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Was the Medici Really the Most Powerful Family in Florence? Analysis of the Relationship Network of the 15th Century Florentine Merchant Families

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Abstract: In Florence in the 15th century, several families competed for power, during which they developed complicated business and family relationships. These families can be considered the big companies of the age. The results of network science have shown that a company's market power is determined not only by its financial and market positions, but also by its network position in the business network. The purpose of the research is to present the role of 15th-century Florentine families in their network of relationships and the resulting power position using quantitative methods. The research considers the business and family relationships of families as a multi-layered, complex network and examines them using network science methods. The research shows which families occupied the various positions of power in the complex network of relationships, and which families formed close groups within the network. One of the new areas of 21st century management is the network management, which focuses on examining the internal and external network of companies. The research examines the business positions of 15th-century Florentine families using the network management approach.

Keywords: Network science, Complex networks, Business networks, Market position, Power

Introduction

The using of management methods can give to companies an advantage over their competitors. After a while, these methods become widely known, can be mastered, and can be successfully applied. However, the more people use them, the less competitive they are. For this reason, the use of known methods is no longer an advantage, but its absence causes a disadvantage for a company. In the era of industrial management, the advantage could also come from the possession of resources. In order for a company to grow, it needed resources, and typically a company with more resources was more likely to grow. Typically manufacturing companies were able to make it more efficient with production management methods, and companies producing individual products with project management methods. After the advancement of the service sector, one of the keys to competitive advantage became the application of quality management methods. After the spread of the Internet, information became widely available in large quantities and quickly, resulting in a competitive advantage for companies that could learn and adapt more quickly. In this period, the application of knowledge management and change management methods became decisive.

In the late 1990s, a new field of science began to emerge, namely network science, which began to investigate real networks. The results of this new science opened a new perspective in the field of management, which is now increasingly used by companies. In the course of their activities, organizations establish various types of relationships with other market actors, and these relationships can be organized into a complex network that can be used to model the relationship system of the given business actors. The business network position of organizations can be revealed by analyzing this complex network. With the application of network science methods, a new field of management science was created, namely the network management. (Ford et al., 2002).

This new management area examines the internal network of business organizations as well as the network of market organizations and looks for possible new types of competitive advantages based on this.

In the 15th century Florentine Republic, the different families were the actors of business life, we could say they were the big companies of the market at that time. These families competed with each other for political offices, business positions in order to gain as much power, and wealth as possible. Their power and business relationships strongly influenced their domestic and foreign business success (Molnár, 2022). In the leadership of the Republic of Florence, politics and business were closely intertwined, as the members of the guilds elected the supreme leader of the city. One of the best-known actors in the power struggle was the Medici family, which played a significant role in the political and economic life of Florence for three centuries from the 15th century. The Medici family was forced out of power three times, but in all three cases they were able to regain their leading position in the management of the city. The aim of the research was to use network science methods to analyze the relationship network of 15th-century Florentine families and to reveal how the power of the Medici family was related to their network position.

Literature Review

In the field of history, many historical research results are available from the 1960s, rise and fall of the Republic of Florence. We learned about the functioning of the Medici government from the works of Nicolai Rubinstein (Rubinstein, 1997), the world of the Italian city-states was presented in detail by the work of Daniel Waley (Waley, 1969), the country's political system. John M Nayemi (Nayemi, 1982) has researched the Florentine Republic. One of the first detailed studies on the relationships of Florentine families investigated the richest 116 Florentine families (Kent, 1978). Kent examined contemporary documents, including voter rolls, tax returns filed by families, business records, marriage certificates and personal correspondence. Breiger and Pattison investigated the relationship system of Florentine families using mathematical methods, and using Wille's formal concept analysis method (Wille, 1996) they presented the hierarchical relationships of families (Breiger & Pattison, 1986). They researched the business and marital relationships of Florentine families, based on Kent's research results. This research shows the hierarchical network relationships of families in the form of a graph. Out of the 116 families, they processed the data of the 16 most influential families and formed their relationships from this. In their research, individual families were taken as the unit of analysis, and in the case of financial relations, loans and business relations were also taken into account. During their sociological research, Padgett and Ansell used statistical methods to examine the relationships of different families according to aspects such as financial situation, friendships, employment and residential relationships, and based on these, they showed how the families formed different types of clusters. (Padgett & Ansell, 1993). Many historians have researched the history of the Medici family. In Hibbert's book, he presents the rise of the Medici family and discusses in detail the struggles with the rival Pazzi family (Hibbert, 1979). In Strathern's book, we get a comprehensive picture of the relationships of the Medici and the financial transactions relevant to the acquisition of power (Strathern, 2016).

Research into the development of social relationships between people in psychology began in the 1930s. In the field of human relations, the psychologist living in New York, Jacob Levy Moreno, developed the method of sociometry (Moreno, 1978). He observed that relationships between people are not randomly formed and distributed in an organization and are not the same as formal structural order, but the human relations create a network, which is a structure different from the organizational structure. However, Moreno only examined human relationships based on mutual sympathy. Mérei, who, in addition to relationships based on sympathy, also took into account opinions about social functions and abilities, developed the multi-point sociometric test (Mérei, 1996).

The next milestone in human network research was Stanley Milgram's experiment, during which he examined the network of social relationships (Milgram, 1967). He concluded that the average path length in the network of social relations between two randomly selected people does not reach 6 steps, and based on these, the principle of six degrees of separation became famous. It is interesting in the history of science that this phenomenon was first described not by a scientist, but by a writer. In Frigyes Karinthy's short story „Chains", the protagonist offers a bet to another member of the company. He claims that if someone names anyone in the world, he can reach him through only five connections (Karinthy, 1929). Although Karinthy was not a scientist, she was still very close to one of the basic principles of human relationship networks, the six degrees of separation. In human networks, the distance between two people is quite small, so networks with this topology are called „small-world" in network science. Later in network science, this term denotes a network with a specific topology. As a psychologist, Milgram only explored the small-world phenomenon inherent in human relationships, but Watts and Strogatz created the network science model (Watts & Strogatz, 1998). In their research, they concluded that the small-world phenomenon appears not only in social networks, but also in natural and technological networks. Their mathematical model proved that neither random nor regular networks describe well the group formation properties of real networks. This refuted the earlier scientific position that human relationships are Erdős-Rényi random networks (Erdős & Rényi, 1956). In network science, the research of large groups of people brought another result, which affected several scientific fields, including economics. During his research, the Italian economist

Vilfredo Pareto noticed that the wealth distribution of Italy's population is asymmetrical. He found that people's income follows a power function distribution, according to which about 20 percent of the people receive 80 percent of the incomes (Pareto, 1964). Although Pareto was ahead of his time with his results, it became known in several scientific fields as the Pareto principle or the 80/20 rule. Practical experiences in the field of corporate management, quality management, and decision theory have substantiated Pareto's results, and management methods have been developed based on this. The 80/20 phenomenon has even been confirmed in the field of scientific publications. Derek de Solla Price examined the citations of scientific works and came to the conclusion that the number of references also follows this rule (Price, 1965). Price's results were also ahead of their time, but thirty-three years later a research also related to scientific references confirmed it (Render, 1998). In 1999, Barabási and his colleagues, researching the network topology of the Internet, came to the conclusion that the World Wide Web also operates according to a power-law distribution (Barabási & Albert, 1999). They defined the concept of scale-free networks and thereby defined a new type of network topology that, like small-world networks, is not only characteristic of human networks (Barabási, Albert, & Jeong, 1999). We now know that the Pareto phenomenon indicates the presence of a scale-free network.

Data

During my research, I used the relationship data of Breiger and Pattison, which they reduced to 16 families. and the data includes business and marital relationships between families (Table 1).

Table 1. The original table of connections (Breiger & Pattison, 1986)

	Business	Marriage
1. Acciaiuoli	....	........X.......
2. Albizzi	....	.....XX.X.......
3. Barbadori	....XX..X.X.....	....X...X.......
4. Bischeri	......XX..X.....	......X...X...X.
5. Castellani	..X....X..X.....	..X.......X...X.
6. Ginori	..X.....X.......	.X..............
7. Guadagni	...X...X........	.X.X...X.......X
8. Lamberteschi	...XX.X...X.....	......X.........
9. Medici	..X..X...X...X.X	XXX.........XX.X
10. Pazzi	........X.......	.............X..
11. Peruzzi	..XXX..X........	...XX.........X.
12. Pucci	....	....
13. Ridolfi	....	........X.....XX
14. Salviati	........X.......	........XX......
15. Strozzi	....	...XX.....X.X...
16. Tornabuoni	........X.......	......X.X...X...

The relationships are symmetrical, which means that the business relationships do not contain information about the nature and direction of the business relationship between the two families. For example, if one family provided a loan to another family, it is not clear from the relationship who was the creditor and who took out this loan. In the same way, in the case of marital relations, it is not possible to identify that, for which family the husband belonged to and for which the wife. Of course, this information would be effective in a broader power investigation, since the relationship between the lender and the borrower is asymmetric in terms of power. In the same way, in the social hierarchy of the time, the power relationship between husband and wife in the family was asymmetrical. Since Breiger and Pattison's table shows that the Pucci have neither business nor marriage relations with the other families, I reduced the number of members of the inter-family network to 15 in my research.

Method

During my research, I used graph theory and network science methods. Although the network science uses the methods of graph theory, it is important to know that network science is not the same scientific field as graph theory. The essential difference is that network science examines real networks, while graph theory examines fictitious mathematical objects.

I created a multigraph from Breiger and Pattison's business and marriage data. In a multigraph, there can be more than one edge between two vertices, and the different types of edges have different properties. The edges in the multigraph that I was created can be business or marriage type relationships. I created a complex network from the multigraph. Complex networks have network layers, and each layer has the same nodes, but each layer has different connections (Kivela et al., 2014), and each layer represents a specific type of connection subnet (Figure 1).

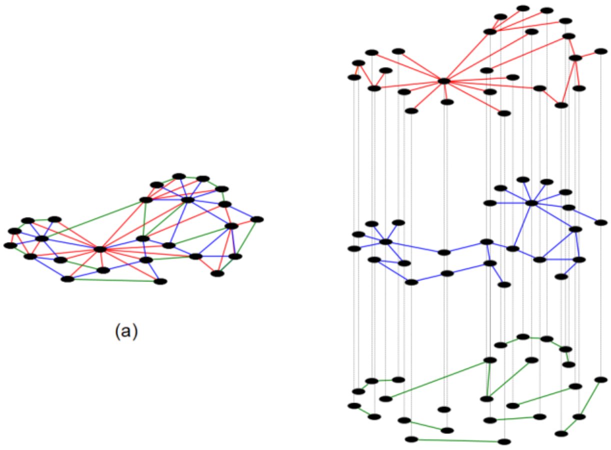

Figure 1. A multigraph (a), with three network layers (b). (Own figure)

The complex network I have created has two network layers, one contains marital relationships and the other contains business relationships. I investigated the properties of the complex network using quantitative methods I calculated the diameter of the network, the average degree, and the average path length, and used degree distribution to explore the topological properties of the network. I examined the groupings using natural clustering, and clique percolation methods. I calculated the degree centrality, the betweenness centrality, the closeness centrality and the pagerank of each node. I performed the calculations for the listed tests based on Barabási (Barabási, 2016). I drew the networks with the Yed network drawing software, and used the Gephi network analysis software for the quantitative network analyses.

Results and Discussion

To draw the networks, I created adjacency matrices of business (A^B) and marriage (A^M) relationships (Jungnickel, 2005). The individual families are in the rows and columns of each adjacency matrix, and the elements of the matrices indicate the relationships between them. The value of an element of the adjacency matrix is 0 if there is no connection between the families belonging to that element, and 1 if there is. If an element takes an integer value greater than one in the adjacency matrix, it means that the network is weighted or multigraph. If we add the business adjacency matrix and the marriage adjacency matrix, we get the adjacency matrix of the complex network as a result.

$$A^B + A^M = A^C \tag{1}$$

The adjacency matrix of the complex network is shown in Table 2. The value of 2 for the elements in this matrix indicates that there was an economic and marital relationship too between the given two families. This matrix is symmetric about the main diagonal because the connections are reciprocal, it contain values 0, 1 and 2, so the weights of the edges are different, therefore the complex network a directed and weighted network (Figure 2).

Table 2. The complex adjacency matrix of the fifteen families. (Own table)

	ACCIAIUOLI	ALBIZZI	BARBADORI	BISCHERI	CASTELLANI	GINORI	GUADAGNI	LAMBERTESCHI	MEDICI	PAZZI	PERUZZI	RIDOLFI	SALVIATI	STROZZI	TORNABUONI
ACCIAIUOLI	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
ALBIZZI	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0
BARBADORI	0	0	0	0	2	1	0	0	2	0	1	0	0	0	0
BISCHERI	0	0	0	0	0	0	2	1	0	0	2	0	0	1	0
CASTELLANI	0	1	2	0	0	0	0	1	0	0	2	0	0	1	0
GINORI	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0
GUADAGNI	0	0	0	2	0	0	0	2	0	0	0	0	0	0	1
LAMBERTESCHI	0	0	0	1	1	0	2	0	0	0	1	0	0	0	0
MEDICI	1	1	2	0	0	1	0	0	0	1	0	1	2	0	2
PAZZI	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
PERUZZI	0	0	1	2	2	0	0	1	0	0	0	0	0	1	0
RIDOLFI	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1
SALVIATI	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0
STROZZI	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0
TORNABUONI	0	0	0	0	0	0	1	0	2	0	0	1	0	0	0

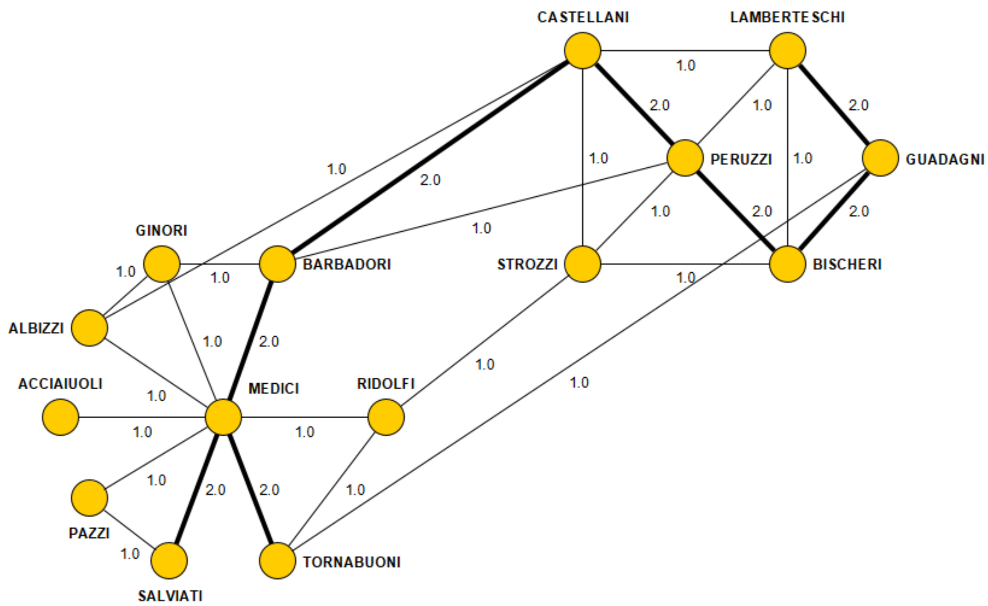

Figure 2. The complex network of Florentine families. (Own figure)

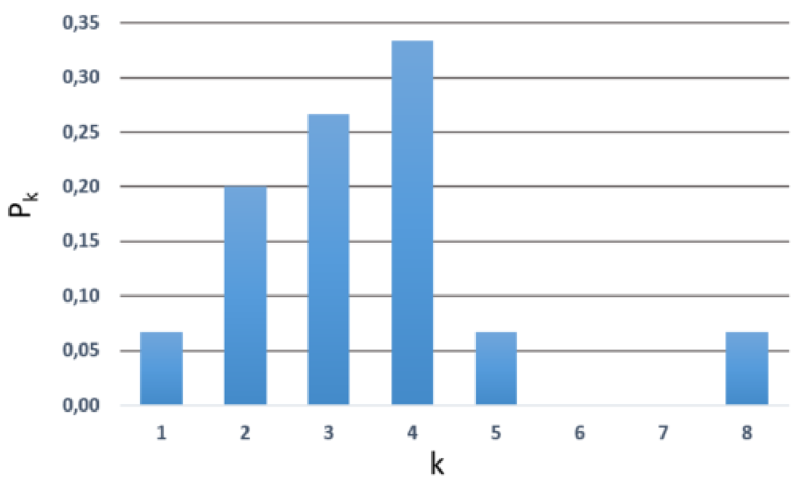

Figure 3. Degree distribution in the complex network of Florentine families. (Own figure)

The complex network has 15 nodes and 27 links, and the average degree is k_{avg} = 3,6. The degree (k) shows how many connections a node has. The diameter of the network is d_{max} = 4, which means the shortest distance between two arbitrary nodes. The average path length is d_{avg} = 2.09, so anyone in the network can be reached in just over 2 steps on average. In an Erdős-Rényi random network what consisting 15 nodes and 27 links, the d_{max} ~ 4 and d_{avg} ~ 2.49. From this, it can be concluded that the network of Florentine families does not have a random topology, but deviates towards a small-world topology, because it contains more connections with the same diameter. The topological properties of the network can be deduced based on the degree distribution (P_k) (Barabási, 2016). The result of the degree distribution also confirmed the small world nature. Figure 3 shows that the graph of the degree distribution shows an asymmetry on the right, which indicates a small-world deviation. The figure shows the degree numbers on the horizontal axis, and their distribution on the vertical axis.

I examined the network positions of individual families based on their centrality values. Betweenness centrality is a ratio that shows how many of the shortest paths pass through a given node. In a human network, we can infer the information position of a given node. The value of closeness centrality indicates the average length of the shortest paths starting from the given node, therefore, it shows how central someone is. Pagerank considers the importance of a node with the importance of its neighbors. The more important the neighbor is, the more it increases the importance of that node. The quantitative values of each node are listed in Table 3.

Table 3. The centralitiy values of the Florentine families. (Own table)

Nodes	Degree	Closness Centrality	Betweeness Centrality	PageRank
ACCIAIUOLI	1	0,40	0	0,03
ALBIZZI	3	0,52	4,33	0,06
BARBADORI	4	0,56	13,50	0,07
BISCHERI	4	0,42	2,58	0,07
CASTELLANI	5	0,52	9,83	0,08
GINORI	3	0,48	0,33	0,06
GUADAGNI	3	0,45	5,33	0,06
LAMBERTESCHI	4	0,42	3,67	0,07
MEDICI	8	0,64	44,08	0,15
PAZZI	2	0,41	0	0,05
PERUZZI	5	0,52	7,67	0,08
RIDOLFI	3	0,54	7,08	0,06
SALVIATI	2	0,41	0	0,05
STROZZI	4	0,50	6,25	0,07
TORNABUONI	3	0,52	9,33	0,06

The Medici has the highest value in all tests and is therefore the most defining node of the complex network. Barbadori is outstanding both in terms of its informational and central role, and it also plays the role of a bridge in the network. The other bridge is the Tournabuoni, which also has a good network position in terms of information flow. Acciaiuoli, Pazzi and Salviati occupy the weakest positions in the network, these families in the network are cut off by Medici from the rest of the network. In terms of information, Barbadori also occupies a good place in the network, which is because it is connected to a bridge and directly to Peruzzi. His position also stems from the fact that he has a business and marital relationship with both Barbadori and Peruzzi.

I performed a cluster analysis on the complex network, which showed which nodes of the network form common groups. First, I used Grivan-Newman's non-hierarchical, natural cluster analysis (Grivan & Newman, 2002). This algorithm classifies nodes into clusters based on betweenness centrality. The natural cluster analysis classified the nodes into three clusters. One group belongs to the Medici family, another to the Peruzzi family, and the third includes the Ridolfi and Tornabuoni families. These are connected to both other groups and thus connect the two large clusters, so they are the bridges in the network (Muisal & Juszczyszyn, 2009). It also plays the role of the Barbadori who are bridge in the network, but due to its position in the network, both cluster analyzes classified it as part of the Peruzzi cluster (Figure 4). The results of natural clustering were also confirmed by the CFinder clustering method. This algorithm classifies the directly related triple groups into a cluster (Derényi et al., 2005). The result of the CFinder method is shown in Figure 5.

The cluster belonging to Medici forms a fully centralized sub-network, while the Peruzzi cluster corresponds to shared network structures according to Baran's network typology (Baran, 1964). In Medici's centralized network, most vertices are directly connected to Medici, and there are few connections between nodes. Losing the central vertex would result in the network immediately collapsing into a disjunct network, In the Peruzzi cluster, a minimum of 2 nodes must be lost for the network to fall apart into non-connected sub-networks, therefore it is more robust than the Medici one (Callaway et al., 2000). Therefore, the sub-network belonging to Medici was significantly more vulnerable than Peruzzi. In a rapidly changing market environment, from a network management point of view, the Peruzzi sub-network would have been much more efficient because it responds faster to changes and is more robust against targeted attacks and accidental errors than the centralized Medici. However, due to the slowly changing market nature of those times, this did not mean a market advantage for Peruzzi. Perhaps due to the Peruzzi cluster's better ability to tolerate disturbances, the Peruzzi network of connections remained even after the family's bankruptcy.

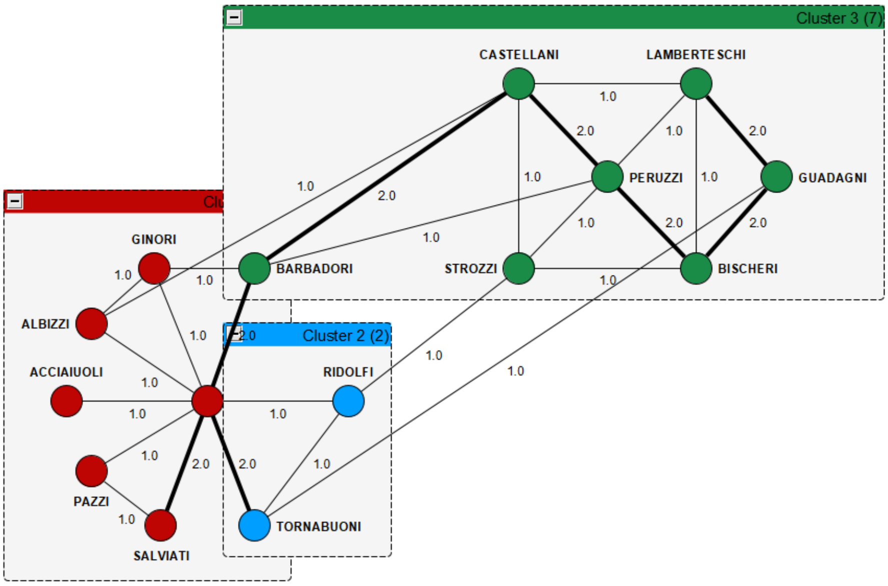

Figure 4. Result of the natural clastering methode. (Own figure)

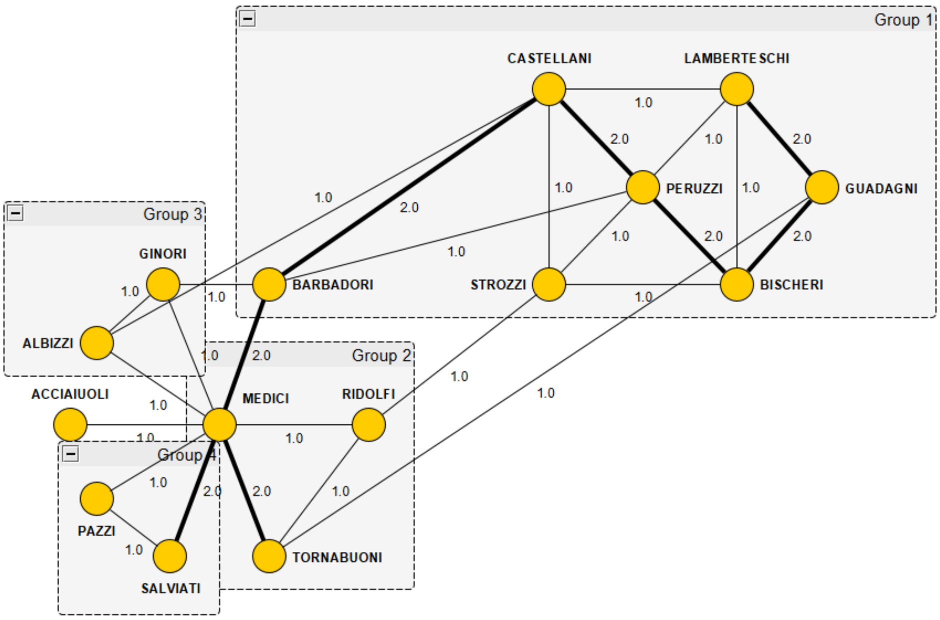

Figure 5. Result of the CFinder clastering methode. (Own figure)

Conclusion

The research examined the relationships of 15th-century Florentine families using network science methods. The aim of the research was to use network science methods to reveal the network position of Medici in the relationship system of Florentine families. In the process, based on business and marriage relationships, a complex network was created, the members of which are the 15 most influential families. The research explored the topological properties of this network and showed that overall, this network was a small-world network.

This was confirmed by the quantitative values of the network and the degree distribution. The two dominant families in the network were the Medici and the Peruzzi, around whom the other families in the network were arranged in clusters. The internal structure of the two clusters was completely different in terms of topology, Medici formed a centralized sub-network, while Pruzzi formed a strongly small-world type. As a result, the fall of the Medici from the network would have immediately resulted in the collapse of its sub-network, but even with the loss of 2 families, the Peruzzi cluster would have disintegrated only to a small extent. The Medici had to hold its cluster together with autocratic means and direct control, while the Peruzzi had to do indirect control. In the network of families, 3 families connected to the two clusters as a bridge, the Tournabuoni, the Ridolfi and the Barbadori. This held a particularly important network position, because on the one hand, it had a direct connection to both the Medici and Peruzzi, and on the other hand, it had business and marital ties to the two clusters. The research revealed that Medici's power also came from its network position. Based on his network indicators, it can be said that it was a central element of the network, and it had the greatest control over the flow of information in the network. However, the research also highlighted that the Medici relationship system was much more vulnerable than the Peruzzi was. If Peruzzi had known the network management methods, it would have been able to take targeted and effective action against the influence of the Medici and perhaps even regain its previous business position. Of course, this would have required Peruzzi's previous financial position, but based on the research, its network position would have given it the opportunity. Overall, it can be concluded that although Medici's network strength was great, its network position was very vulnerable.

Scientific Ethics Declaration

The author declares that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the author.

Notes

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