The network of interfamily marriages in 'Ndrangheta

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ABSTRACT

A common claim is that mafia families arrange marriages strategically to seal alliances, cement partnerships and enhance cohesion. However, this claim is mainly based on anecdotal evidence and limited case studies. In this paper, by relying on an original database of biographical and relational information on over 4,600 members, we carry out the first large-scale exploratory analysis of the network of interfamily marriages in 'Ndrangheta. Our analysis shows that this alliance network is polycentric, made up of cohesive subgroups centered around well-connected, powerful families, that occupy different positions in the network. The presence of patterns suggests that marriages in 'Ndrangheta are possibly the result of family strategies to explore and exploit their power and business. We discuss the implications of these findings for the study of marriages as an organizational instrument.

1. Introduction

14th century, Florence, Italy. Cosimo de' Medici used marriages to increase the power of his family. These strategic unions involved also members of hostile families, like the Strozzi, the Pazzi, and the Pitti, to exploit structural holes (Padgett and Ansell, 1993; Padgett, 2010).

19th century, Germany and Europe. The Rothschild family owned one of the most powerful financial institutions in the world. To maintain control of their banks and keep their business secret, Rothschilds married other Rothschilds: fifteen out of twenty-one marriages between 1824 and 1877 were celebrated between direct descendants (Ferguson, 1998, 2000; Kuper, 2001).

21st century, Reggio Calabria, Italy. In 2014, members of 'Ndrangheta clan Coluccio forced their daughter Giulia Immacolata, a thirteen-year-old girl, to break up with her boyfriend and engage with Cosimo Commisso, nephew of Vincenzo Macrì, the boss of another prominent 'Ndrangheta family. This union would have cemented the relation between the two mafia families, thus increasing their power inside the organization and allowing the Coluccio family to enter the drug business (Tribunale di Reggio Calabria, 2015, 1115).

Throughout the centuries, marriages have been an organizational instrument widely used by the elites, who have strategically relied on kinship for preserving power, reinforcing alliances, and preventing unwanted people from interfering in the family business.

The same concept applies to mafia families. For them, marriage is a particularly valuable and effective organizational instrument because it fosters trust, a resource crucial for their functioning and survival. Indeed, contrary to legal organizations, illegal ones cannot rely on conventional rules, mechanisms, and institutions to regulate transactions and disputes because they operate in a hostile environment and illicit markets (Gambetta, 1993; Paoli, 2002).

Specifically, mafia families use marriage strategically, both to explore and exploit their own power and business (March, 1991). On the one hand, they use exogamic marriages, i.e. unions between members of different mafia families, to expand their territory of influence, enter new businesses, seal alliances and smooth out conflicts with rival families (Ciconte, 1996). In this respect, unions are so important that the network of marriages reflects the structure of the organization and the actual network of alliances (Siebert, 1996). On the other hand, families rely on endogamic marriages, i.e. unions between members of the same family, to prevent intrafamily conflicts and business fragmentation by fostering cohesion (Schneider and Schneider, 1976).

Although suggestive, these claims are mostly based on anecdotal evidence or very limited case-studies. To better support them, this study complements the literature on the strategic use of marriages in mafia organizations by conducting a large-scale exploratory analysis of the network of interfamily marriages in 'Ndrangheta. To our knowledge, this is the first systematic analysis of matrimonial ties in a mafia organization.

We chose 'Ndrangheta because it is a blood-based organization: 'Ndrangheta families are actual families, a characteristic that makes this organization particularly well suited for our most-likely case research design (Yin, 2017). Moreover, 'Ndrangheta is also an empirically relevant case for its global organizational and economic 'success'.

Our analysis relies on an original database that includes relational information on over 4600 'Ndrangheta members since the second half of the XIX century. The database is based on information extracted from over 40,000 pages of judicial documents issued by the Courts of Reggio Calabria and Catanzaro, and the family trees of some of the most powerful 'Ndrangheta families.

We use exploratory social network analysis to visualize and describe the features of the interfamily marriage network (alliance network) and the position of the different families in it. In particular, after having identified the network components, we study the largest one. We detect commu-

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nities and cohesive subgroups, and identify the most important families in terms of centralities, prestige and aggregate constraint resulting from the absence of structural holes to be exploited. The analysis of the interfamily marriage network shows the existence of matrimonial patterns and significant variance across families, a result that possibly hints at a strategic use of marriage by 'Ndrangheta families.

The rest of the paper is organized as follows. Section 2 discusses the role of marriage in mafia organizations according to the existing literature and points out the lack of systematic studies. An illustration of the main relevant organizational features of 'Ndrangheta follows. Section 3 presents the data and the analytical strategy. In Section 4, we illustrate the main results. In Section 5, we discuss them. Section 6 concludes.

2. The strategic use of marriage in mafias

Throughout history, elites have relied on marriages as an organizational instrument to seal alliances for increasing business and power, and fostering intrafamily cohesion (e.g. Padgett and Ansell, 1993; Ferguson, 1998).

Mafia families have also used marriages strategically. For instance, in the Seventies, the alliance between Ursini and Scali, two 'Ndrangheta families from Marina di Gioiosa, in the ongoing war over smuggling, was sealed through a marriage (Gratteri and Nicaso, 2018). In fact, as pointed out by Varese (2017, 125), in mafias "marriage is always strategic, never the culmination of a genuine passion".

For these organizations, marriage is a particularly valuable tool because of its ability to generate trust even where it is scarce and difficult to build. Indeed, trust is widely recognized to play a central role in all organizations (Zand, 1972; Gambetta, 1988; Kramer and Tyler, 1996; Bachmann et al., 2001; Nee and Opper, 2012; Jiang and Probst, 2015), but it is really crucial for secret societies (Simmel, 1906), including criminal organizations (von Lampe and Johansen, 2004; Campana and Gelsthorpe, 2020). The reason is that these organizations operate in a hostile environment, where the repression of law-enforcement agencies makes them vulnerable to infiltration by undercover agents and informers (the so-called *pentiti*). Moreover, criminal organizations cannot rely on conventional rules, mechanisms, and institutions to regulate transactions and disputes (Paoli, 2002), and they have to generate trust through personal relations (Beckert and Wehinger, 2012).[1]

Mafias put a lot of efforts in nurturing trust. In this respect a primary goal of mafia rituals, including the affiliation ceremony (called 'baptism' in Italian mafias),[2] the ceremonies for the award of new offices and ranks, and the *mangiate* (shared great meals) is precisely the creation of trust,

a shared social identity and sense of belonging among its members (Paoli, 2003; García, 2006; Catino, 2019). Selection of trustworthy new members is also at the heart of recruitment in mafia organizations. Since shared ethnicity fosters trust (Brewer, 1981; Landa, 1994; Fearon and Laitin, 1996; Habyarimana et al., 2009; Abascal and Baldassarri, 2015), ethnicity-based recruitment is a strategy commonly adopted by mafias.[3]

Marriage is another mean to foster trust. In this respect, matrimonial unions are particularly effective, because they create bonds made of sons and daughters, of brothers and sisters rather than of legal clauses. Because of their ability to create trust, for mafias marriages are a valuable instrument to explore and exploit their power and business (March, 1991). On the one hand, by sealing alliances and partnerships, marriages can favor business expansion and power increase (exploration); on the other hand, by fostering intrafamily cohesion, they can preserve and increase family economic and military power (exploitation).

To foster intrafamily cohesion, mafias rely on endogamic marriages, i.e. unions between members of the same family. This type of union is used to prevent intrafamily conflicts, avert the entry of 'unwanted' members who may compromise internal trust and increase business efficiency by preventing asset fragmentation (Ciconte, 1996; Arlacchi, 1986). For instance, in Villamaura, a small village in western Sicily, to foster intrafamily cohesion families associated with mafia have favored marriage between cousins, and especially between patrilinear cousins. This strategy was deemed necessary because, contrary to the general population, brothers from mafia families carry on working together even after the death of their father to maximize productivity of herds and avoid land fragmentation. Nevertheless, as the family grows, so does the risk of strains among relatives (Schneider and Schneider, 1976).

Mafia families use strategically also exogamic marriages, that is unions between members of different families. The goal of these marriages is, on the one side, to seal alliances and smooth out conflicts with rival families; on the other side, to expand the territory of influence and enter new businesses (Ciconte, 1996). As examples of unions aimed at sealing alliances and reducing conflicts, it is worth recalling the marriage between Venanzio Tripodo and Teresa Romeo, members of families belonging to two opposite factions. Their union marked the end of the first war of 'Ndrangheta in 1977 (Gratteri and Nicaso, 2018). Another example is the marriage between Giuseppe Barbaro and Elisa Pelle, children of two prominent 'Ndrangheta families, that was meant to reassert and strengthen the alliance between the two families and to display their power in front of the other 'Ndrangheta families.[4] As an example of unions aimed at in-

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[1]In general, cooperation can be generated via trust or control, two mechanisms that tend to be supplementary (Das and Teng, 1998). Since control methods (e.g., violence, monitoring, incentive systems) can jeopardize security by exposing criminal organizations to law-enforcement agencies, mutual trust represents the most effective mechanism to maintain secrecy (Catino, 2019, 299-303).

[2]It is the moment when recruits formally enter the organization and they are given a new identity as 'men of honor'.

[3]Shared ethnicity-based trust is a typical situation of trust based on generalization, as trust relates to the characteristics of a social group rather than individuals (Smith, 1980; von Lampe and Johansen, 2004).

[4]The wedding took place on August 19, 2009 in San Luca, a small village in the Aspromonte area (Calabria), a prominent 'Ndrangheta stronghold. So many guests were invited that the reception needed to be held in two different places.

creasing influence and entering new businesses, it is worth recalling the case involving the Coluccio family. In 2014, the thirteen-year-old Giulia Immacolata was forced by her parents to engage with Cosimo Commisso, nephew of Vincenzo Macrì, to increase the Coluccio family's power inside 'Ndrangheta and allow them to enter the drug business (Tribunale di Reggio Calabria, 2015, 1115).

Finally, another characteristic of marriage in mafia organizations is the role of women. As illustrated by the case of Giulia Immacolata, women play a central, yet passive, role in the matrimonial strategies of their families. As pointed out by Arlacchi (1986) and Siebert (1996, 2007), women are indeed a mean to seal alliances, economic partnership and peace among families. In mafia organizations, women are objects of exchange to be 'given away'.[5] The instrumental role of women can be explained by the fact that "the mafia is an authoritarian organization [...] with unwritten laws, traditional behavior, and interpersonal relationships informed explicitly by powerful patriarchal family traditions" (Siebert, 2007, 39).

Summing up, the literature has highlighted three main characters of marriages in mafia organizations: i) exogamic marriages are an organizational instrument strategically used to seal alliances and business partnerships among mafia families; ii) women are the passive means used by families to pursue the above strategy; iii) endogamic marriages are strategically used by families to enhance their internal cohesion.

However, these statements are mostly based on anecdotal evidence or very limited case-studies. In this respect, our study complements the existing literature on the strategic use of marriage in mafias by conducting a large-scale exploratory analysis of the network of interfamily marriages. Whereas some scholars have systematically studied matrimonial corpuses in small communities and found nonrandom patterns (Roth et al., 2013; Ramirez and Legendre, 2018), to the best of our knowledge, this is the first large-scale analysis of matrimonial ties in mafia organizations.

In particular, we analyze the network of interfamily marriages in 'Ndrangheta, an Italian mafia that emerged in Calabria (a Southern Italian region) in the late 19th century (Ciconte, 2014). Today 'Ndrangheta is present in many areas around the world. In several of these areas, it does not just trade in both illicit and licit markets (Sergi and Lavorgna, 2016), but it also performs mafias' typical activities of governance and supply of extra-legal services to other actors, activities that require a certain degree of territorial control: business development, limitation of competition and contract enforcement (Catino, 2020, 106). 'Ndrangheta can perform such activities also outside Calabria because it is the only mafia that successfully reproduced its organizational structure in non-traditional areas, both in Italy and in other European and non-European countries (e.g., Australia, Germany, the Netherlands) (Paoli, 1994, 2003; Ciconte and Ma-

crì, 2009; Forgione, 2009a; KLPD, 2011; Calderoni et al., 2016).[6]

'Ndrangheta is an economically and organizationally successful criminal organization to the point that today it is considered one of the most threatening organized crime groups at a global level (Ciconte, 2014). Among the Italian mafias, it is the one with the most diversified revenues, as the majority of its income is generated outside Calabria (Calderoni, 2014). It was able to reproduce its structure in several countries and at the same time maintain a remarkable level of internal cohesion in spite of the geographical dispersion to the point that "'ndrine around the world perceive themselves as being part of the same collective entity" (Varese, 2011, 32).[7]

One of the reasons of the success of 'Ndrangheta is that the basic organizational units are patriarchal, hierarchical actual blood families (Ciconte, 2014; Sergi, 2020). 'Ndrangheta is the only mafia that made bloodline recruiting an organizational pillar: the sons of 'men of honor' are considered young 'men of honor' from their birth, although they formalize their entry into the organization only when they get older (Zagari, 1992; Ciconte, 1996; Paoli, 2003). Because of blood-based recruitment, the level of trust and security in 'Ndrangheta are relatively high, and 'Ndrangheta counts the lowest number of *pentiti* (collaborators with justice) among Italian mafias (Catino, 2019, 2020).

In what follows, we reconstruct 'Ndrangheta network of interfamily marriages in order to analyze in a large-scale study three aspects of marriage in mafias highlighted by the literature discussed above: i) 'Ndrangheta interfamily matrimonial patterns; ii) possible differences in the strategic matrimonial 'use' of females and males by 'Ndrangheta families; iii) the strategic use of endogamic marriages.

3. Data and methods

Social Network Analysis (SNA) has already proved useful to advance our understanding of criminal organizations and their illicit activities (Morselli, 2010; Calderoni et al., 2017; DellaPosta, 2017; Giommoni et al., 2017; Morselli and Boivin, 2017; Campana, 2018, 2020; Bouchard, 2020; Gollini et al., 2020; Tumminello et al., 2021). This study applies SNA to the analysis of a different organizational aspect of criminal organizations: interfamily marriages. Our aim is to carry out an exploratory analysis to outline and an-

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[5]According to Bourdieu (2001), women are "symbolic instruments of male politics", they are "assets [...] which, when invested in exchanges, can produce alliances, in other words social capital, and prestigious allies, in other words symbolic capital" (2001, 43-45).

[6]'Ndrangheta geographic expansion was led by several factors, such as the need to escape from prosecution and criminal wars, and the opportunity of new profits (Varese, 2006, 2011).

[7]All over the world, the organization displays the same structure. The basic organizational level is the *'ndrina*, consisting of up to a few dozen members of different hierarchically organized families. Several *'ndrine* from the same area form the *locale* (the local), or *società*), a consortium of at least 49 members operating in a specific territory. Each *locale* decides over criminal activities, membership and promotions within its territory of competence. Different *locali* can cooperate while preserving their autonomy and their areas of influence (Paoli, 2003; Forgione, 2009b; Ciconte, 2014). Lastly, at the supra-local and regional levels there are, respectively, *mandamenti* (districts) and *Provincia* (Province), or *Crimine* (Crime), managing structures aimed to reduce feuds among families and give the organization a unified governance (Catino, 2019).

alyze the features of the matrimonial network and to assess the positions of the different families in it.

3.1. Sources and data extraction

The analysis is based on an original database of over 4,600 'Ndrangheta members[8] and the individuals they are linked to through blood or by marriage. For each individual, the database contains both personal details (surname, first name, date and place of birth) and relational information on marriages and lineage (sons).

Data were collected from two sources. The first consists of the family trees of nine of the most important 'Ndrangheta families, namely: Barbaro, Galati, Iamonte, Mancuso, Moscato, Papalia, Perre, Sergi, Trimboli. We retrieved these trees from judicial documents pointed out and provided by prosecutors and field experts from law enforcement agencies.

The second source is made up of judicial documents (over 40,000 pages) related to 40 different criminal investigations against 'Ndrangheta led and coordinated by public prosecutors of the Reggio Calabria and Catanzaro DDAs (Antimafia District Directorates) between 2007 and 2016.[9] We selected these DDAs because of their jurisdiction over Calabria, the region considered the 'Ndrangheta's stronghold (Calderoni, 2011). The investigations were selected according to the following sampling strategy. First, since mafia-related investigations are referred to in DIA annual reports, we created a database of all criminal investigations for 416-bis conducted against 'Ndrangheta in Calabria and named in DIA reports issued between 2007 and 2016 (about 50,000 pages). The screening process resulted in a list of 192 investigations, out of which 129 (approximately 2/3) were led by the DDA of Reggio Calabria and 63 (approximately 1/3) by the DDA of Catanzaro. From the 192 investigations we randomly selected a sample of 40 investigations stratified according to the distribution of investigations between Reggio Calabria (2/3) and Catanzaro (1/3). In particular, we randomly selected 25 investigations among the 129 led by the DDA of Reggio Calabria and 15 among the 63 led by the DDA of Catanzaro (see Appendix). For these investigations, we retrieved the associated judicial documents: 29 pre-trial court orders (OCC); 4 public prosecutor's requests to the judge for suspects' freedom pre-trial restrictions; 7 orders to hold the crime suspect into custody issued by a public prosecu-

tor (*fermo*).[10] Since the Italian law requires a judge to validate pre-trial detention upon evaluation of the existence of serious indications of guilt and risk of flight, suppression of evidence or repetition of offences, these documents include detailed biographical information about the suspects and the individuals they are connected with.

By using these data sources, we created three datasets: one with personal details (name, surname, date and place of birth and, when available, date and place of death); one comprising the list of matrimonial ties; and one which associates each individual to his/her parents.[11]

Although admittedly the judicial files are not necessarily representative of the criminal groups overall, and, as a secondary data source, they were collected for purposes different from those in this research, they nevertheless contain relevant and reliable information concerning the relational dynamics of criminal groups (Berlusconi, 2013; Campana and Varese, 2020; Bright et al., 2021).

3.2. Network construction

The data extraction resulted in a database of 4,675 individuals and linkages among them who form standard kinship networks, i.e. kinship networks where the two conditions of unique descent and heterosexual marriage are satisfied (Hamberger et al., 2011). Because of the patriarchal nature of 'Ndrangheta (Siebert, 2007) and also following what done by Padgett and Ansell (1993), we partitioned the network on the base of individuals' last name and shrank each partition into a single node. We decided not to carry out properly defined kinship network analysis because there are likely many missing links in the dataset. This is due to the nature of our sources, namely judicial documents that were prepared for purposes other than carrying out kinship analysis.

Generally speaking, the boundary of a 'family' is defined according to the lineage, i.e. the descendance from a common ancestor. Depending on the culture of the society, the lineage may be either the father's lineage (agnatic kinship) or the mother's lineage (uterine kinship). In the former case, we have a patrilineal system, in which family membership of individuals is based on the father's lineage; in the latter, we have a matrilineal system, where family membership is based on the mother's lineage. Because of the patriarchal nature of 'Ndrangheta, family is here defined by the agnatic kinship.

Table 1 reports some descriptive statistics for the whole sample of individuals in our database and the 27 families

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[8]We use 'members' to indicate both full members and recruits. In fact, individuals become members of 'Ndrangheta only after undertaking the initiation ritual, i.e. baptism. Until then, they are recruits called *contrasti onorati* (honored contrasts) or, if they are sons of 'ndranghetisti, they are considered young men of honor. In this latter case, baptism is just a formalization of their entry into the organization (Ciconte, 1996).

[9]Antimafia District Directorates (*Direzioni Distrettuali Antimafia*, DDAs) are special sections of public prosecutor's offices in Italy. There are 26 DDAs, one in each district of Courts of Appeal. DDAs are coordinated at the national level by the National Antimafia Directorate (*Direzione Nazionale Antimafia*, DNA) in Rome. The investigations were conducted by different law enforcement agencies, in particular by the Antimafia Investigative Directorate (*Direzione Investigativa Antimafia*, DIA), an Italian multi-force law enforcement agency made up of officers from the three main Italian police forces (Polizia, Carabinieri, Guardia di Finanza) and specialized in anti-mafia investigations.

[10]All judicial documents were kindly provided by Milan-based DIA. Pre-trial detention orders (*Ordinanze di Custodia Cautelare*, OCC) are judicial documents similar to arrest warrants that are issued by the preliminary investigation judge (*Giudice per le Indagini Preliminari*, GIP) upon request by the public prosecution. Under special circumstances, the public prosecutor may independently issue an order to hold the suspect in custody (*fermo*), that has to be eventually validated by the GIP.

[11]The data were extracted and coded manually. First, we entered personal details and relational information about all individuals included in family trees. Second, we retrieved relational information and personal details from the selected judicial documents using ten keywords related to Italian terms for family members (e.g. husband, wife, mother, father, son, daughter). Finally, we run consistency checks on individuals, marriages and families and consolidated duplicated individuals and families.

Table 1
Statistics by family (for families with at least 20 members in the sample)

Surname	Members	Female (%)	Birth year		Place of birth (Mode)			
			Mean	Median	Municipality	%	Province	%
Barbaro	110	47	1960	1963	Platì	92	Reggio Calabria	98
Romeo	49	33	1962	1966	Platì, San Luca	18	Reggio Calabria	97
Alvaro	48	25	1958	1963	Sinopoli	62	Reggio Calabria	100
Galati	36	31	1963	1968	Mileto	55	Vibo Valentia	92
Morabito	36	36	1960	1963	Bova Marina	28	Reggio Calabria	92
Sergi	36	31	1964	1963	Platì	57	Reggio Calabria	95
Serpa	33	27	1968	1966	Paola	68	Cosenza	84
Papalia	32	44	1962	1965	Platì	77	Reggio Calabria	94
Vallelunga	32	31	1961	1962	Mongiana	43	Vibo Valentia	75
Torcasio	31	39	1975	1975	Lamezia Terme	92	Catanzaro	100
Gualtieri	30	33	1977	1977	Lamezia Terme	87	Catanzaro	87
Trimboli	28	39	1963	1963	Platì	83	Reggio Calabria	100
Tripodi	28	54	1953	1953	Reggio Calabria	57	Reggio Calabria	100
Bellocco	27	26	1971	1979	Rosarno	35	Reggio Calabria	96
Iamonte	27	30	1962	1961	Melito di Porto Salvo	88	Reggio Calabria	100
Minniti	26	58	1948	1937	Melito di Porto Salvo, Reggio Calabria	50	Reggio Calabria	100
Palamara	26	35	1965	1966	Africo, Roccaforte del Greco	25	Reggio Calabria	100
Giampà	25	36	1969	1971	Lamezia Terme	75	Catanzaro	94
Chirico	23	26	1956	1951	Reggio Calabria	68	Reggio Calabria	84
Cordì	23	30	1961	1972	Locri	100	Reggio Calabria	100
Mancuso	23	17	1951	1949	Limbadi	74	Vibo Valentia	87
Condello	22	41	1967	1972	Reggio Calabria	63	Reggio Calabria	100
Piromalli	21	43	1948	1945	Gioia Tauro	90	Reggio Calabria	100
Commisso	20	25	1956	1954	Siderno	80	Reggio Calabria	100
Longo	20	30	1963	1964	Galatro, Taurianova	15	Reggio Calabria	55
Moscato	20	45	1963	1968	Desio	50	Monza	55
Raso	20	20	1959	1948	Cittanova	55	Reggio Calabria	75
All sample	4675	31	1965	1967				

(operationally defined by common last name, as we have just discussed) with at least 20 members. In particular, for each family we report: number of members; percentage of females; mean and median year of birth. Moreover, for each family, we have analyzed the spatial distribution of the place of birth of its members and the same table reports the mode (along with its relative frequency) of the places of birth in terms of municipalities and Provinces (NUTS 3 regions). The spatial concentration for most of the families is very high and it gives a rather precise indication of the geographical area where they live and operate.[12]

We use the 'family-nodes' to determine the network of interfamily marriages, which is a weighted directed network (or valued digraph). In this network, each node (or vertex) i is a family, that is, each node represents all the individuals having the same last name. Each directed link (or arc) (i, j) between node i and node j represents marriages between members of family i and of family j. The source node i is the family of the bride/wife whereas the target node j is the family of the groom/husband.[13] The weight attached to the arc (i, j) is the number of marriages between females of family i and males of family j.

The network is in fact an example of what Hamberger et al. (2011, 544) term alliance network, i.e. "a network composed of vertices representing groups of individuals and arcs representing marriage frequencies between the groups, where the value of an arc from A to B indicates the number of marriages of a woman of A with a man of B".

The construction of a directed network, where the direction of links goes from the bride's family to the groom's family is coherent with the literature discussed in Section 2, that points out the fact that in 'Ndrangheta women are used by families as 'gifts' to be given away to seal alliances. It is also consistent with Lévi-Strauss' (1971) 'generalized exchange'

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[12]This spatial analysis has also allowed us to make targeted checks for the actual existence of agnatic kinship among individuals classified in the same family following the criterion of the common surname, in the cases where the resulting spatial concentration of the places of birth was low. Namely, we checked families with 50% or less of their members born in the same municipality. We found that the dispersion was due to one or more of the following reasons: i) father, brothers and sisters born in different but very close municipalities (e.g. Morabito, Palamara); ii) members of a branch of the family born in a different municipality within the same province (e.g. Vallelunga); iii) members of a branch of the family born in a different province (e.g. Vallelunga) or region (e.g. Moscato). The only exception is the Longo family, whose members were born in three different provinces (Catanzaro, Reggio Calabria and Cosenza) and we did not find a common ancestor. However, since Longo turns out to be marginal in our analysis, we decided not to split the family in three parts.

[13]In the network analysis, we do not consider and remove loops. Loops actually identify 'endogamic marriages'. We shall deal with them in the last part of the analysis.

Figure 1: Weighted directed network of interfamily marriage relations in 'Ndrangheta. The network is directed, the family of the marrying female (male) is the source (target) node, and weighted, with weights given by the number of marriages (line thickness).

model of alliances, according to which women are circulated among groups according to an oriented cycle of alliances. Therefore, if women from group A tend to marry men from group B and vice versa, matrimonial relations between group A and B are symmetric, otherwise they are asymmetric.[14]

The network has 1504 nodes, out of which 868 nodes are not isolated.[15] The subnetwork made up of these 868 nodes is shown in Figure 1.[16] The largest weak component of this network, i.e. the maximal weakly connected subnetwork with the greatest size, comprises 623 nodes (71.8%).[17]

In what follows, we shall consider the symmetrized version of this subnetwork, obtained by transforming all arcs (directed links) in edges (undirected links) by summing up the weights of the bidirected arcs among pairs of nodes, and we will refer to it as the network of interfamily marriages. We shall consider the directed network only when we will deal specifically with the analysis of the 'use' of females in matrimonial strategies across families.

Finally, it is worth pointing out that the network is likely incomplete and biased towards some families as it might be characterized by non-random (node and link) missingness. Indeed, since the network is based on data retrieved from judicial documents, missingness can be influenced by the level of enforcement and the changing priorities of police and law-enforcement agencies, along with their degree of selectivity of enforcement (Calderoni, 2014; Campana and Varese, 2020). Moreover, in the network there is probably an 'under-representation' – in terms of members and matrimonial ties

– of the families for which we do not have family trees (see Section 3.1).[18]

3.3. Analytical plan

To explore matrimonial patterns, we analyze the structure of the network of interfamily marriages and the position of 'Ndrangheta families in it. To assess the position of 'Ndrangheta families, we analyze their relational properties. In particular, we compute different measures of node centrality and nodes' aggregate constraint.

With regard to the measures of node centrality, we compute: i) degree centrality, i.e. the number of different families each family is connected with; ii) strength, i.e. the number of interfamily marriages each family is involved in; iii) closeness centrality, i.e. the number of other nodes divided by the sum of all distances between the node and all the others, a centrality measure that extends degree centrality by looking also at indirect connections between families; iv) Freeman's (1977) betweenness centrality, i.e. the proportion of all the shortest paths between pairs of other nodes that include the node, a measure of the importance of a node in connecting other nodes in the network, thus capturing the role of a family as an intermediary in the transmission of information or resources between other families in the network and that has been used to explain also the rise of the Medici (Padgett and Ansell, 1993; Jackson, 2008); v) eigenvector centrality, or Bonacich (1972) centrality, where the centrality of a node depends on the centrality of its neighbors (Wasserman and Faust, 1994; De Nooy et al., 2018).[19]

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[14]The issue of asymmetry in matrimonial relations between groups has been widely debated by anthropologists (e.g. Leach, 1951; Ackerman, 1964; Needham, 1964; Hamberger et al., 2011; Ramirez and Legendre, 2018).

[15]The presence of isolated nodes is due to missing info: each isolated node represents a family for which the information about the (blood or marriage) relations with individuals having a different surname is missing.

[16]All the graphs and network analysis were made using Pajek 5 (De Nooy et al., 2018).

[17]The size of the second largest component is only 7.

[18]The effect of nonrandom node missingness on network measurement has been recently investigated by Smith et al. (2017). They find that the bias is worse when more central nodes are missing and, among centrality measures, closeness and betweenness centrality have higher levels of bias than degree centrality, while eigenvector centrality appears the most sensitive to the missing of central nodes. Moreover, distance is more affected than triad census.

[19]Although there are generalizations of closeness and betweenness cen-

To assess the overall structure of the network, we compute also the corresponding centralization measures, i.e. the actual variation in the measure of node centrality divided by the maximum variation that is theoretically possible for the same measure in a network of the same size (Wasserman and Faust, 1994; De Nooy et al., 2018). From the degree centrality, we compute the degree assortativity coefficient r (Newman, 2003), which ranges from -1 to 1 and it tells us if well-connected families (nodes with high degree) are linked on average with well-connected families ($r > 0$) or poorly-connected families ($r < 0$).

To investigate families' power related to the existence of brokerage opportunities to be exploited, we identify the structural holes in the network of interfamily marriages and compute the resulting aggregate constraint on each family (Burt, 1992, 2005; De Nooy et al., 2018). From this perspective, a family's opportunity of brokerage is related to the absence of marriages between its neighbors, i.e. the families it is connected with. A complete triad in the ego-network of a family (marriages between two of the family neighbors) implies instead a constraint for the family itself, known as the dyadic constraint associated with a link from the ego's point of view. The higher the sum of these constraints, the fewer the opportunities to broker. Thus, to measure families' opportunity of brokerage, we determine the network of dyadic constraints resulting from the network of interfamily marriages and compute the associated aggregate constraint for each family.

Then, we apply community detection methods to identify the clusters of families on the base of their marriage relationships, i.e. the clusters of nodes for which the strength of links inside clusters is larger than the density and strength between clusters. In particular, we apply the Louvain method that searches for the partition of nodes into clusters with the highest value of modularity, a measure for comparing density and weights of links inside and outside clusters (Blondel et al., 2008; Rotta and Noack, 2011; De Nooy et al., 2018).[20]

We identify cohesive groups of families by determining the k-cores in the network. k-cores are maximal subnetworks in which each node has at least degree k within the subnetwork, i.e. each node has got at least k neighbors in it (Seidman, 1983; Wasserman and Faust, 1994). For instance, a 3-core contains all the families that are linked through marriage to at least three other families in the core. To identify cohesive subgroups, one has to eliminate the nodes of the lower k-cores until the network breaks up into relatively dense components (Wasserman and Faust, 1994; De Nooy et al., 2018).

To identify cohesive groups, we analyze also the structure of overlapping cliques. More precisely, we concentrate on the analysis of the subnetwork induced by the overlapping complete subnetworks of size three (complete triads) and four found in the network of interfamily marriages. In this induced subnetwork the nodes that are not part of at least one complete subnetwork (of size three or four) are removed and cohesive subgroups are identified by looking at the components (De Nooy et al., 2018, 86-91).

To disentangle the different roles played by females and males in matrimonial strategies of 'Ndrangheta families, we compute authority and hub scores of nodes (Kleinberg, 1999) and identify hubs and authorities in the weighted directed network of interfamily marriages. Hubs are nodes that are important 'senders' connected with authorities, whereas authorities are nodes that are important 'receivers' connected with hubs.[21] As discussed in Section 3.2, since the literature has pointed out that women are used by families as 'gifts' to be given away to seal alliances, we classify the family of the marrying female as the source node and the family of the marrying male as the target node, and therefore the former family is a potential hub and the latter a potential authority.

Finally, to explore the role of endogamic marriages in the matrimonial strategies of 'Ndrangheta families, for each family we compute the percentage of endogamic marriages on their total marriages.

4. Results

Regarding the position of 'Ndrangheta families in the interfamily marriages network, Table 2 shows summary statistics of the distributions of node centrality indices (degree, strength, eigenvector, closeness and betweenness) in the network of interfamily marriages.

On average, every family is linked to two other families (the mean degree centrality is 2.47), and some are connected by multiple marriages (the mean strength is greater and equal to 2.73). The distributions of degree centrality and strength are positively skewed (the means are higher than the medians), with the most connected families being linked through marriages with about twenty other families.

Considering eigenvector centrality, 95% of the families show a value lower than 0.06, whereas the score of the top five ranges from 0.42 (Barbaro) to 0.23 (Morabito). This is reflected in the rather large eigenvector centralization measure (0.6).

Results for betweenness centrality displays a similar although less pronounced pattern: on the one hand, the mean is close to zero (0.01) and 95% of the families exhibit values lower than 0.05; on the other hand, the top five scores range from 0.23 (Romeo) to 0.11 (Piromalli).

Compared with the other measures of centrality, closeness centrality is less dispersed and asymmetric. The mean is 0.15 (almost equal to the median) with a standard deviation of 0.025. The 95th percentile is 0.11, whereas 0.23 (Romeo) is the highest value. These data suggest that no family in the network can easily reach most of the others, and the

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tralities to weighted networks (Newman, 2001; Opsahl et al., 2010) and eigenvector centrality can be readily computed also for weighted networks, we decided to compute these measures on the binarized network to reduce somehow the bias induced by the possible 'under-representation' of some families in the data, an issue discussed at the end of Section 3.2.

[20]We also apply VOS clustering (Rotta and Noack, 2011), an alternative method which uses the VOS quality function instead of modularity, and we study the association between the two partitions (De Nooy et al., 2018).

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[21]A node may be both an authority and a hub. In the symmetrized network, authority and hub scores coincide with eigenvector centralities.

Table 2
Centrality measures and aggregate constraints for the network of interfamily marriages

	Degree		Strength		Eigenvector		Closeness		Betweenness		Aggregate constraint
Mean	2.47		2.73		0.013		0.154		0.009		0.701
Median	1		1		0.001		0.155		0.000		1.000
SD	2.66		3.64		0.038		0.026		0.021		0.337
5th percentile	1		1		0.000		0.111		0.000		0.167
95th percentile	8		9		0.058		0.199		0.046		1.000
Highest (lowest) values:											
1	Romeo	22	Barbaro	48	Barbaro	0.423	Romeo	0.228	Romeo	0.234	(Galati) 0.054
2	Galati	20	Romeo	28	Romeo	0.361	Tripodi	0.225	Tripodi	0.189	(Bellocco) 0.077
3	Barbaro	18	Papalia	25	Papalia	0.328	Barbaro	0.221	Condello	0.141	(Tripodi) 0.087
4	Tripodi	18	Galati	22	Perre	0.246	Condello	0.219	Galati	0.136	(Morabito) 0.087
5	Morabito	15	Tripodi	20	Morabito	0.228	Morabito	0.218	Piromalli	0.110	(Romeo) 0.093
Centralization	0.032				0.604		0.149		0.225		
Assortativity	-0.097										

Notes: Eigenvector, closeness and betweenness centrality and centralization indices are computed on the binarized network.

network is not centralized: the centralization score is rather low (0.15).

Moreover, the negative, although rather low, degree assortativity coefficient (-0.1) points out that poorly-connected families (low degree centrality) are connected on average with well-connected ones (high degree centrality).

The above statistics point to three characteristics of the alliance network. First, the high dispersion of centrality measures, the low value of the closeness centralization score and the (slightly) negative degree assortativity coefficient, all hint at the fact that the network is polycentric, revolving around few, well-connected families.

Second, the variation in centrality measures scores across the most central families suggests that those well-connected families may occupy different positions in the network. As far as node centrality is concerned, it is worth making a comparison between two of the most central families according to the different indices in our database: Barbaro and Romeo. Although the total number of interfamily marriages involving a member of the Barbaro family is significantly larger than the Romeo family (strength: 48 vs. 28), the latter is connected with a higher number of different families (degree: 22 vs. 18) and this resolves itself in larger betweeness and closeness centralities for Romeo, although Barbaro has yet a larger eigenvector centrality (0.42 vs. 0.36) for it is connected with a smaller number but more central families.

Finally, the analysis of structural holes and families' aggregate constraints confirms a significant variance in relational features across 'Ndrangheta families, and specifically the polycentric structure of the network. In particular, the analysis shows that well-connected families tend to be also powerful. The last column of Table 2 reports summary statistics of the distribution of aggregate constraints along with the families exhibiting the lowest scores. The mean aggregate constraint is rather high (0.7, with a standard deviation of 0.34), but the 31 families in the 5th percentile show an aggregate constraint lower than 0.17. Moreover, 7 out of the 10 families with the lowest constraint score also in the top

10 in at least one centrality measure.

Galati stands out for the very low aggregate constraint (0.05), followed by Bellocco (0.08), Tripodi, Morabito and Romeo (0.09). Looking at the latter families in Figure 2, which shows a subnetwork of the valued directed network of dyadic constraints (energized with Kamada-Kawai using the line values as similarities) resulting from the network of interfamily marriages,[22] it appears that their ego-networks exhibit many structural holes they can exploit, suggesting that they wield a certain amount of power toward the other families they are connected with.[23] This becomes apparent if we compare Romeo and Tripodi to Barbaro. Barbaro's higher aggregate constraint (0.18) reflects the higher density of their ego-network.

The polycentric structure of interfamily marriages network is also confirmed by the analysis of communities and cohesive subgroups. Figure 3 shows (in different colors) the 23 communities the network of interfamily marriages have been partitioned in through the Louvain community detection method (with resolution parameter set to 1).[24] In the figure, edge width is proportional to the number of interfamily marriages and node size is proportional to the number of members in each family in the database. The largest cluster in terms of families (51 families, 247 individuals, in black in the figure) is the one that revolves around the Tripodi family, by far the most important in terms of all the centrality indices (degree, strength, betweenness, closeness and eigenvector centrality) in the respective cluster, where the other two most central families in the cluster are Minniti and Iamonte. The largest cluster in terms of individuals (47 families, 440 individuals, in blue in the figure) is instead the one

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[22]This subnetwork comprises all the nodes belonging to the two largest communities identified via community detection (see below).

[23]The lower the aggregate constraint of a certain node, the more its ego-network approximates a star-like structure.

[24]VOS clustering with resolution parameter set to 0.15 finds the same number of communities, and the association between Louvain and VOS community partitions are rather large, with an adjusted Rand Index of 0.47 and the three Rajski coefficients over 0.7.
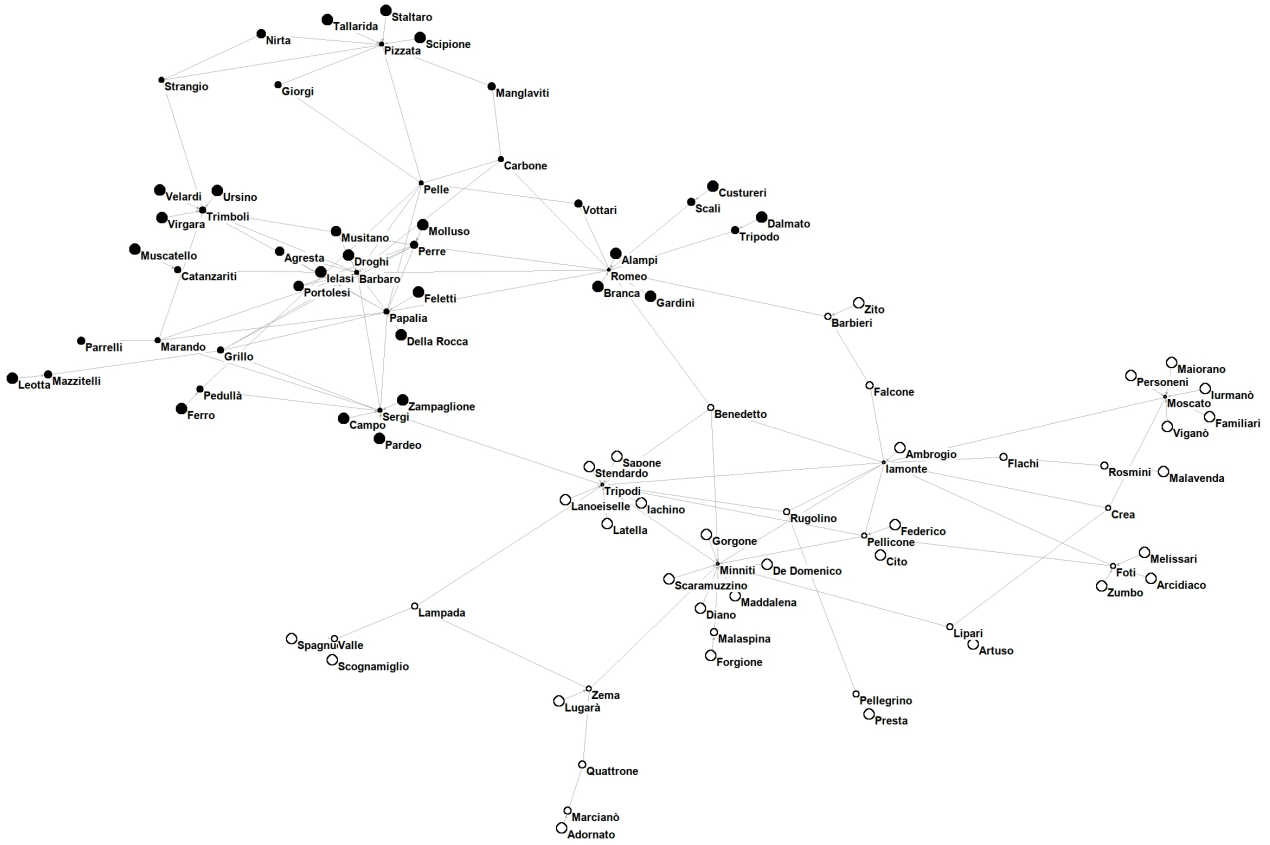
The network of interfamily marriages in 'Ndrangheta

Figure 2: Structural holes in the two largest communities of the network of interfamily marriages in 'Ndrangheta. Weighted directed network of dyadic constraints, computed from the network of interfamily marriages and energized with Kamada-Kawai using line values as similarities. Node size is proportional to aggregate constraint.
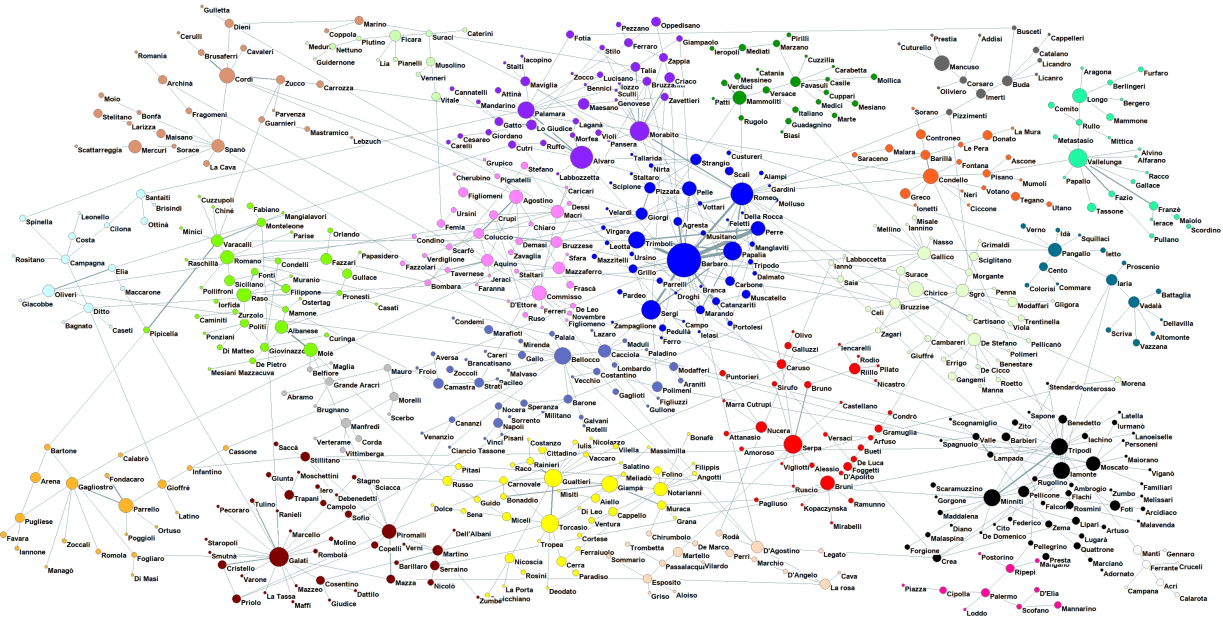

Figure 3: Communities in the network of interfamily marriages in 'Ndrangheta. The communities (23) have been identified via the Louvain method (resolution parameter set to 1) and are shown with different colors. Node size is proportional to the number of family members.
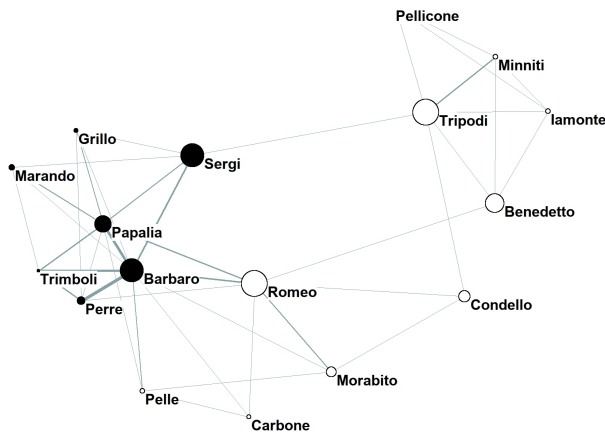
Figure 4: 3-core of the network of interfamily marriages in 'Ndrangheta. 4-core in black. Node size is proportional to betweenness centrality in the 3-core.

whose most important members are Romeo, Barbaro, Sergi and Papalia, some of the most central families in the whole network.

Although the previous families end up being classified into two different clusters (Barbaro, Romeo, Sergi and Papalia, on one side; Tripodi, Minniti and Iamonte, on the other), they all belong to the connected 3-core, i.e. the maximal subnetwork made up of the families that have marriage relations with at least 3 other families within the subnetwork.[25] The 2-core in the network comprises 202 families out of which only 17 families belong to the 3-core, and in this subnetwork there are 7 families (Barbaro, Grillo, Marando, Papalia, Perre, Sergi, Trimboli) that form the denser connected 4-core.

The 3-core and the nested 4-core are shown in Figure 4, where node size is proportional to the betweenness centrality index computed for the 3-core. According to this index, which allegedly captures the role of each family as an intermediary in the transmission of information or resources between the other families in the cohesive subgroup, the most central families are again Romeo and Tripodi (0.23), followed by Barbaro and Sergi (0.18).

The k-core analysis suggests that, although polycentric, 'Ndrangheta alliance network is somehow also cohesive. Indeed, 202 families (about one third of the network) belong to the 2-core. Moreover, the 3-core subnetwork is formed by families belonging to four different communities (as detected by the Louvain method).

The k-core analysis also sheds light on differences in positions occupied by well-connected families in the network: whereas Barbaro and Sergi tend to be connected with families belonging to their own cohesive subgroup, Romeo and, to a lesser extent, Tripodi are also connected with families belonging to other communities. This finding is coherent with the observed variation in centrality measures across

well-connected families (e.g., Barbaro and Romeo's difference in betweenness centrality scores).

The separation between Barbaro, Romeo, Sergi and Papalia, on the one side, and Tripodi, Minniti and Iamonte, on the other side, re-emerges instead in the analysis of the subnetwork induced by complete triads in the network of interfamily marriages. This subnetwork, shown in Figure 5, is made up of 72 nodes belonging to 10 components. The two largest components have size 25 and 14. Barbaro, Romeo, Sergi and Papalia belong to the largest component (in black in the figure), whereas Tripodi, Minniti and Iamonte are part of the other (in white in the figure). If we increase the size of the complete subnetworks we are looking for, moving from triads to subnetworks of size 4, the induced subnetwork comprises 13 families divided in two components: Barbaro, Papalia, Sergi and Trimboli belongs to the largest component, made up of 7 families, whereas Tripodi, Minniti and Iamonte to the other (Figure 6).

The analysis of complete triads shows that matrimonial triads among 'Ndrangheta families are not the exception. Indeed, over 10% of the families, belonging to 10 different communities are part of at least one triad. Moreover, whereas the small components are formed by families that are part of the same community, the two biggest components are formed by families belonging to four and three different communities, respectively. This finding suggests a certain degree of cohesion in the polycentric alliance network.

Finally, the analysis also highlights differences in matrimonial patterns of well-connected families. For instance, Barbaro, Papalia and Perre are part of triads formed only by families belonging to the same community, whereas Romeo and Condello are part of triads formed also by families belonging to other communities. Finally, other well-connected families, such as Galati, are not included in triads.

These differences can be explored also by comparing the E-I (External-Internal) indices (Krackhardt and Stern, 1988) computed at the family-node level with respect to the Louvain communities.[26] The index ranges from -1 (all matrimonial ties of the family are with families belonging to the same community) to 1 (all ties are with 'outsiders'). The distribution of these indices is positively skewed, with a negative mean (median) value of -0.875 (-1).[27] The index is: low for Perre (-1), Papalia (-0.92) and Barbaro (-0.88); higher for Commisso and Galati (-0.63); significantly higher for Piromalli (-0.45), Morabito (-0.33) and Tripodi (-0.30); and extremely higher for Romeo (-0.07).

After analyzing the structure of the network of interfamily marriages, we explore possible differences in the strategic matrimonial 'use' of women by computing the hub and

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[25]It is worth recalling that, although k-cores are nested, a k-core is not necessarily connected.

[26]The (weighted) E-I index for node i belonging to community c is computed by: i) summing the weights attached to the links of i with 'outsiders', i.e. nodes not belonging to community c; ii) subtracting the weights attached to the links of i with 'insiders', i.e. nodes belonging to community c; iii) dividing the result by the strength of node i.

[27]This is expected since the communities have been identified searching for the partition of nodes into clusters with the highest value of modularity, i.e. a measure to compare the density of ties and their weights inside and outside clusters.
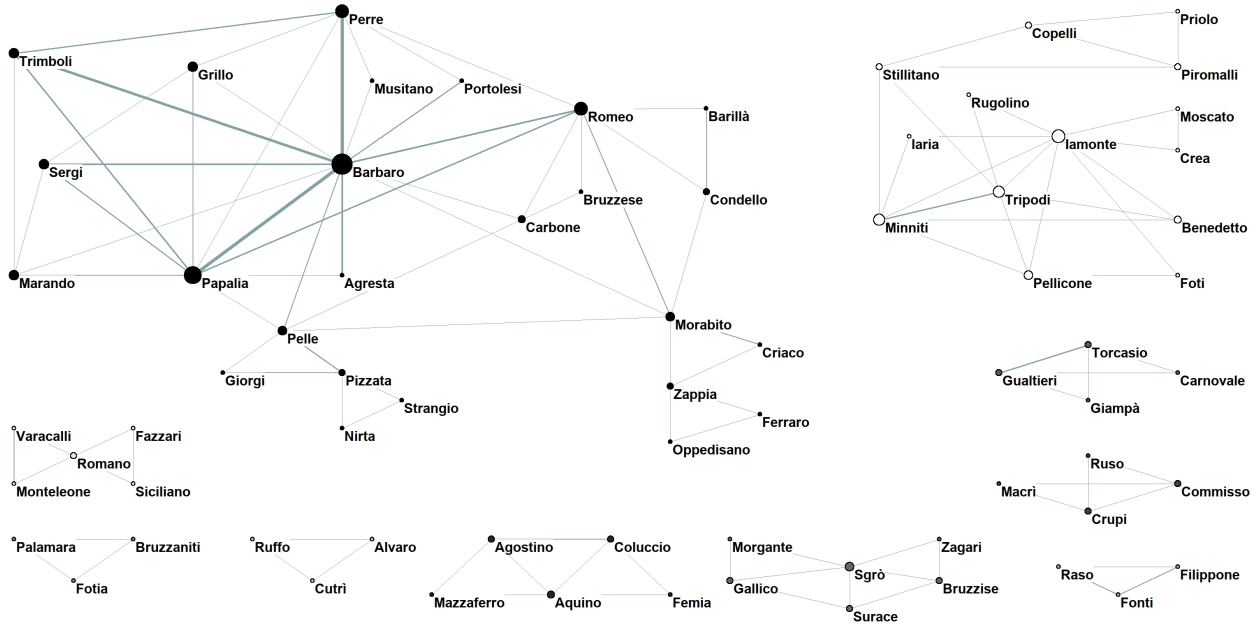
Figure 5: Complete triads in the network of interfamily marriages in 'Ndrangheta. Node size is proportional to the number of complete triads the node belongs to.
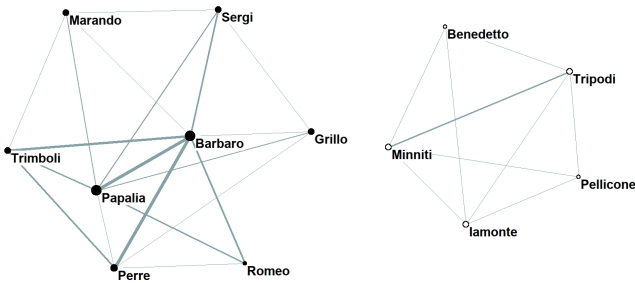

Figure 6: Complete subnetworks of size 4 in the network of interfamily marriages in 'Ndrangheta. Node size is proportional to the number of complete subnetworks the node belongs to.

Table 3
Hub and authority scores in the directed network of interfamily marriages in 'Ndrangheta

		Hub		Authority
Mean		0.004		0.005
Median		0.000		0.000
SD		0.040		0.040
5th percentile		0.000		0.000
95th percentile		0.011		0.009
Highest values:				
1	Barbaro	0.912	Perre	0.624
2	Papalia	0.250	Trimboli	0.481
3	Perre	0.158	Papalia	0.396
4	Romeo	0.122	Romeo	0.327
5	Marando	0.110	Sergi	0.210
6	Trimboli	0.095	Barbaro	0.197
7	Portolesi	0.093	Pelle	0.098

authority scores for the weighted directed network of interfamily marriages in 'Ndrangheta. The scores are reported in Table 3. The results highlight differences in the 'use' of females across families, even across the most central ones. Some of the most central families (e.g. Barbaro, Morabito, Marando) show hub scores higher than authority scores; for others (e.g. Romeo, Papalia, Perre), authority scores are higher than hub scores.

In this respect, it is worth considering the case of the Barbaro and Perre families. On the one hand, Barbaro's hub score (0.91) is significantly higher than the second highest value (0.25), which is Papalia's hub score. On the other hand, Barbaro's authority score (0.197) is lower than both their own hub score and the authority scores computed for the families in their ego-network (e.g., Perre, Trimboli, Papalia and Romeo). On the contrary, Perre's hub score (0.158)

is significantly lower than their authority score (0.624). By recalling that hubs (authorities) are the families whose females (men) tend to marry many men (women) from other families to seal alliances, this could possibly hint at the fact that Barbaro may have used females and males in a different strategic way: whereas they possibly tend to marry their daughters to men of families they want to ally with, they do not tend to marry their sons to women from other 'important' families. Vice versa, Perre possibly tend to marry their sons to women from other families, but they marry their daughters to men from other 'important' families to a far lesser extent.

Indeed, as shown by the analysis of endogamic marriages across 'Ndrangheta families (see Table 4), in the Barbaro

Table 4
Total and endogamic marriages (%) by family (families with at least 10 marriages in the sample)

Family	Marriages	Endogamic marriages (%)	Family	Marriages	Endogamic marriages (%)
Barbaro	64	25.00	Condello	13	7.69
Romeo	31	9.68	Iamonte	13	0.00
Papalia	25	0.00	Pelle	13	0.00
Galati	24	8.33	Torcasio	13	15.38
Morabito	20	10.00	Commisso	12	8.33
Tripodi	20	0.00	Giampà	12	8.33
Trimboli	19	5.26	Serpa	12	8.33
Minniti	18	11.11	Piromalli	11	0.00
Sergi	18	11.11	Pizzata	11	9.09
Perre	17	0.00	Gallico	10	0.00
Alvaro	16	12.50	Macrì	10	0.00
Vallelunga	15	13.33	Romano	10	0.00
Gualtieri	14	0.00	Sgrò	10	0.00
Bellocco	13	0.00	Varacalli	10	0.00

family endogamic marriages i.e. unions between members of the same family, are 25% of all marriages, suggesting that Barbaro may prefer marrying their sons to women of their own family. More generally, the analysis shows that the use of endogamic marriages varies significantly across 'Ndrangheta families, suggesting that, unlike Barbaro, not all the families favour this type of union. The variance holds true also when we compare the most well-connected and powerful families. For instance, whereas 25% of the marriages involving the Barbaro are endogamic, the percentage is far lower in the case of Romeo (9.7%) and it drops to 0% for Tripodi and Perre, other well-connected and powerful families.

5. Discussion

The academic literature has pointed out the relevance of marriage to Italian mafias, which use it strategically to seal alliances and business partnerships and to foster internal cohesion. Centralization measures of the network and cohesive group analysis have highlighted the existence of clusters of families that tend to celebrate weddings among each other rather then with 'outsiders'. As marriages are strategically used to seal alliances and business partnerships, these data suggest the existence of 'factions' inside 'Ndrangheta. This interpretation is coherent with the organizational structure of 'Ndrangheta. Indeed, this organization at its basic level is formed by *'ndrine* (families) which are organized in *locali*. Each *locale* decides over criminal activities, membership and promotions within its territory of competence. Different *locali* may decide to cooperate, but they preserve their autonomy and their areas of influence (Paoli, 2003; Ciconte, 2014; Catino, 2019, 2020).

The results of our exploratory analysis are consistent with the strategic use of marriages by 'Ndrangheta families as pointed out by the literature, but they have also highlighted the existence of differences in matrimonial strategies across families. First, as shown by centrality measures, whereas some families tend to create matrimonial ties with a large number of families (e.g. Romeo, Galati, Tripodi), others

tend to make ties with a small number of families, though more important and well-connected (e.g. Barbaro). Moreover, whereas some families create matrimonial ties with families belonging to the same cohesive subgroup (e.g. Barbaro), others make ties also with families belonging to other cohesive subgroups (e.g. Romeo).

Second, our analysis points out that 'Ndrangheta families rely on endogamic marriage to a very different extent, and the difference holds true also among well-connected families. So, for instance, in our dataset one in four marriages involving a Barbaro turns out to be endogamic, whereas this ratio is about one in ten for Morabito, Romeo and Sergi, and it drops to zero for Iamonte, Papalia and Piromalli.

Finally, matrimonial strategies of 'Ndrangheta families diverge also in the strategic matrimonial 'use' of females: whereas some families tend to marry their daughters 'outside' the family, others marry their daughters 'within' the family. Once again, the difference holds true also among well-connected families.

In a nutshell, our analysis has highlighted the existence of family-specific matrimonial patterns in 'Ndrangheta. In view of these findings, we can formulate three working hypothesis. First, differences in matrimonial strategies may be influenced by the family's status. Specifically, compared to lower status families, high status families might rely on marriages mainly to consolidate their own position in the organization and their business, whereas lower status families may use marriage to increase their power and expand business.

Second, matrimonial patterns can be affected by location and geography. In fact, given the traditional division of 'Ndrangheta in different *mandamenti* and the distribution across the region, location might be one of the primary driver of marriages. In this respect, future research should explore whether and to what extent the network of interfamily marriages is spatially clustered.[28]

Third, matrimonial strategies may also vary according to the type of activity carried out. Specifically, the riskier the family business, the more the trust the family needs. Since marriage creates trust, we hypothesize that families involved in riskier activities (e.g., drug trafficking) may create multiple matrimonial ties with a smaller number of families to build particularly strong bonds, and rely more on endogamic marriages to increase internal cohesion.

6. Conclusions

Scholars have argued that in mafia organizations marriage is not based on love, but it is the result of family strategies aimed at exploring and exploiting power and business. Marriage is a particularly effective organizational instrument for its ability to generate trust even in adverse conditions and enhance organizational control of agents. This is the case of mafias that, like other criminal organizations, operate in hostile environments and illicit markets, where they cannot rely on conventional rules, mechanisms, and institutions to regulate transactions and disputes.

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[28]We acknowledge one of the reviewers for this suggestion.

Our analysis has highlighted that marriages have been used strategically by 'Ndrangheta families, and that matrimonial strategies change across families. To study the strategic use of marriage, we carried out the first (to the best of our knowledge) large-scale analysis of matrimonial unions in mafia organizations. Relying on an original database of over 4,600 'Ndrangheta members distributed over more than 1,500 families, we made an exploratory analysis of the network of interfamily marriages in 'Ndrangheta to investigate the main relational features of families and the overall structure of the alliance network.

Our study is a first step in the analysis of the strategic use of marriage. We relied on info taken from judicial documents reporting the family trees of some of the most important families in 'Ndrangheta and on data gathered from the judicial documents related to 40 criminal investigations against 'Ndrangheta led by DDA prosecutors in the districts of Reggio Calabria and Catanzaro between 2007 and 2016. Future research could expand the scope and the time horizon. Moreover, the same analysis could be applied to other mafia organizations such as Sicilian Cosa Nostra, American Cosa Nostra, Triads and Yakuza. A comparative study could highlight differences and similarities in the strategic use of marriage and blood ties in mafia organizations.

Our analysis shows that some families are bounded by multiple marriages and, on a more structural level, the existence of cohesive subgroups of families in the network of interfamily marriages. This finding points out two interesting aspects future research should explore. First, a longitudinal analysis of marriages could provide deeper insights into the goals and organizational valence of single marriages as well as of overall matrimonial strategies of mafia families. For instance, were multiple marriages between two families celebrated within the same generation or they span across generations? Did they play a role in the raise to power of the most prominent 'Ndrangheta families? Second, a spatial analysis of the network could shed light on possible geographical patterns of marriages. Is the network spatially clustered? To what extent spatial clusters and cohesive subgroups coincide?

Future research may also investigates if a family uses marriage differently depending on the type of activity. For instance, we may hypothesize that, since matrimonial ties create more trust, they are the preferred instrument to seal partnerships in illegal markets, especially when conducting the riskiest activities. On the contrary, when operating in legal markets, mafia families may prefer to rely on business partnerships with white collars acting as knowledge brokers and providers.

Finally, marriage has been used as organizational instrument by political and economic powerful families. Families play a decisive role also in capitalism (James, 2006). For instance, family-owned business represents the large majority of registered companies in industrialized countries, and it includes very large companies, especially in continental Europe. Even if today marriages are no longer arranged, this does not rule out the possibility that upper class individuals still tend to marry within their own class. Matrimonial class closure is a not trivial subject of research, even less so in a context of rising social and economic inequalities.

Acknowledgments

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A. Operations included in the study

Province	Type	Name	Year	Arrested
Catanzaro	Fermo	Anaconda	2008	34
Catanzaro	OCC	Chimera	2014	33
Catanzaro	OCC	Chimera 2	2014	21
Catanzaro	OCC	Dirty soccer	2015	50
Catanzaro	OCC	Frontiera	2016	68
Catanzaro	Fermo	Kyterion	2015	37
Catanzaro	OCC	Lo Giudice	2011	4
Catanzaro	OCC	Medusa	2012	52
Catanzaro	OCC	Omnia	2007	77
Catanzaro	Fermo	Overloading	2010	83
Catanzaro	OCC	Pandora	2009	54
Catanzaro	OCC	Perseo	2013	74
Catanzaro	OCC	Stop	2013	31
Catanzaro	OCC	Tela del Ragno	2012	78
Catanzaro	RMC	Telesis	2010	87
Catanzaro	RMC	Terminator 1	2008	29
Reggio Calabria	Fermo	Acero/Krupy connection	2015	49
Reggio Calabria	OCC	Alchemia	2016	74
Reggio Calabria	OCC	Bellezza	2007	20
Reggio Calabria	Fermo	Bellu Lavoru	2008	42
Reggio Calabria	OCC	Blue call	2012	18
Reggio Calabria	OCC	Bucefalo	2015	12
Reggio Calabria	OCC	Buongustaio	2014	24
Reggio Calabria	OCC	Cent'anni di storia	2008	24
Reggio Calabria	OCC	Circolo formato	2011	49
Reggio Calabria	OCC	Cosa mia	2010	57
Reggio Calabria	OCC	Crimine	2010	156
Reggio Calabria	OCC	Faida dei boschi	2012	19
Reggio Calabria	OCC	Gambling	2015	128
Reggio Calabria	RMC	Imelda	2011	11
Reggio Calabria	OCC	Meta	2010	73
Reggio Calabria	OCC	Ndrangheta banking	2014	27
Reggio Calabria	OCC	New bridge	2014	18
Reggio Calabria	RMC	Nuovo potere	2009	59
Reggio Calabria	Fermo	Oro nero	2011	42
Reggio Calabria	Fermo	Reghion	2016	14
Reggio Calabria	OCC	Saggezza	2012	66
Reggio Calabria	OCC	Shark	2009	30
Reggio Calabria	OCC	Sistema Reggio	2016	19
Reggio Calabria	OCC	Virus	2009	17