant which we have coded as 2, and one in the other.

Their ego networks are represented below:

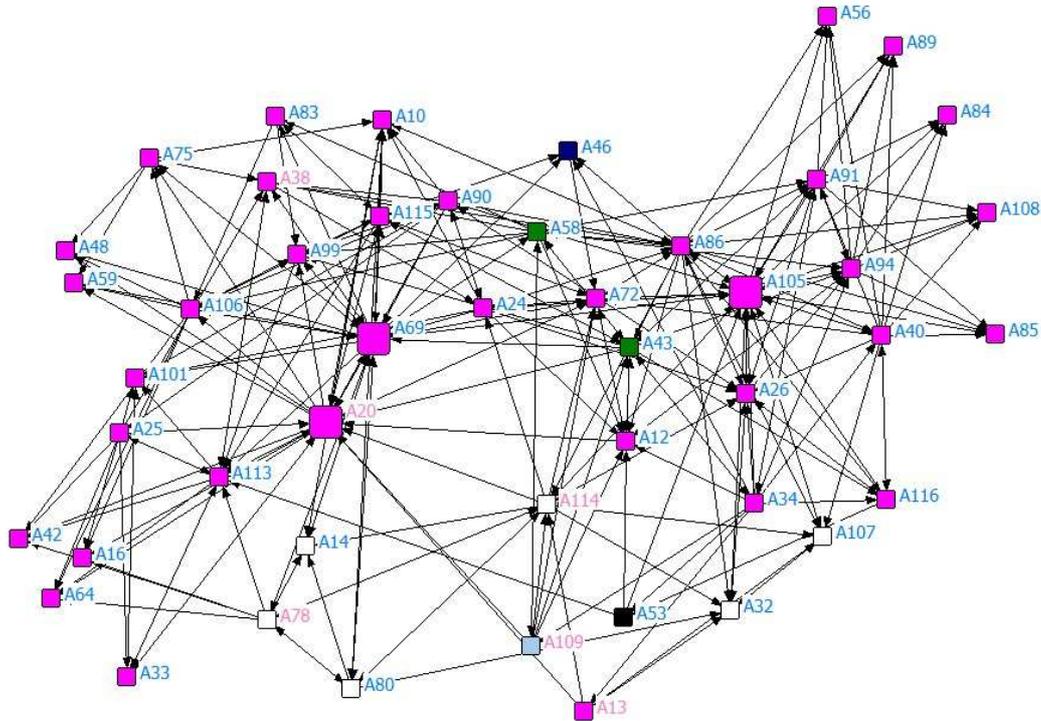


Figure 5.6-2- Leaders' ego network (joint representation)

5.7 A NEW ROLE: THE ΛΟΧΑΓΟΣ (LOCHAGOS)

We decided to study both accessibility and utility network together with the aim to provide the literature with a new informal role.

To identify this new leading key role, we studied the intersection of the above reported networks by multiplying the two different adjacency matrices. Following this methodology, if a link is not present in one of the two networks (i.e. the tie is not present) then the relationship is also null in the final network³⁹. Hence, the condition *si ne qua non* the actor *i* is signed to play this specific role for actor *j* is that both relations are present from *j* to *i*. That is if and only if *i* is source of valuable information for *j* and he is also available to share with him a sufficient amount of time.

³⁹ Final network in this case is intended as the network obtained by the multiplication of the utility and the accessibility networks.

After the multiplication of the two matrices, we obtained the following distribution (Table 5.7-1):

DISTIRBUTION OF TIE AFTER MATRIX MULTIPLICATION											
NUMEBER OF TIES	0	1	2	3	4	5	6	7	8	9	10
NUMBER OF ACTORS	28	29	23	7	7	5	2	2	1	2	1

Table 5.7-1 - Distribution of ties in the Accessibility-Utility network

That must be interpreted as 28 actors were not accessible and useful at the same time for neither one other actor. 29 actors were useful and accessible at the same time for just 1 other actor, and so on. The situation is graphically depicted in the graph below:

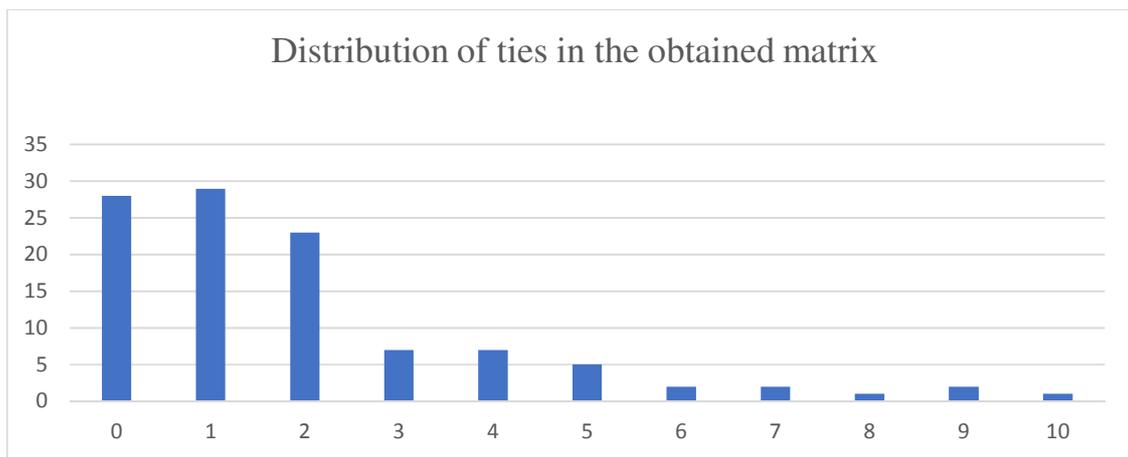


Figure 5.7-1 - Distribution of ties in the Accessibilty-Utility network

If an actor is at the same time present in both networks, we define him/her a Lochagos.

We called this role Lochagos (from ancient greek: λοχαγός, lochagós, from λόχος, "squad", e ἄγω, "lead"), which literally means "leader of a lochos". The lochos were tactical sub units of Classical Greece army, and each of them were guided by a Lochago. Differently from the Strategos – which had the complete control over the entire army – the Lochagos just had control over his lochos, and his duties went behind the pure implementation the strategy

imposed by the Strategos, but also included psychological support of the sub unit, coordination with others Lochagos in charge of other units and control over the equipment necessary for the military expedition in progress.

From the definition provided above, theoretically speaking, if an actor is accessible and useful for just one alter then she should be labelled as Lochagos. Anyway, we believe this type of distinction would not be of any use for the company or for future classifications. In particular not useful to find a strategically important role in the organization, that in our opinion would be a person barely replicable thanks to the great number of people who relies on his wisdom and help.

Hence, we decide to consider the people who are in the higher 95-percentile among all the people in the organization. That is - in SNA language - the people who score a higher Indegree in the matrix obtained by the multiplication of the others two. The 95 percentile results in the people who serve both for accessibility and for utility to at least other 5 people. The results are 13 actors who can be labelled as Lochagos, since for their colleagues are a point of reference to whom they turn to resolve problems in the day-by-day activities. Metaphorically, like ancient Spartans did with their Lochagos during military expeditions. In the figure below, we highlighted actors who belong to the group of Lochagos (Figure 5.7-1). From the analysis emerged that 13 people play the role of Lochagos. Among them we highlighted in dark red the Lochagos who have a higher level of Indegree respect the others. These three are both accessible and useful at the same time for, respectively, 9 and 10 people.

CHAPTER 6

6 DISCUSSION OF THE RESULTS FROM THE CASE STUDY

This Chapter contains reflections on the main findings of the SNA performed on the company reported in Chapter 5. Following the same structure of Chapter 5, we critically discuss and provide managerial implications, highlighting those key features of the networks that we think could be strategically important for Novelis. In particular, we discuss the connectivity of the whole company and among units, focusing on the information network; we then address the accessibility problem arisen through interviews and surveys, in particular between Sales and Operations. Subsequently, we dig into the distinction core-periphery in the information network. The last sections are dedicated to the critical assessment of the identified roles, i.e. the brokers, the bottlenecks, the leaders, and the Lochagos.

It is fundamental to stress that quantitative results not always appeared clear and easy to interpret, but they often required a closer examination. Interviews and contacts with the company were crucial and allowed us to validate our findings.

6.1 CONNECTIVITY

We reported in Chapter 5, the density measures applied both on the information network (i.e. to whom people daily look for information) and on the communication one (i.e. to whom people speak everyday about job and private related topics). We looked at densities also partitioning the network into units and plants to detect the level of cohesion among different units and different plants.

The **overall density** the two networks it is **not high**. Indeed, as highlighted in Results, just 5.5% of all the possible linkages among individuals are effectively in place in the information network (overall network density measure). In the communication network, this is slightly higher (8.7%).

The Geodesic distance computed on both the friendship and the information networks reveals that in the first the average number of geodesic is equal to 2.67 while in the second to 3. These values are above 2, the threshold proposed by Cross and Parker (2004) to obtain a well-connected network and collaboration among employees. Executives usually try to promote the collaboration using technical solutions. However, informal network is a matter of people behaviour, which can be supported by changing the organizational context.

One of the key findings relates to the absence of cohesion among BU that are expected to be connected. In particular, thanks to the density analysis in the information network, we noticed **a lack of information transfer between Supply chain and Procurement**. Owing to the importance of Supply chain for the coordination among Procurement-Production-Sales, we would have expected high *Outdegree* and high *Indegree density* values between the couples, but this result does not emerge between Procurement and Supply chain. The cohesion appears to be null also in the communication network. At a first glance, this is in contrast with what one would assume from a theoretical viewpoint. However, a possible explanation for the lack of cohesion might be the reliance on information systems that allow a widespread distribution of data and information across all the different functions, making a direct request of information between supply chain and procurement unnecessary. Currently, these enterprise management systems (in the specific case, Novelis uses AS/400) are widely diffused as integrating mechanisms; they help in reaching a desired level of connectivity (Cross and Parker, 2004).

Other **BU that showed low information exchange** were: HR with all the other BU except for Operation, and Supply chain with IT and Finance.

Low level of density must not necessarily be interpreted negatively, since a very high number of connections among departments would hamper and increase the complexity of the information flow. Indeed, it is also a signal that the information flow is lean. Many organizations report to be overwhelmed by the problem of a too dense information network. However, also an **extremely low level of density can be dangerous for the firm**. We can refer to what Hansen (1999) stated for teams whose members do not interact with many other

members (i.e. low-density teams): as he said for teams, BUs might be not able or unwilling to exchange vital, job-related information and tacit knowledge with one another.

In order to **promote an increase in connectivity**, Cross, Nohria and Parker (2002) suggest to:

1. **Change** the formal structure: create time and space for cross unit collaborations. This is a critical leadership challenge.
2. **Work management** practice: give assignments that can lead to effective collaboration.
3. **Employee management** practices: hire/promote/reward people who demonstrate collaboration practices. In the hiring phase, critical-incident techniques can be adopted to evaluate candidate's propensity to collaborate.
4. Focus on the development and **reward of collaborative behaviour**.
5. Focus training on **integration points** (Krachardt, 1994).
6. Reinforce **cultural values**: not just give reward to the person who was officially in charge of a project, but also publicly give credits to people who made possible the achievement of the goal, though a public acknowledge of the collaborative work.

About the last point, it is important to remark that Novelis is already implementing a policy of people's work valorisation through personal "Recognition cards". Despite this, we believe that to instil in the organizational culture the habit of public recognition of the people who made possible to reach determinate goals can boost the collaboration spirit inside Novelis.

Another solution for BU generally isolated from the others, or with extremely low density with other units (like HR with others, or Supply chain with Finance, IT, Procurement) may be to **define individuals that act as brokers** among poorly connected units. These actors would exercise a very important role, necessary for the connectedness of the organization. Anyway, it should be highlighted that a high reliance on a few individuals leads the company to run the risk of involuntary distortion of information or the hampering of task completion, since if those actors are temporary not available, no one could offset their absence. (Baker & Iyer, 1992; Burt, 1992). For this reason, we have dedicated a section of our discussion to the brokerage role played by actors in Novelis (see 6.3).

Moreover, the analyses of the two networks has pointed out that **density of communication and information exchange is higher within the same plant**. Considering these values and the ones related to the units' cohesion, we can state that these results seem in line with the findings of literature on geographical proximity, reported in Chapter 1.

6.2 THE ACCESSIBILITY ISSUE

In order to assess one problem that emerged from the interviews and the questionnaire, in Chapter 5, we have examined the accessibility network, focusing on the subgraph comprising only actors from Sales and Operations and the respective ties.

It emerged that, only 5 five linkages go from Sales to Operations, meaning that the first function's members perceive as not very accessible individuals of Operations. This situation may not be optimal for Novelis. Sales BU is the one in touch with customers, hence, if Sales experiences a problem then there is high probability this problem will be reflected to Novelis' customers. For instance, sales representatives may need to provide their client with samples, which are crucial to acquire new contracts, to consolidate/renew existing ones or to increase the satisfaction of a client that may have a doubt or specific requests about the product. If Sales' members are not able to access Operations' ones to obtain samples or fundamental information and clarifications, this might not only be an internal problem that needs to be addressed, but it may also acquire importance for the company's business, since it affects the relationship with the customer and so revenues.

To improve the *status quo*, we suggest a solution, which consists in the creation of figures that have the formal authority to query people in the Operations functions, or alternatively, to establish weekly meetings with some representatives per unit in which Sales function and Operation function's members are invited to participate. Here, SNA can be of great help. In fact, it is undoubtable that Novelis can increase the effort devoted to convincing the most central actors (or coordinator) of the Operations to join these meeting. We believe that the effectiveness of this action would rise enormously if Novelis was able to bring together the most central actors. These types of solutions are certainty not a magic potion for solving Novelis' issues, in fact even of two actors are exposed each other's, there is no assurance

that they will form a tie in the future, anyway, since it is established that more contacts increase the likelihood an informal tie will form (Krackhardt, 2000), we believe these are feasible solutions.

Since meetings occur quite often and incur in the risk to be perceived as a waste of time by people inside the organization, another solution could be the creation of a task force composed by the members of these two divisions (and others if the management is interested in increase the cohesiveness among others group). Anyway, this apparently simple solution could not work as planned by executives. As reported by Krackhardt (2000), it is fundamental to choose properly the people who will lead this task force. For example, if the management chooses a person who has poor connections in the trust network or lack of credibility at colleagues' eyes, this can lead to a low effectiveness of the tactical change of the formal structure and a widespread low level of collaboration among the members of the task force.

Leveraging on SNA's results can be helpful, since it can spot these types of connections and exploit them to create meaningful changes. For instance, in our questionnaire we asked people to whom they turn to for advices. It is out of any doubt that in general people seek for advice from people they also trust and who are perceived as source of expertise in their area (Wasserman et al., 1994). Hence, by combining the advice network of the Operations and Sales functions, it was possible to identify actors who could be particularly suited to be part of a task force encompassing both functions. They are the following: A96 (Sales, N, male), A20 (Operations, n-1, female), A105 (Operations, n-2, male)

Another alternative we envision for the solution of this problem that can be undertaken by the management is to intentionally assign joint projects to selected members of the two functions. The projects should require a high level of collaboration to be resolved or, alternately, can just be seen as a broadening assignment for some members. Even if initially the presence of more people belonging to different functions could lead to a solution that is not the most efficient one, we believe in the long term that can create ties which will reveal to be effective for the rapid solution of other problems (Cross et al. 2002).

6.3 CORE-PERIPHERY IN THE INFORMATION NETWORK

This important procedure allowed us to identify a particularly dense group inside the company. As shown in the results chapter through a hill climbing algorithm we were able to classify Novelis' employees into two categories: the core – dense and connected- and the periphery – sparse and disconnected.

It is of particularly importance because in dense group information flows more rapidly, bottlenecks are avoided given the high redundancy of ties, and more in general, the group has a higher cohesion. Moreover, core is seen in literature (Collier and Kraut, 2012) as an “elite” group in which only few members have access and usually newcomers in organization are often forced to stay at the periphery.

The effect of having a core network inside the organization should not be underestimated by management: since this subgroup is much denser than the rest of the organization, it often displays higher velocity in the transmission of information but also can lead to the polarization of opinion dynamics.

For all these reasons, it could be of strategic importance **to try to include in the core group actors that belong to different units or represent different subgroups⁴⁰ inside the organization.** This would be done in order to:

1) Increase the level of heterogeneity of the core.

Subgroup can vary depending on the management's preferences: for example, it may be indicated to include in the core more women or men to increase gender diversity; or instead different ethnicity. But also, different units or different plants. The positive effect gained by a larger heterogeneity would be in term of reduced opinion clustering.

2) Include people who belong to isolated subgroup so that they can spread the information to sparse clusters gathered in the core.

In our case there are 29 people in the core, 18 are from operations, 1 from finance, 2 from IT, 4 from Supply Chain, 2 from Procurement, 2 of sales. Hence could be meaningful try to

⁴⁰ With subgroups here we intend a broad definition of them: a subgroup can be represented by man, women, or people with different ethnicity; or again people belonging to different plants or job functions.

include more people of the sales BU and someone of the HR BU. Plants instead are almost evenly split in the core.

6.4 THE BROKERS OF THE INFORMATION EXCHANGE

In chapter 5, we applied SNA techniques to spot those actors that play broker roles for the information flow across units in the company. In this section, we provide an extended critical examination and some key managerial implications related to these characters.

The following table summarizes the roles and the identified actors.

Brokerage role	Actor	BU	Level	Gender
<i>Coordinators</i>	A104	Operations	n-1	M
	A35	Operations	n-1	M
	A75	Operations	n-3	M
	A108	Operations	n-3	M
<i>Consultants</i>	A58	Procurement	n-1	M
	A68	Procurement	n-1	F
	A73	Operations	n-2	M
<i>Gatekeepers</i>	A46	HR	n-1	M
	A80	Supply chain	n-2	M
	A93	Finance	n-1	M
<i>Representatives</i>	A47	Sales	n-2	F
	A53	IT	n-1	M
	A73	Operations	n-2	M
	A82	IT	n-2	M
<i>Liaisons</i>	A14	Supply chain	n-1	M
	A78	Supply chain	n-2	F

Table 6.4-1 - Information brokers at Novelis

The identification of the brokers can have critical implication for Novelis Management. indeed, **the removal of one of them can cause system's paralysis.**

From literature about brokerage, we know that brokers assume a critical role in every information network effectiveness because they retain the power of central connectors without necessarily possessing the elevate number of direct ties these connectors have.

Indeed, they are basically characterized by a wealth of indirect connections (Cross and Prusak, 2002). Given the importance these actors have, a good strategy to empower further these individuals inside the organization could be to allow them to spend part of their time supporting the network, and publicly design them as go-to people in their areas of expertise. In fact, these are the people among which the system itself function. It would be a quite interesting investment to let these people nurture their social interactions inside the organization. Furthermore, a valuable managerial practise would be to schedule meetings (e.g., twice a month) and frequent online forums to promote the communication among individual holding such an important informal role because this would allow to leverage their crucial position in the network to rapidly detect and find rapid solutions to problems, which arise inside the organization.

Going into specific into the situation depicted in the Operations function we identified one actor who play **the role of bridge**. Bridges in the organization make possible the connection among different parts of the organization otherwise disconnected or barely connected. It is straightforward that the removal of this actor (A35) would have some consequences on the information network of Operations function. The function seems quite resilient given the high density, hence, even if A35 was removed, consequences should not be catastrophic in term of system paralysation. It is clear, in any case, the importance of this actor – who act as coordinator - for the functioning of the Operations function.

Moreover, it emerged from the analysis that there are other criticalities that would need to be addressed in order to improve the information network of Novelis. For example, it emerged the absence of brokerage role inside Sales function, one of the cores. Probably, in order to improve the as-is situation in Novelis, it could be beneficial to create a coordinator also in Sales, the second most important unit.

6.5 THE BOTTLENECKS IN THE INFORMATION NETWORK

In the Results chapter, we discussed how we were able to identify through a scenario analysis some bottlenecks in the information network of Novelis. Now we discuss the results and present some suggestion about how management should address this issue.

The actors identified as bottlenecks were A20, A61 and A105.

Actor	BU	Level	Plant	Gender
A20	Operations	n-1	2	F
A61	Operations	n-2	2	M
A105	Operations	n-1	1	M

Table 6.5-1 - Information bottlenecks at Novelis

Actors who have been identified as bottlenecks belong to the function Operations. This is not surprising since this function is the most crowd and most complex. As often happens, in complex context people tend to rely more on leaders. Actor A20 is female who work in the Plant 2 and has n-1 hierarchical level. A61 has been classified as bottleneck despite his “low” hierarchical level, he is a male and works in plant 2. A 105 instead is a n-1, works in both plants and is a male.

Central people who have become bottleneck should shift burdens for providing information and making decision to others in network (Cross et al, 2002). A possibility is to shed responsibility for owning certain information and decision. In fact, people often acquire high centrality in a network because they now things and possess expertise that bridge different parts of the organization. But such people have to give up on the losing battle of trying to answer everyone’s questions. Instead, then should try to learn to point people toward others in the network with the expertise to provide answers. Such types of actions not only open up bottlenecks, but it also draws in peripheral people to the centre of the network.

Hence, as **managerial implication** we should remark that a good way to relief bottleneck is proposed by Burt (1992), who suggests reallocating some of the information domains (that is, who’s responsible for what information) and change the attribution of decision rights (allowing others to make decisions).

6.6 THE LEADERS

Following Cross et al. (2004), we identified the leaders in the network, specifically those actors who display simultaneously high levels of centrality in the friendship and in the

information network. In order to recognize the employees that play this role, we have considered the Indegree centrality of the information and the friendship networks both separately and combining the two networks. We also looked at another measure of centrality (Betweenness centrality) and we ended up with the identification of three leaders.

Actors A20, A69 and A105 are reported to be simultaneously the top performer of all the centrality measures computed. We conclude that these actors act as leaders for the whole network.

Actor	BU	Level	Plant	Gender
A20	Operations	n-1	2	Female
A69	Operations	n-2	2	Male
A105	Operations	n-1	1	Male

Table 6.6-1 - Leaders at Novelis

People who simultaneously display high Degree level in the friendship and in the information network are recognized as informal leaders in the organization (Cross et al., 2004). These people are provided with great social capital because they rely on important paths in the information and communication flow. They are often the actors towards whom others people go both to talk about work related and private topics. In this way, they are able to **build meaningful connections** with the people in the organization. Having highly sought expertise or information or of being a close friend to many others will lead the individuals to have **greater access to, and a larger amount of, information** or social support from the social network (Adler & Kwon, 2002).

Knowing which actors cover the role of leaders can reveal very useful in the moment in which Novelis will decide to or will have to implement a major change or face a complex problem. In fact, if the leaders of the organization will be convinced to pursue the cause, this can increase the likelihood that the whole company accepts these changes and in general can increase the collaboration toward the implementation of the project (Cross et al. 2004).

Their ego networks are represented below and you can see how through just the help of three people, 47 people of the whole organization are reached.

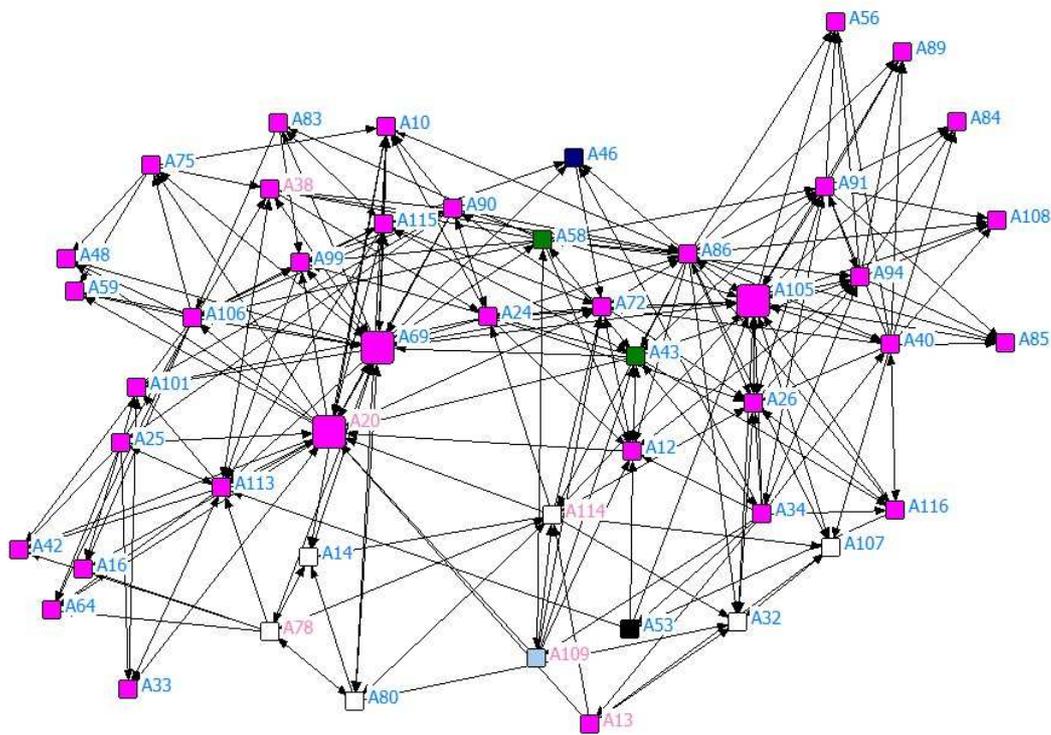


Figure 6.6-1 - Joint representation of leaders' ego networks

6.7 A NEW ROLE: THE LOCHAGOS

After the analysis on different kind of networks, we decided to undertake a joint analysis of the accessibility network and of the utility one. Our aim was to define a new key informal role assumed by individuals who are contemporaneously problem solver – and then give useful information – and accessible. Actors who display high levels of centrality in the utility network are actors who systematically provide useful information to the others. These have been identified as actors in whom knowledge lies. Anyway, having the knowledge and capabilities to help the organization and colleagues but not having the time would be like have a weapon and not the capability to use it. Often happens that more knowledgeable employees are overwhelmed by requests, and end up not being able to help their colleagues for a lack of time. Somehow, some of them are able to accomplish at the same time both

roles⁴¹, maybe due to exceptional time management skills. But unfortunately this is not always the case, in fact our analysis is aimed to identified those actors who with incredible mastery are able to fulfil colleagues' request in a valuable manner.

From the analysis emerged that there are 13 Lochagos in Novelis. These are A70, A49, A95, A12, A43, A61, A106, A20, A69, A113, A96, A105, A26.

Actor	BU	Level	Plant	Gender	Tenure (years)
A70	Finance	n-2	2	F	15
A49	IT	n-1	2	M	41
A95	IT	n	1	F	29
A12	Operations	n-2	Both	M	14
A43	Procurement	n	Both	M	0,6
A61	Operations	n-2	2	M	23
A106	Operations	n-2	2	M	30
A20	Operations	n-1	2	F	14
A69	Operations	n-2	2	M	38
A113	Operations	n-2	2	M	40
A96	Sales	n	2	M	18
A105	Operations	n-1	1	M	28
A26	Operations	n-2	1	M	30

Table 6.7-1 - The lochagoi at Novelis

61.5% of them work in the Operation function, and 10 out of 13 are men. 8 out of 11 work in the plant number 2 and only two work in both the plants.

Among them we identified the top three performers⁴², which are highlighted in the figure in the dedicated section. These are A96, A69 and A105.

We believe the results find can have practical **managerial implication** beyond those for scientific research. In fact, through this type of analysis the management can identify a strategic important role that otherwise would pass overlooked. In addition to that,

⁴¹ i.e. be useful and be accessible

⁴² Actors among the 13 who performed better than the rest of the group.

management can set up “training” session in which people with high centrality in the utility network learn from Lochagos how better manage their time and address college requests; or executives can fix a series of interviews with Lochagos to better understand how they perform their role and then promote a series of best practices to the rest of the organization.

In conclusion, we are convinced that this new role, identified combining two fundamental networks can represent a step forward in the SNA research. Moreover, the identification of the employees that play this role can be significant for companies, since they are the ones that the others perceive as holding valuable information and accessible to help them to accomplish their tasks.

One last final mention for the actors A20 (Operations, n-1, female) and A105 (Operations, n-2, male) who are at the same time Leaders, Bottlenecks and Lochagoi (A105 appears also as top performer)

CHAPTER 7

7 TESTING OF THE HYPOTHESES

In Chapter 2, we formulated hypotheses regarding the determinants of the creation of ties in the Advice network. In this chapter, we test them, using one of the most diffused technique in SNA, namely the QAP. We describe the selected variables and the specification of the models that constitute the basis for the hypotheses testing and provide a discussion of the main results of the analysis.

7.1 DYADIC TESTS

In order to test the hypotheses formulated in chapter 2 we performed both the QAP correlation and the LR-QAP Regression.

The use of QAP and MR-QAP for Hypotheses testing is a common practice in SNA and it has been applied by many researchers (e.g. Borgatti et al. 2003; Krachardt 1988). Since the dependent variable of our test is represented by a dichotomous matrix, we applied the LR-QAP as suggested by Borgatti, Everett and Johnson (2018). We discussed the validity of this approach in Chapter 3. However, we confirm again that is important to note that Ucinet accounts for the non-independence of cases, since all the actors belong to the same company, so they are not randomly picked. Indeed, the software while performing the QAP analyses, which will be implemented in the following pages, executes a permutation of the rows and columns of the matrices selected as variables. This allows testing for the significance (i.e. p-value) of the obtained values (Hubert, 1989; Krachardt 1988).

7.2 MATRICES USED IN THE HYPOTHESIS TESTING

As mentioned in Chapter 3, QAP's adoption is very common in SNA and its unit of analysis consists in dyadic matrices.

Given the information, we gathered on relations among individuals from the questionnaire, we reported the answers as binary matrices in Excel and then converted them into Ucinet Dataset. For what concerns the data related to single individuals (such as gender, tenure, unit and so on) we had to perform a transformation in order to convert them into relational data (as mentioned in the Chapter 3).

As regards the **first set of hypotheses (H1, H2 and H3)**, we considered in the analysis the following variables: The Utility network (*Utility*), the Accessibility network (*Accessibility*), the Friendship network (*Friendship*). The adjacency matrices for these networks are all squared binary matrices and we have created basing on the answers to the questionnaire. Hence, given actors i and j , if the value in the cell x_{ij} is equal to 1, it means that a relationship is in place between i and j , 0 otherwise. These are all dyadic matrices; therefore, they did not require any transformation to fit into the regressions.

For the **second set of hypotheses (from H4 to H7)**, the related variables are the matrices that represent the Formal communication network (*Formal and RepRel*), belonging to the same plant (*Colocation*), being part of the same unit (*SameUnit*), having the same hierarchical level (*SameHierarchy*). As regards *Formal*, in order to build the adjacency matrix, we have considered the information we were given on reporting relationships (i.e. the organigram) and on the meetings (namely, at which meetings individuals must take part). Hence, we considered that a formal relationship (basically, 1 in the adjacency matrix) is in place if the individuals have a reporting relationship or participate to the same meeting. Instead, in the variable *RepRel* we included just the reporting relationships. For the other variables, we had to perform a transformation on the information that we had, since they were non-dyadic. Therefore, we created three squared binary variables, where 1 stands for being in the same plant (in *Colocation*), belonging to the same unit (in *SameUnit*), having the same hierarchical level (in *SameHierarchy*) respectively in each matrix; 0 otherwise.

Finally, to test the **last set of hypotheses (H8-H9)** related to personal characteristics, we have built i) one matrix for what concerns Gender, performing the same transformation of the non-relational variables of the previous block accounting for same gender (*SameGender*); ii) to study the tenure's effect, we firstly divided into six bins (0-5; 5-10; 10-15; 15-20; 20-

25; >25) and put a 1 in case the actors to which the cell refers belong to the same bin; 0 otherwise. then we built the variable based on this matrix, but we put a 1 in case the actor on the row displayed a lower tenure compared to the one on the column.

In order to verify our exploratory hypothesis(H10), we created a matrix as intersection between *Tenure* and *SameUnit* by multiplying them (*TenureXunit*).

The hypotheses are tested setting as dependent variable the adjacency matrix of the advice network (*Advice*).

7.3 QAP CORRELATION

In order to analyse the correlation between networks containing the same actors, we have performed a QAP Correlation analysis. This allows understanding whether two actors who are tied in one network are likely to be tied also in another. Table 7.3-1 shows the Correlation indexes with reference also to the significance level.

Variables	1	2	3	4	5	6	7	8	9	10	11
1 <i>Advice</i>											
2 <i>Utility</i>	0.595***										
3 <i>Accessibility</i>	0.682***	0.544***									
4 <i>Friendship</i>	0.390***	0.443***	0.417***								
5 <i>Formal</i>	0.247***	0.192***	0.248***	0.266***							
6 <i>RepRel</i>	0.075***	0.065***	0.051***	0.053***	0.048***						
7 <i>Colocation</i>	0.111***	0.126***	0.121***	0.225***	0.136***	-0.023					
8 <i>SameHierar.</i>	0.032**	0.026*	0.060***	0.090***	0.030*	0.016	0.108***				
9 <i>SameUnit</i>	0.118***	0.125***	0.128***	0.157***	0.236***	-0.012	0.040	0.101			
10 <i>SameGend.</i>	0.018	0.018	0	0.005	0.042**	0.003	-0.058*	0.001	0.300*		
11 <i>Tenure</i>	0.023*	0.018	0.012	0.018	-0.004	0.027	-0.011	-0.005	-0.008	-0.016*	
12. <i>TenXunit</i>	0.085***	0.078***	0.087***	0.092***	0.128***	0.08	0.013	0.050	0.548***	0.154*	0.489***

Table 7.3-1 - QAP correlations

All the variables related to informal networks are strongly positively correlated with the dependent

one. Indeed, *Advice* shows high and significant levels of correlation with *Accessibility* (0.682, $p < 0.001$), *Utility* (0.595, $p < 0.001$), and *Friendship* (0.39, $p < 0.001$). This gives a first meaningful support to our first set of hypotheses. The correlation is also significant with most of the variables associated to the second set, especially with *Formal* (0.247, $p < 0.001$). The correlation between *Advice* and the variables related to the third set is low with *Tenure*, while it is not significant with the gender-related variable. Since the level of correlation between *Accessibility* and *Utility* exceeds the level for joint inclusion in regression (0.5), we firstly decided to include them alternatively and then, since the correlation was not too high, we decided to build a model keeping them together.

7.4 QAP REGRESSIONS

To test our hypotheses, we built different models. As said, in order to take into account for correlations that were higher than .5 we initially built distinct models, including separately these variables. Since *Accessibility* and *Utility* displayed a correlation higher than .5, we decided to build a first model (M1) in which we included both variables owing to the fact the correlation was not so high. To check if results would have changed if considering the two variables separately, we built M2 including *Utility* and M3 including *Accessibility*. Moreover, to check for the robustness of the variable *Formal*, we ran a regression excluding this variable and including *RepRel* which encompassed reporting relationships only. The obtained results lead to the same conclusions.

We run the LR-QAP regressions with 1000 permutations, in order to test the validity of our models. This analysis tests if similarities between two individuals and/or the presence of a tie in one network predicts the creation of a tie between them also in the advice network. Basically, if the independent variable reveals to be significant, then the presence of a tie among two actors in the underlying variable is said to predict the creation of a tie also in the dependent one. The higher the beta, the higher the predicting power.

We now provide the regressions' results.

Independent variables	M1	M2	M3	M4	M5
<i>Utility</i>	3.095***	3,837***			
<i>Accessibility</i>	3.281***		4.019***		
<i>Friendship</i>	1.115***	1,615***	2.037***		
<i>Formal</i>	1.279***	1,626***	2.623***	1.909***	
<i>Colocation</i>	0.579*	0.651*	1.625*	1.256***	1.512***
<i>SameUnit</i>	-0.151	0.098	0.092	0.931***	1.495***
<i>SameHierarchy</i>	-0.189	0.264	-0.373	0.089	0.067
<i>SameGender</i>	0.436	0.147	0.405	-0.111	-0.164
<i>Tenure</i>	0.347	0.284	0.371	0.342*	0.331*
<i>R²</i>	0.550	0.424	0.493	0.057	0.034

Table 7.4-1 - QAP regressions' results

We can see that all the models show very similar results in terms of significance and coefficients' values.

The first one (M1) we have included all the variables. It shows an R^2 of 0.55, thus it should account for the 55% of variance. Relational variables are all very significant ($p < 0.001$), and *Accessibility* and *Utility* shows higher betas compared to *Friendship* (3.281 for *Accessibility* and 3.095 for *Utility*). *Formal* ($p < 0.01$) also displays a quite high beta (equal to 1.279), which is higher than the one of *Friendship*. *Colocation* is also significant, though less than the previous mentioned variables.

Since *Accessibility* and *Utility* displayed a correlation higher than .5, we decided to build two models in which we alternatively included them. Indeed, in M2 we have included *Utility* and excluded *Accessibility*, the opposite in M3. The results do not display major changes in significance of the variables compared to M1.

In order to isolate the effect of the variables which do not relate to networks, we built model M4 first, then M5 which excludes also formalized mechanisms of communication (*Formal*). The R^2 of the last two models drops dramatically compared to the ones of M1, M2, M3 in which we included networks variables, which means that networks variables are more relevant in determining who an individual seeks advice from. Though, looking at significance in M4, *Colocation* has $p < 0.001$, thus further supporting H5. Excluding networks-related variables, *SameUnit* (H6) and *Tenure* (H9) become significant. The first has $p < 0.001$ thus it provides support to (H6) and it can also be derived that the effect of similarity in work domain vanishes when we consider ties in informal networks. The second has low significance, $p < 0.05$, and a beta of 0.342 which confirms that there could be the tendency to ask for advice to people that have spent higher number of years in the company. Hence, it provides a weak support to H9.

We then ran two more regressions to test our exploratory hypothesis, excluding *SameUnit* and *Tenure* and including *TenureXunit*. In the first we included all the networks' variables while in the second we excluded them, similarly to what we did in models M1 and M4. The significant independent variables were the ones already emerged in M1, M2, M3. However, in the first model the variable was not significant, while in the second, when we excluded the networks variable, we saw that *Colocation* became very significant once more and the same happened to *TenureXunit*. This provides support to our last hypothesis, H10.

7.5 DISCUSSION

We now provide a discussion of the hypotheses formulated in chapter 2, based on the results we obtained through our models.

7.5.1 Advice network and the presence of ties in other networks

If we consider the first set of hypotheses (in which the presence of a tie in other networks is said to predict a tie formation in the Advice network), we can affirm that linkages in these three networks, namely *Utility*, *Accessibility* and *Friendship* are consistently predictors of tie formation in the Advice network. Indeed, **results provide support to H1, H2, H3**. In particular, the presence of ties in the Accessibility and in the Utility network seems to

strongly predict the choice of the advisor, since they have always high significance and the highest betas.

7.5.2 Advice and formal structure

As concerns the second set of hypotheses (related to the formal structure), **we found evidences which provide support to H4**. Indeed, both considering just the reporting relationships (variable *RepRel*) and their combination with the meetings to which people participate (our variable *Formal*), it appears that formalized mechanisms of communication foster the choice of the person to whom asking for advice. Particularly, *Formal* showed higher beta compared to *friendship*, thus meaning that a formal communication tie is even more effective in predicting a tie in the advice network compared to a friendship tie.

Colocation was significant in all the models, particularly with a $p < 0.05$ in the first two and with a $p < 0.001$ in M4 and in M5, in which we excluded the informal networks variables. Hence, we are confident in saying that **results provide support to H5 and affirm that geographical proximity predicts the creation of ties in the Advice network**.

Less strong evidences were found in favour of H6, since *SameUnit* shows to be significant ($p < 0.001$) just in the models in which we excluded the networks variables. This suggests that the effect of belonging to the same BU vanishes when we consider informal ties.

As concerns the hierarchical level, we found no support for H7, since the variable did not show significance level below the threshold value.

7.5.3 Advice network and individual characteristics

As regards the last set of hypotheses, which dealt with individual characteristics. Despite the voluminous research on gender homophily (e.g. Ibarra 1993; Mcpherson 2008; Klainbaum 2013), **we did not find support to H8** in any of the models we built.

Tenure showed little significance just in models M1 and M4. This leads us to say that **results provide weakly support in favour of H9**. As for SameUnits, the predicting power related to having a higher tenure vanishes when we consider Accessibility and Utility networks since in M2 and M3 the independent variable *Tenure* was not significant.

As concern the our explorative hypotheses, we found support in model M7, when excluding Informal networks. From what said for Tenure and SameUnit, we can say that belonging to the same unit and having a higher tenure can foster the tie creation in the advice network.

Informal networks and formal communication ties are the determinants that, all else being equal, seem to have the highest predicting power for tie creation in the advice network. In particular, ties in the Accessibility (i.e. considering the person available in sharing her time and knowledge) and in the Utility (i.e. having the opinion that a person has a valuable and useful knowledge) look to predict the most the selection of the advisor.

HYPOTHESIS	SUPPORT
1. Utility	Strongly in favour
2. Accessibility	Strongly in favour
3. Friendship	Strongly in favour
4. Formal communication	Strongly in favour
5. Colocation	In favour
6. Same Unit	In favour
7. Same hierarchical level	No evidences
8. Gender	No Evidences
9. Tenure effect	Weakly in favour

Table 7.5.3-1- Summary of Hypotheses testing results

CHAPTER 8

8 CONCLUSIONS

The main purpose of this thesis was to apply the SNA's techniques to study informal networks and their interplay with the formal structure on a real case. Specifically, we had the chance to work with Novelis, a multinational firm, leading producer of flat-rolled aluminium products and the world's largest recycler of aluminium. The firm has two plants located in the Milanese area and our analysis has encompassed both.

Researchers have provided evidence in favor of the importance of informal networks within firms and on how a clear assessment of the ties among individuals is vital for the efficiently running of the firm. According to literature, the management should be aware of the social ties among people and leverage on them to enhance the individuals' and firm's productivity or to face critical situations (such as crises or strike periods).

Firstly, we studied the main concepts of the formal and the informal organizations, assessing predominantly their definitions and key elements, their differences and links. Specifically, we decided to focus our attention on the informal networks, which represent how individuals interact with each other despite what prescribe by the formal structure. Specifically, we collected papers on the impact of informal networks on the determinants behind the creation of ties and the firm's performances. It is important to stress that researchers have defined several types of informal networks that may arise inside the organization. In this work, we referred to the definitions of Cross and Parker (2004), encompassing in our analysis these networks: communication, information, utility, accessibility and advice.

We adopted the SNA approach because represents the most diffused one in this research field and it is widely used by the papers we included in our literature review.

In order to learn the concepts that would have allowed us to complete the analysis, we mainly relied on the book written by Wasserman and Faust (1994), which provided us the fundamental understanding of key SNA themes.

In the empirical part of the thesis, we adopted a mixed method approach, combining qualitative and quantitative data and methods. Interviews with the firm's management were crucial to grasp information about the processes and the formal structure of the firm. To collect the data needed to perform the SNA, we administered a questionnaire to a selected group of firm's employees and performed two follow-ups to increase the response rate. We had also to deal with the management of the data privacy. For this reason, we agreed with the management that we would have not displayed any of the personnel's names nor it could have been possible to associate the results to specific employee's answers. Once gathered, the data were analyzed using Ucinet, NetDraw Software.

8.1 CASE STUDY – MAIN RESULTS AND PRACTICAL IMPLICATIONS

We have reported the main findings that emerged from the analysis of Novelis that lead us to unearth some criticalities and spot key people inside the organization. Specifically, first we focused our attention on the connectivity and the cohesion of the whole firm and among units looking at the information network. Second, we addressed the accessibility problem arisen through interviews and surveys, in particular between Sales and Operations. Third, we dig into the distinction core-periphery in the information network. Finally, we aimed at identifying those actors that play a significant role inside the firm i.e. the brokers, the bottlenecks, the leaders, and what we labelled as the Lochagoi.

About the last point, while the first three roles based on insights provided by the reference literature, the last was developed by us thanks to the combination of two fundamental networks, the utility network and the accessibility one.

For all the cited topics, we have provided managerial implications and solutions that the firm can adopt to limit the effect of criticalities and better control/leverage on the actors to which a significant role was associated.

Key theoretical implications of this work relate to two main aspects: first, we have adopted SNA on a real context, thus confirming its validity and its applicability; second, we have designed a new role, the Lochagos.

8.2 HYPOTHESES - THEORETICAL AND PRACTICAL IMPLICATIONS

The collected data allowed us not only to develop a critical examination of the networks inside the firm, but they have also permitted us to test some meaningful hypotheses that we formulated based on the reference literature. Indeed, we found a gap in the backgrounds related to the determinants behind the creation of ties in the advice network, i.e., a specific type of informal network - and thus we choose to provide evidence on this topic. Specifically, we created several models aimed at testing if the advice network linkages are predicted by several dimensions. First, by bonds in other informal networks, namely in utility (H1), accessibility (H2), and friendship (H3) network. Second, the formal characteristics of the firm, explicitly the formalized mechanisms of communication (H4), plant colocation (H5), belonging to the same unit (H6), being at the same hierarchical level (H7). Third, individuals' personal characteristics, i.e. having the same gender (H8), showing different tenures (H9), and additionally the combined impact of tenure and belonging to the same unit (H10).

To test these hypotheses, we have studied the correlations among variables and ran regressions using the QAP technique on Ucinet.

From the results, we can conclude that considering the knowledge of the other person useful and valuable, perceiving her as accessible or having a friendship relation increase the chance to go to that person for advice.

According to our results, relational characteristics and reporting relationships seem to have a strong effect on tie creation in the advice network. Among these, the networks Accessibility (i.e. considering the person available in sharing her time and knowledge) and Utility (i.e. having the opinion that a person has a valuable and useful knowledge) appear to affect the most the decision of the advisor.

Despite the evidence provided by literature on the significance of gender homophily in building relationships, results did not provide support to the hypothesis related to this theme. On the other hand, for what concern tenure we thought that the higher the advisee would search for advice from people that have a higher tenure. This seems to hold, but the effect vanishes when we consider ties in informal networks. The same can be stated for belonging to the same business unit. We have also assessed the combined impact of this last two

characteristics (one formal, one personal) and the results leads to the same conclusion we had for the separated variables.

This work provides new evidences on the rationales that lead to the creation of ties for a specific type of informal network, namely the advice network. Indeed, researchers have widely investigated the importance of social interaction as a vehicle for knowledge acquisition and transfer (e.g. Nahapiet & Ghoshal, 1998, DeToni et al. 2010; Maurer, Bartsch & Ebers, 2011, Hansen 1999), information seeking (Borgatti, 2003), but little is known for what concerns specifically the of advice and help in problem solving.

Our result can lead also to formulate managerial implications. The choice of the individual from looking for advice in a firm can affect the advisee's performance. Literature has provided evidences that in general informal networks are connected to performances and this holds true also for the network on which we have focused our attention. Hence, it should be important for the firm to make sure that people who have the right expertise and knowledge to help others with advice or to solve problems are effectively accessible and that everybody in the firm knows who has valuable knowledge, since they are likely to be chosen as advisors.

CHAPTER 9

9 LIMITATIONS AND FUTURE DIRECTIONS OF RESEARCH

In this last chapter of our thesis, we highlight the limitations of the analysis and the spaces for future developments.

The limitations we had to face encompass these categories: i) data gathering and sufficient answering rate; ii) privacy concerns; iii) questionnaire design; iv) Tools used for the analysis; v) non-generalizability of the result; vi) observer bias

9.1 LIMITATIONS

Many issues and limits about SNA have been reported. Following Bender – de Moll (2008) we can categorize the limits of SNA in four categories: lack of privacy and related ethical issues, incomplete data, oversimplification and misreading, and misuse of network measures.

As concerns the first issue, Borgatti and Molina (2005) discuss ethical guidelines for using SNA. Basically, it is important to bear in mind that people who are subject of the study must be completely aware of what the researcher is asking to them. At the same time, the researcher must be good enough to collect a sufficient amount of data in order to have a meaningful set of information. Hence, the ability of the survey administrator to process this type of data must be high.

We followed what proposed by Hoppe and Reinelt (2010) to mitigate the probability an actor decides not to answer to our survey:

1. Educate people about the value of network data and about the benefits of SNA.
2. Explain clearly who will see the network data
3. Design a survey consistent with the intended use. For example, asking personal or delicate questions when the results of the survey are shared could be counterproductive.

About 1. and 2., we elaborated a presentation of the aims of thesis project to present in front of all the individuals belonging to the selected sample to provide them the listed information and to increase the rate of answer. We are confident in saying that this allowed us to reach a 77% of responses, which is above the suggested threshold to conduct this kind of analysis

(Borgatti, Carley & Krackhardt, 2006). Nevertheless, a missing answer leads to a consistent loss of information, since network survey results are particularly sensitive to **data omission**.

Other questions could have been included to have a clearer and more comprehensive understanding of the organization, but the **length** of the survey and the **time** to fill it are key to increase the willingness to answer.

The potentiality of the work was affected by the fact we dealt with **personal data and the agreement** in place with Novelis according to which in the final output there could not be any explicit reference to the respondents, nor the company directors would have ever visualized the networks with names. However, this had a positive impact in increasing the trust of the respondents towards us and for sure impacted positively on the answering rate.

For what concern **oversimplification**, sometimes it useful to use the networks map more to rise question than for answering them. For example, it is quite easy to jump to premature judgement about peripheral actors: but he could simply be the bridge between what studied and another critical part of the organization not detected with the survey. A researcher who is intended to improve the situation in a company should be ready to go in deep whenever the circumstances require for it.

Some measures of SNA are more likely to **be misused and misinterpreted**. For instance, density, which seems to be intuitive can be misinterpreted. Caution, and a clear understanding of the logical behind the metrics are required not to commit silly errors.

Another aspect that has not been furtherly exploited owing to time constraints regards the chance to have **feedback sessions** with company's management and the development of further interviews especially with key players to deeply dig into results (Cross, 2004). Though, we have provided Novelis with results and discussion elaborated. However, the provision of a more detailed and possibly direct feedback represents a future development that can be properly conducted by us also after the delivery of this thesis.

One significant limit is linked with the fact that this study encompasses **one company only**, which is very common in this research field (e.g. Kleinbaum 2013, Soda, ...; Borgatti 2008).

As a consequence, there cannot be any claim on the generalizability of our results beyond the boundaries of this single firm, since we cannot define the level of dependence of our results and findings on the configuration and organizational structure of Novelis.

As regards the **tool used for the analysis**, we relied on the QAP analysis. In particular, to test our models we had to run a LR-QAP regression which is the respective version of the MR-QAP, but used in case the dependent variable is a dichotomous matrix. Its application is suggested by Borgatti et al. (2018); but it is not as common as the MR-QAP. We suggest for future research to perform a similar analysis either collecting “valued relations” for what concerns the advice request in order to perform the MR-QAP. Since we wanted to encompass in the analysis a large number of employees to obtain an overall view of the company, we could not make them rate each relationship they have with the rest of the organization. Indeed, it would have required a high amount of time given the dimension of the sample, thus lowering the expected answer rate. Hence, we preferred to simply ask to report the persons that fit the characteristics of each question.

Since we have adopted a Mixed method, we are subject to the “**the observer bias**” which is typical of qualitative studies and happens when the researcher alters the outcome of the study. This may lead to the loss of valuable information and insight and is linked to several factors (for instance, the informant’s poor understanding of the researcher’s questions and the inaccurate recollection of events or the inability of the researcher to interpret and properly aggregate information provided by informants. To avoid this issue, we recommend using the same method we chose to adopt, that is register and transcript the interviews.

Moreover, we had to deal with **lack of benchmarks**, especially for what concerns the “case study”. Despite SNA is affirmed also among consulting companies, we could not find significant numbers that could represent a reference in the discussion of the implications of SNA results for Novelis (see for instance the level of cohesion among business units). This absence finds an explanation in the efforts and constraints that researchers of SNA face while performing this kind of analysis. Indeed, many of the analysed papers stress all the difficulties that arise in gathering data and the problems related to the privacy management.

9.2 FUTURE RESEARCH

During our work, we mainly used as a **reference database Scopus**, so first our advice for future researches is to expand the analysis also to other databases

One important element that we wanted to explore was the effect of networks and in particular of individuals' measures on **performances**. We could not perform this kind of analysis since the firm did not provide us performance measures. It could be interesting to create some KPI with target values and see how they change after performing a restructuring of the company based on SNA results.

In addition to the personal characteristics encompassed by our hypotheses (namely, gender and job tenure) it would be of interest to study how other features affect the creation of ties in the advice network, for instance the **level of education of the actors and their age**. Moreover, it would be interesting to assess whether the proportion of men/women in a particular department of the organization affects the creation of gender-homophile ties, namely if a significant presence of one gender weakens the gender homophily effect.

It would be interesting to develop this kind of study also in non-industrial networks, for instance co-authorship networks and test if the same hypotheses that we have tested in this thesis lead to similar results.

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