UNIVERSITY OF BELGRADE, SCHOOL OF ELECTRICAL ENGINEERING
Department of Software Engineering

Report for the Course Social Network Analysis

OVERVIEW OF SCIENTIFIC COLLABORATION AT THE FACULTY OF MEDICINE IN BELGRADE

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Contents

ABSTRACT

This document represents the report of the second project assignment for the course Social Network Analysis, conducted as part of the Master's program at the School of Electrical Engineering, University of Belgrade. The objective of the assignment was the practical application of theoretical knowledge acquired in the course to a concrete research problem. Through the given research problem, the collection, processing, and preliminary analysis of a primary (raw) dataset were performed. Relevant data were extracted, and the problem was modeled as a network of an appropriate type. The resulting network was analyzed using various tools for social network analysis, and its visualization was also produced.

1 INTRODUCTION

The occurrence of an unexpectedly high number of cases of a certain disease within a population or region over a specific period of time, commonly known as an epidemic, has been known to humanity for centuries. The plague in the Middle Ages, cholera in the 19th century, and the Spanish flu after World War I are just a few examples of infectious diseases that claimed tens of thousands of lives in a short time. Globalization in the 20th century facilitated the international movement of people and goods. However, this same phenomenon also enabled the faster spread of infectious diseases. The pandemic of the **SARS-CoV-2** virus (Severe Acute Respiratory Syndrome Coronavirus 2), which struck the world in early 2020, is a clear example that confirms this claim, while also emphasizing the importance of scientific disciplines in the field of medicine that focus on the study of epidemics in contemporary society.

The analysis of the scientific collaboration network at the Faculty of Medicine in Belgrade represents a highly significant study within the institution, as it reveals how professors collaborate at the faculty level within Serbia—specifically in Belgrade—as well as how employees from different departments engage in research together and collaborate with international scientists.

2 PROBLEM STATEMENT

This research focuses on analyzing the scientific output of individual researchers at the Faculty of Medicine in Belgrade during the period from 1982 to 2020. Scientific production has become a key factor in the advancement of academic institutions, project approvals, evaluation of research papers, and the accreditation of doctoral studies. At the Faculty of Medicine, scientific work is conducted within various specialized scientific fields, with faculty members and associates organized into departments, specifically:

- ***Department of Epidemiology***
- ***Department of Immunology***
- ***Department of Microbiology***
- ***Department of Infectious Diseases***

The goal of this project is the collection, processing, and analysis of scientific production, as well as the examination of collaboration among faculty employees using data extraction, modeling, and visualization through appropriately structured networks. The results are expected to reveal the state of scientific productivity and the quality of research conducted within the aforementioned departments, the degree of collaboration within the observed research community, the position of Serbian research in the global context, and to highlight key individuals.

Most of the scientific output takes the form of publications such as books, dissertations, journal articles, and papers presented at both domestic and international scientific conferences. However, in terms of evaluation, the most valued are articles published in scientific journals and papers presented at professional scientific conferences. This project focuses specifically on publications in scientific journals with an impact factor.

Scientific collaboration networks are typically modeled using graphs, which is the approach taken in this study as well. The resulting network consists of **58** distinct nodes and **307** edges.

3 IMPLEMENTATION

The entire analysis was implemented using the Python programming language. First, the primary dataset was processed, followed by the modeling of the network based on a secondary dataset to facilitate analysis and answer the research questions. Finally, the networks were visualized using the Gephi software tool. The NetworkX package was used for network modeling.

4 RESULTS

4.1 STATISTICAL DATA ANALYSIS

4.1.1 Question 1

What is the number of papers per author? Use both full and fractional counting. Who are the most productive researchers in the field, and which department do they belong to?

The column ***Num of works per Author*** in the figure shows the number of papers per author. The top **6** most productive researchers are displayed. It is evident that Tatjana Pekmezović from the Department of Epidemiology is the professor with the highest number of published papers. Just below her is Trajković Vladimir from the Department of Immunology, and so on.

	Author	Num of works per Author	id_author	Ime	Prezime	Katedra	H indeks	Broj radova	Kratko ime
0	Pekmezovic T.	270	36	Tatjana	Pekmezovic	Katedra za epidemiologiju	27	267	Pekmezovic T.
1	Trajkovic V.	155	28	Vladimir	Trajkovic	Katedra za imunologiju	37	165	Trajkovic V.
2	Pravica V.	88	26	Vera	Pravica	Katedra za imunologiju	35	98	Pravica V.
3	Markovic Denic L.	84	34	Ljiljana	Markovic Denic	Katedra za epidemiologiju	14	84	Markovic Denic L.
4	Gazibara T.	80	41	Tatjana	Gazibara	Katedra za epidemiologiju	11	79	Gazibara T.
5	Stanojevic M.	66	14	Maja	Stanojevic	Katedra za mikrobiologiju	20	72	Stanojevic M.

4.1.2 Question 2

What is the average number of co-authors per author?

The column ***AVG CoAuthors per Author*** in the figure shows the average number of co-authors per author. It is evident that *Dubljanin E.* collaborates the most with colleagues. This can also be concluded from the primary dataset and the *Authors* column.

	Author	Sum of Co Authors	Num of works per Author	AVG CoAuthors per Author
8	Dubljanin E.	13907	37	374.864865
55	Vujcic I.	9286	27	342.925926
53	Trajkovic V.	4985	155	31.161290
1	Arsic Arsenijevic V.	4057	50	80.140000
51	Stanojevic M.	2238	66	32.909091
39	Pekmezovic T.	1996	270	6.392593
52	Stevanovic G.	1380	40	33.500000
31	Milosevic B.	664	38	16.473684

4.1.3 Question 3

Based on the available data, determine the H-index for each researcher and compare it with the available H-index in the file Autori.xlsx.

The H-index calculated in this assignment closely matches the H-index values provided in the file ***Autori.xlsx***.

	Kratko ime	Izracunati H index	id_author	Ime	Prezime	Katedra	H indeks	Broj radova
0	Jovanovic T.	11	1	Tanja	Jovanovic	Katedra za mikrobiologiju	11	45
1	Savic B.	10	2	Branislava	Savic	Katedra za mikrobiologiju	10	30
2	Mitrovic S.	4	3	Sanja	Mitrovic	Katedra za mikrobiologiju	4	20
3	Ranin L.	7	4	Lazar	Ranin	Katedra za mikrobiologiju	7	40
4	Arsic Arsenijevic V.	17	5	Valentina	Arsic Arsenijevic	Katedra za mikrobiologiju	17	52
5	Djukic S.	8	6	Slobodanka	Djukic	Katedra za mikrobiologiju	8	38
6	Cupic M.	7	7	Maja	Cupic	Katedra za mikrobiologiju	7	31
7	Vuckovic Opavski N.	0	8	Natasa	Vuckovic Opavski	Katedra za mikrobiologiju	1	3
8	Dzamic A.	5	9	Aleksandar	Dzamic	Katedra za mikrobiologiju	6	24
9	Vukovic D.	14	10	Dragana	Vukovic	Katedra za mikrobiologiju	14	45
10	Dakic I.	12	11	Ivana	Dakic	Katedra za mikrobiologiju	12	25
11	Knezevic A.	8	12	Aleksandra	Knezevic	Katedra za mikrobiologiju	8	28
12	Lazarevic I.	8	13	Ivana	Lazarevic	Katedra za mikrobiologiju	8	40

4.1.4 Question 4

Which departments are the most productive in terms of scientific output and citation count in journals based on the available data?

Based on the number of author citations and the number of published papers per author, the figure shows that the ***Department of Microbiology*** is the most productive.

Katedra	Sum of Cited by	Num of works per Author
Katedra za mikrobiologiju	24960	650
Katedra za imunologiju	17509	356
Katedra za epidemiologiju	7862	706
Infektivne bolesti	2389	291

4.1.5 Question 5

In which years were authors most productive at the faculty level and within individual departments?

At the faculty level, researchers were most productive in 2018. At the departmental level, the most productive year was 2020.

	Year	Num of works
33	2018	207
29	2014	181
30	2015	150
34	2019	143
31	2016	140
28	2013	140
32	2017	112
27	2012	99
35	2020	88
22	2007	82

	Year	Katedra	Num of works
111	2020	Katedra za epidemiologiju	44
110	2020	Infektivne bolesti	25
113	2020	Katedra za mikrobiologiju	17
112	2020	Katedra za imunologiju	2
107	2019	Katedra za epidemiologiju	53
106	2019	Infektivne bolesti	38
109	2019	Katedra za mikrobiologiju	38
108	2019	Katedra za imunologiju	14
105	2018	Katedra za mikrobiologiju	72
103	2018	Katedra za epidemiologiju	68

4.1.6 Question 6

Which journals have the highest average number of publications?

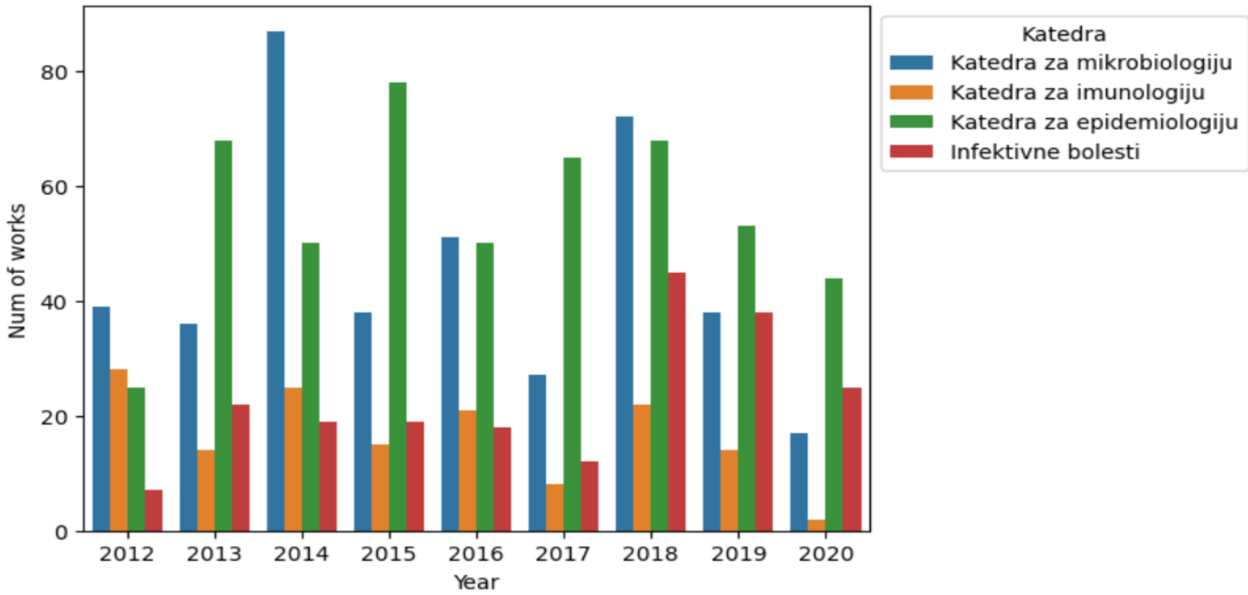
The figure shows that the journal ***Archives of Biological Sciences*** contains the highest number of publications. Below it are other journals with the respective number of published papers.

	Source title	Num of works
47	Archives of Biological Sciences	86
493	Srpski arhiv za celokupno lekarstvo	73
318	Journal of Infection in Developing Countries	59
526	Vojnosanitetski Pregled	58
381	Medicinski pregled	53
492	Srpski Arhiv za Celokupno Lekarstvo	49
434	PLoS ONE	44
322	Journal of Medical Biochemistry	29
527	Vojnosanitetski pregled. Military-medical and ...	28

4.1.7 Question 7

Are there differences between departments in terms of volume and frequency of journal publications?

From Question 6, it is clear that the journal ***Archives of Biological Sciences*** has the most publications. The figure below shows that there are no significant differences in journal publication frequencies across departments.



4.1.8 Question 8

Are there differences in the average number of authors per journal article across departments?

The penultimate and final columns show the results, allowing us to observe variations.

	Katedra	Num of authors	Num of works	Author per work	AVG Author per work
0	Infektivne bolesti	13	291	0.044674	0.031005
1	Katedra za epidemiologiju	13	706	0.018414	0.031005
2	Katedra za imunologiju	8	356	0.022472	0.031005
3	Katedra za mikrobiologiju	25	650	0.038462	0.031005

4.1.9 Question 9

What is the ratio of co-authors from within the faculty to those outside the faculty, per department and for the faculty as a whole?

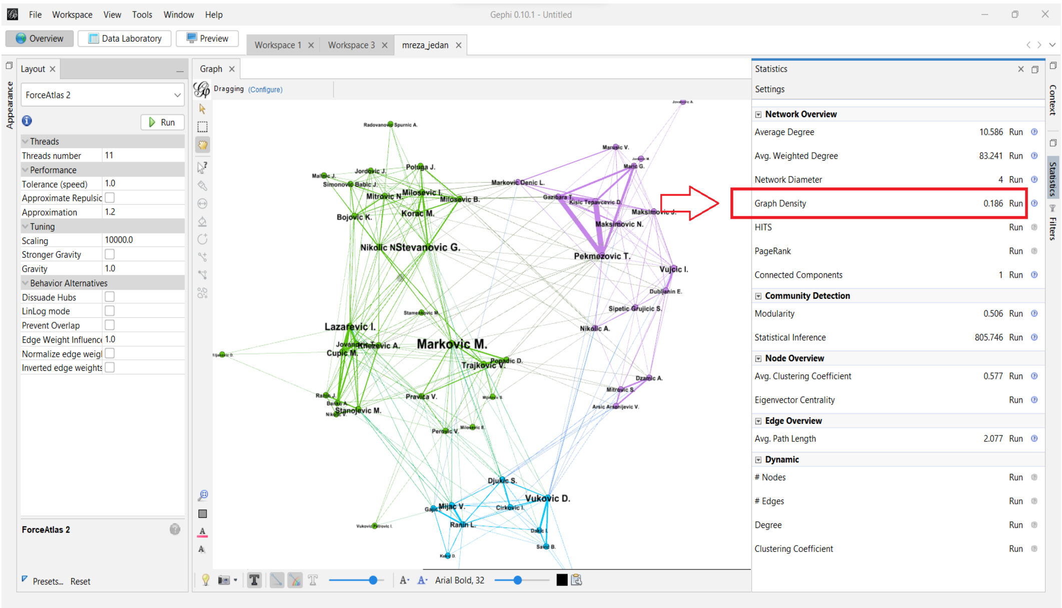
Katedra	Num of domestic authors	Num of foregin authors	The ratio of domesti and foregin authors
Infektivne bolesti	193	2206	0.087489
Katedra za epidemiologiju	504	11640	0.043299
Katedra za imunologiju	317	5262	0.060243
Katedra za mikrobiologiju	372	21055	0.017668

4.2 BASIC CHARACTERIZATION OF NETWORK MODELING

4.2.1 Question 10

What is the network density?

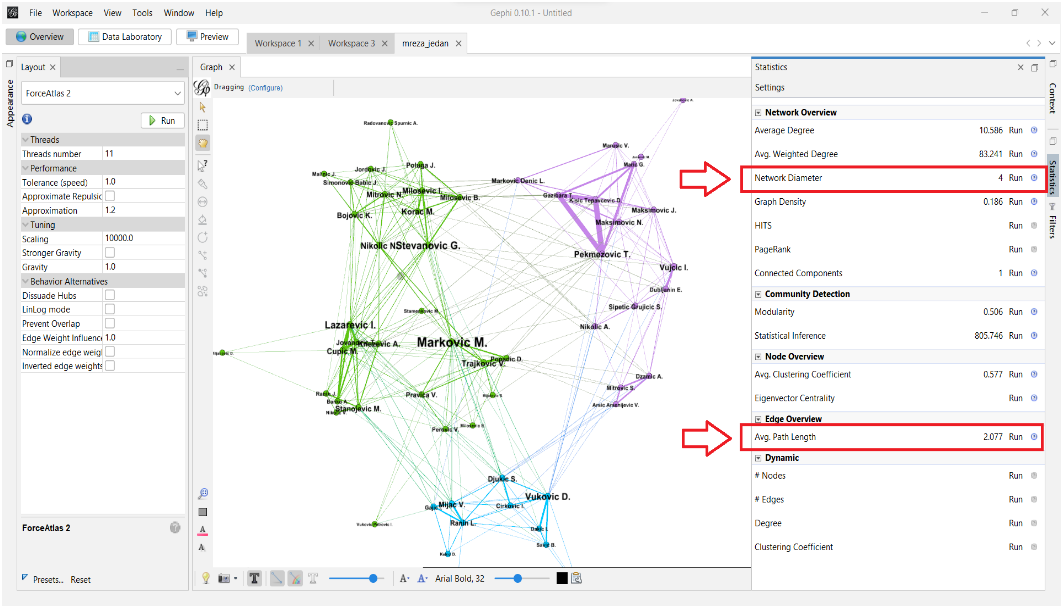
The network density, as shown in Gephi, is: **0.186**



4.2.2 Question 11

What are the average distances within the network and the network diameter?

The average distances and the diameter of the network are also visible in Gephi and are: **2.077** and **4**, respectively.



4.2.3 Question 12

To what extent is the network connected and centralized? State the number and sizes of connected components and assess whether there is a giant component.

The network is highly connected, which is evident from the connectivity graph. Reachability within the network is high, as most nodes can communicate with each other. There are no distinct bridge nodes between communities that are the only paths to move from one community to another; instead, multiple paths exist. We have one connected component involving all 58 nodes, which represents the giant component. Specifically, Professor Marković M. appears to be the most dominant.

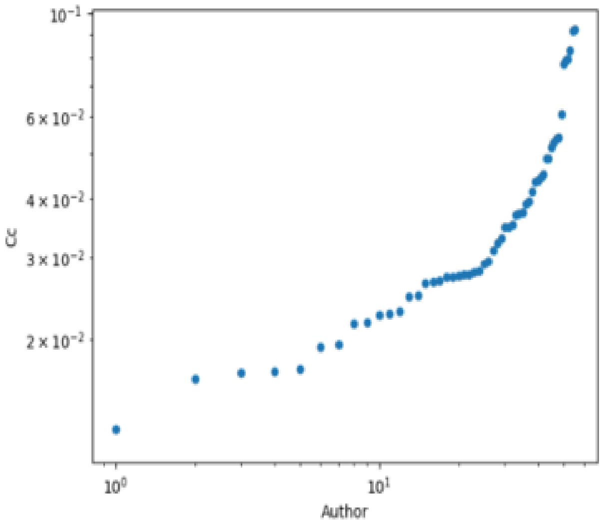
4.2.4 Question 13

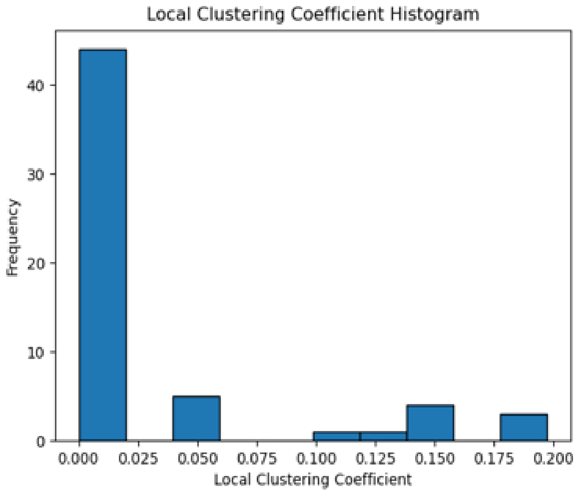
What are the average and global clustering coefficients of the network? What is the distribution of local clustering coefficients of its nodes? Is clustering pronounced? Answer by comparing with randomly generated Erdos-Renyi and scale-free networks of the same dimensions.

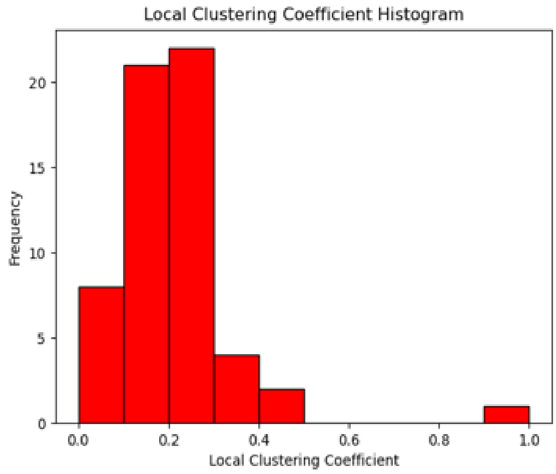
The average clustering coefficient is: **0.5569535644581753**
The global clustering coefficient is: **0.44722955145118 73**

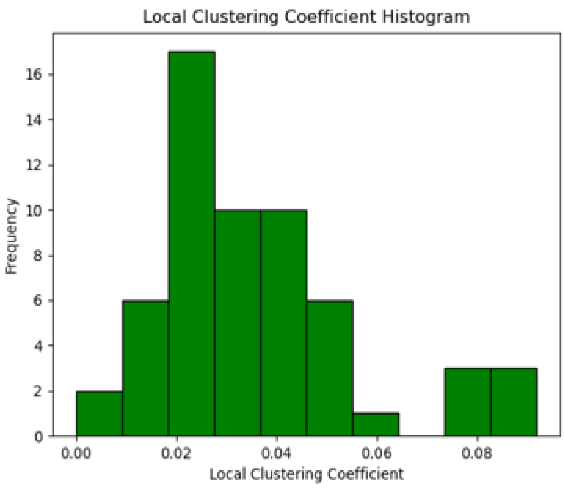
The figures below show the local clustering coefficient. Each graph observes the same number of nodes: for the Random Scale-Free network (blue histogram), the Erdos-Renyi network (red histogram), and our scientific collaboration network at the Faculty of Medicine (green histogram).

```
Max lokalni cc: 0.09200531258775885
Prosečan cc: 0.5569535644581752
Lokalni stepeni klasterisanja koji nisu nula:
                    Author        Cc
14             Markovic M.  0.012048
4               Nikolic A.  0.012838
54              Vukovic D.  0.016438
42              Perovic V.  0.016991
44             Trajkovic V.  0.017067
36      Sipetic Grujicic S.  0.017296
48                Vujcic I.  0.019203
27       Markovic Denic L.  0.019524
16           Stamenkovic M.  0.021617
17            Stevanovic G.  0.021681
21                 Ranin J.  0.022477
```







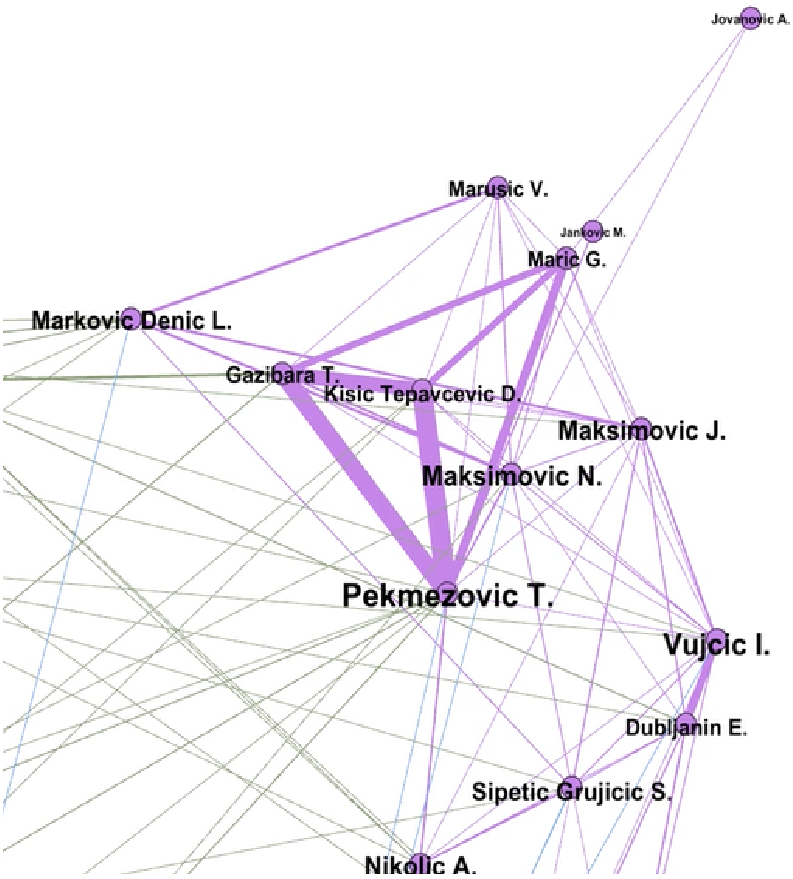


For all three networks, clustering is not pronounced since the clustering coefficient values are close to 0.

4.2.5 Question 14

To what extent do authors tend to publish with the same co-authors?

A visual inspection reveals that researchers frequently collaborate with the same co-authors. This is evident from the edge weights (thickness of edges in the network graph). The figure below shows a fragment of one network community.



4.2.6 Question 15

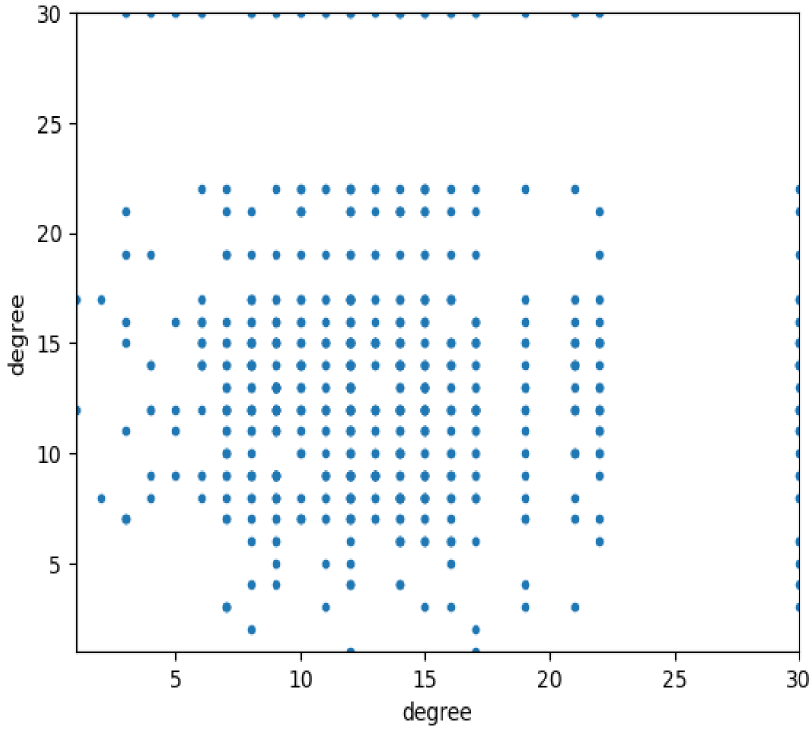
Based on answers to Questions 10 and 12, assess whether the network exhibits small-world properties.

Despite the network being large, the paths between nodes are short. Nodes tend to form dense clusters. Also, the number of long-range connections is small. Therefore, we conclude that the network exhibits small-world properties. The average path length is 2.077.

4.2.7 Question 16

Perform assortativity analysis based on node degree and determine whether assortative mixing is present and to what extent. Include visualization.

Assortativity coefficient based on unweighted node degree: **-0.041228455386**
Assortativity coefficient based on weighted node degree: **-0.0325539678516**

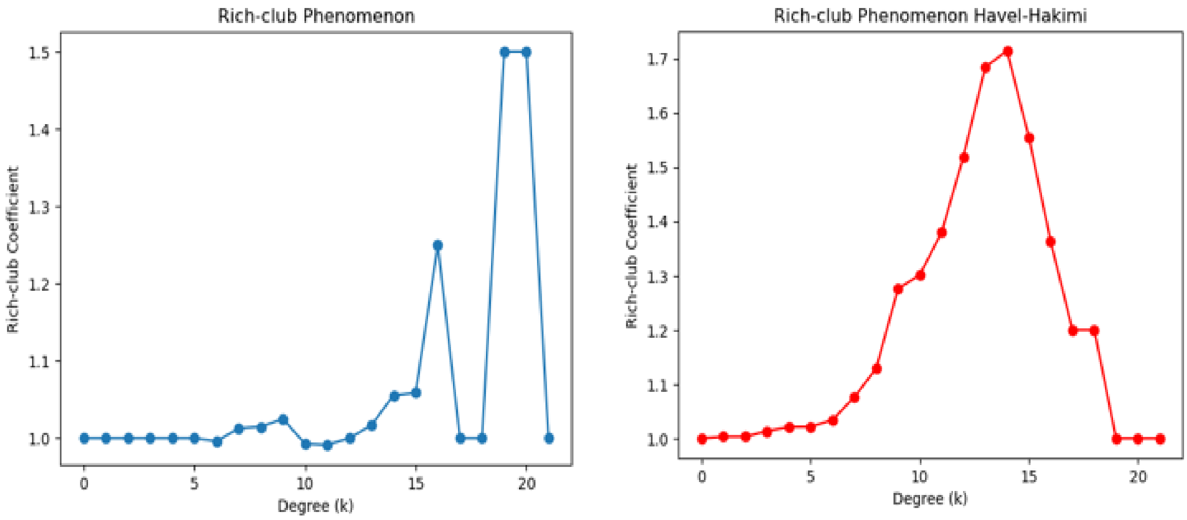


The negative value of the assortativity coefficient (-0.041) indicates disassortative mixing in our graph. Positive values would indicate assortative mixing. Therefore, we conclude that assortative mixing is not pronounced; instead, there is disassortativity, meaning nodes with different degrees frequently form connections.

4.2.8 Question 17

Does the network exhibit the rich-club phenomenon? Conduct the analysis by comparing with a suitable network generated using the Havel-Hakimi algorithm.

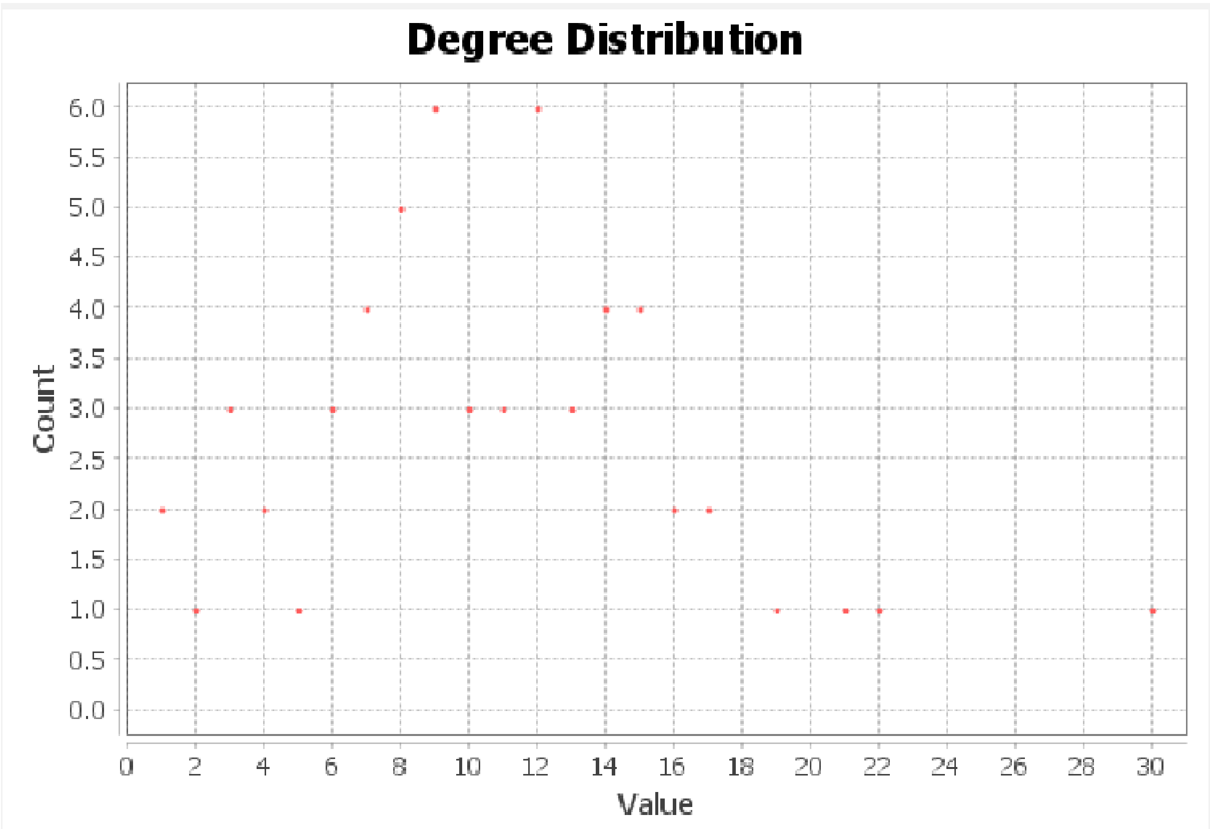
The network shows some degree of rich-club phenomenon, as high-degree nodes tend to form more connections with other high-degree nodes. The figures below show that both graphs have coefficient values close to zero at the beginning but display peaks as the **k** values increase.



4.2.9 Question 18

What is the degree distribution of the nodes, and does it follow a power-law distribution?

From the figure, we can conclude that the node degree distribution roughly follows a power-law distribution.



4.3 CENTRALITY MEASURES ANALYSIS

4.3.1 Question 19

Conduct centrality analysis based on degree, closeness, and betweenness centrality. Provide an overview of the key actors for each measure. Which authors represent central figures within their departments and at the faculty level?

The table below includes four additional columns representing the calculated centrality measures. The first column lists the authors who are the key actors for each department. At the faculty level, the central actor is clearly ***Marković Miloš***, while by departments:

- *Epidemiology*: ***Pekmezović Tatjana***
- *Immunology*: ***Marković Miloš***
- *Microbiology*: ***Lazarević Ivana***
- *Infectious Diseases*: ***Stevanović Goran***

	Author	Degree centrality	Closeness centrality	Betweenness centrality	Eigenvector centrality	id_author	Ime	Prezime	Katedra	H indeks	Broj radova	Kratko ime
11	Markovic M.	0.526316	0.678571	0.180660	0.315049	29	Milos	Markovic	Katedra za imunologiju	11	27	Markovic M.
53	Stevanovic G.	0.385965	0.600000	0.063193	0.264320	51	Goran	Stevanovic	Infektivne bolesti	6	39	Stevanovic G.
9	Lazarevic I.	0.368421	0.575758	0.062268	0.250623	13	Ivana	Lazarevic	Katedra za mikrobiologiju	8	40	Lazarevic I.
5	Vukovic D.	0.333333	0.593750	0.100009	0.176868	10	Dragana	Vukovic	Katedra za mikrobiologiju	14	45	Vukovic D.
27	Pekmezovic T.	0.298246	0.575758	0.107265	0.146342	36	Tatjana	Pekmezovic	Katedra za epidemiologiju	27	267	Pekmezovic T.
45	Nikolic N.	0.298246	0.542857	0.018609	0.225110	57	Natasa	Nikolic	Infektivne bolesti	2	12	Nikolic N.
34	Korac M.	0.280702	0.558824	0.030797	0.205659	48	Milos	Korac	Infektivne bolesti	7	26	Korac M.

4.3.2 Question 20

Who are the most important actors based on eigenvector centrality? What does this tell us about them?

Professors with high eigenvector centrality values are those connected to other highly central professors. The *Eigenvector* column is shown in the table above. These professors play a crucial role in information dissemination throughout the network and indicate the level of collaboration among departments.

	Author	Degree centrality	Closeness centrality	Betweenness centrality	Eigenvector centrality	id_author	Ime	Prezime	Katedra	H indeks	Broj radova	Kratko ime
11	Markovic M.	0.526316	0.678571	0.180660	0.315049	29	Milos	Markovic	Katedra za imunologiju	11	27	Markovic M.
53	Stevanovic G.	0.385965	0.600000	0.063193	0.264320	51	Goran	Stevanovic	Infektivne bolesti	6	39	Stevanovic G.
9	Lazarevic I.	0.368421	0.575758	0.062268	0.250623	13	Ivana	Lazarevic	Katedra za mikrobiologiju	8	40	Lazarevic I.
45	Nikolic N.	0.298246	0.542857	0.018609	0.225110	57	Natasa	Nikolic	Infektivne bolesti	2	12	Nikolic N.
34	Korac M.	0.280702	0.558824	0.030797	0.205659	48	Milos	Korac	Infektivne bolesti	7	26	Korac M.
35	Milosevic I.	0.263158	0.527778	0.014441	0.199233	54	Ivana	Milosevic	Infektivne bolesti	7	30	Milosevic I.
47	Mitrovic N.	0.245614	0.518182	0.005971	0.192688	56	Nikola	Mitrovic	Infektivne bolesti	5	21	Mitrovic N.

4.3.3 Question 21

Based on the previous two questions, propose and construct a heuristic (composite centrality measure) for identifying the most important actors and identify them. Pay attention to the type of network being analyzed (directed or undirected), and accordingly adjust how different network metrics influence the heuristic.

The composite rank was obtained by multiplying the rank based on node degree with the eigenvector centrality rank. The most prominent nodes are: *Marković Miloš*, *Stevanović Goran*, *Lazarević Ivana*, and *Vuković Dragana*.

$$rank = DC \cdot CC \cdot BC \cdot EVC$$

	DC	CC	BC	EVC	DC_rank	CC_rank	BC_rank	EVC_rank	composite_rank
Markovic M.	0.526316	0.678571	0.180660	0.315049	1.0	1.0	1.0	1.0	1.00
Stevanovic G.	0.385965	0.600000	0.063193	0.264320	2.0	2.0	4.0	2.0	32.00
Lazarevic I.	0.368421	0.575758	0.062268	0.250623	3.0	4.5	5.0	3.0	202.50
Vukovic D.	0.333333	0.593750	0.100009	0.176868	4.0	3.0	3.0	9.0	324.00
Pekmezovic T.	0.298246	0.575758	0.107265	0.146342	5.5	4.5	2.0	17.0	841.50
Korac M.	0.280702	0.558824	0.030797	0.205659	7.5	6.5	8.0	5.0	1950.00
Nikolic N.	0.298246	0.542857	0.018609	0.225110	5.5	10.0	19.0	4.0	4180.00
Trajkovic V.	0.280702	0.553398	0.040457	0.151647	7.5	8.0	7.0	15.0	6300.00
Knezevic A.	0.263158	0.558824	0.026251	0.174117	10.5	6.5	11.0	11.0	8258.25
Cupic M.	0.263158	0.542857	0.029504	0.176326	10.5	10.0	9.0	10.0	9450.00

4.3.4 Question 22

Do authors from different departments collaborate with each other, and to what extent? Who are the authors that connect different groups within the network? Based on this analysis, is there an external author who would be highly beneficial to employ at the Faculty of Medicine?

Authors from different departments collaborate significantly. There is not a single hub through which all communication between communities is channeled; rather, communities are connected through multiple links. The authors who connect different groups within the network are clearly visible in the graph. An external author who would be beneficial to hire at the faculty is ***Hutchinson I.V.***, as he collaborates extensively with domestic authors. This is evident from the group of authors listed for each journal. We used this information to create a new column showing author appearances. After grouping, we concluded that ***Hutchinson I.V.*** is the author worth employing.

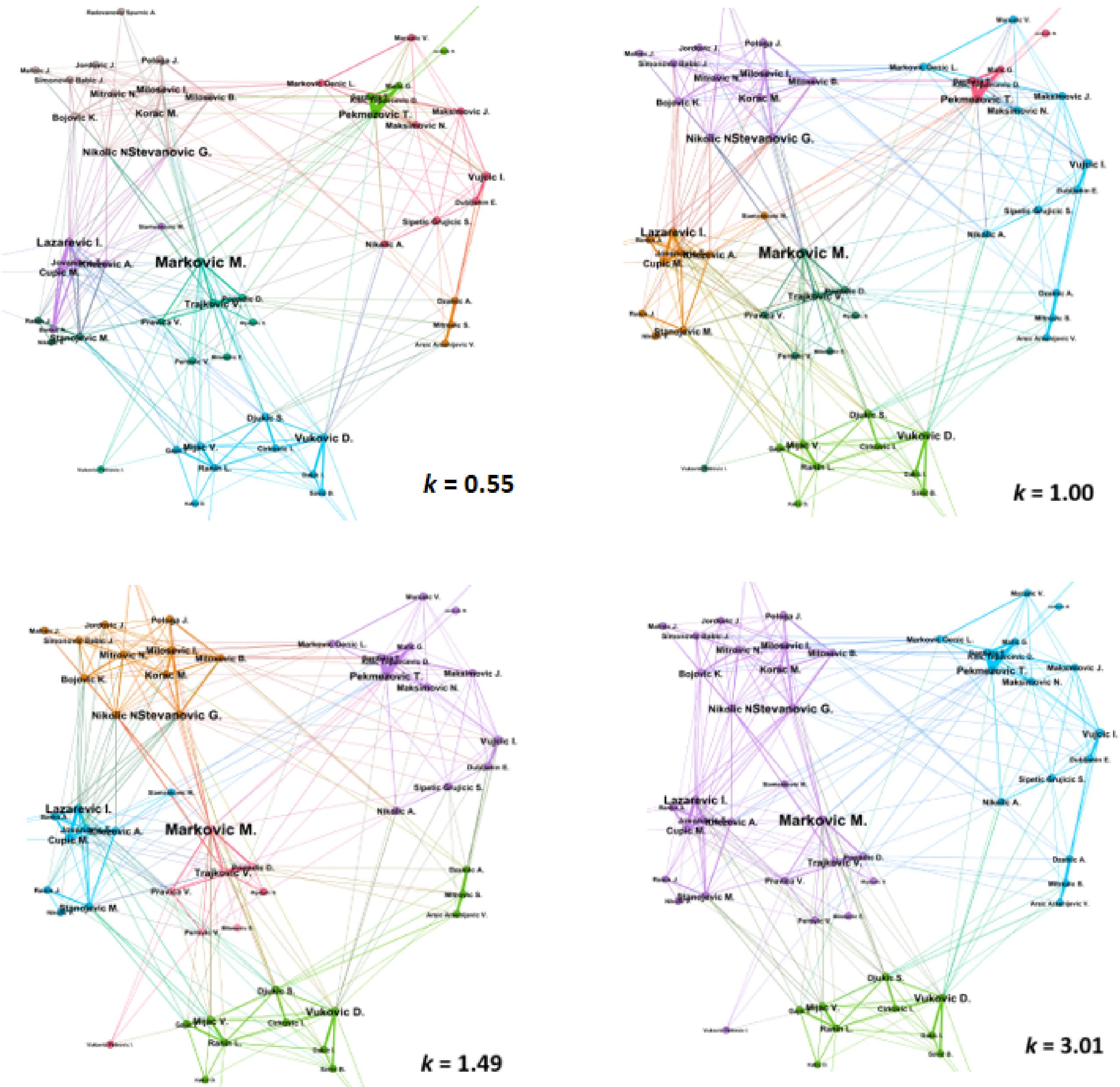
	Author	Num of works per Author
3690	Hutchinson I.V.	59
2339	Drulovic J.	59
3977	Jevtovic D.	56
5458	Marinkovic J.	52
7792	Salemovic D.	46
4611	Kostic V.S.	44
728	Barac A.	44
8581	Stepanovic S.	43
8746	Svetel M.	43

4.4 COMMUNITY DETECTION USING LOUVAIN METHOD

4.4.1 Question 23

Perform clustering using the Louvain method (by maximizing modularity) in Gephi for three different values of the resolution parameter. Construct visualizations and discuss how the choice of the resolution parameter affects the resulting clustering (number and size of clusters).

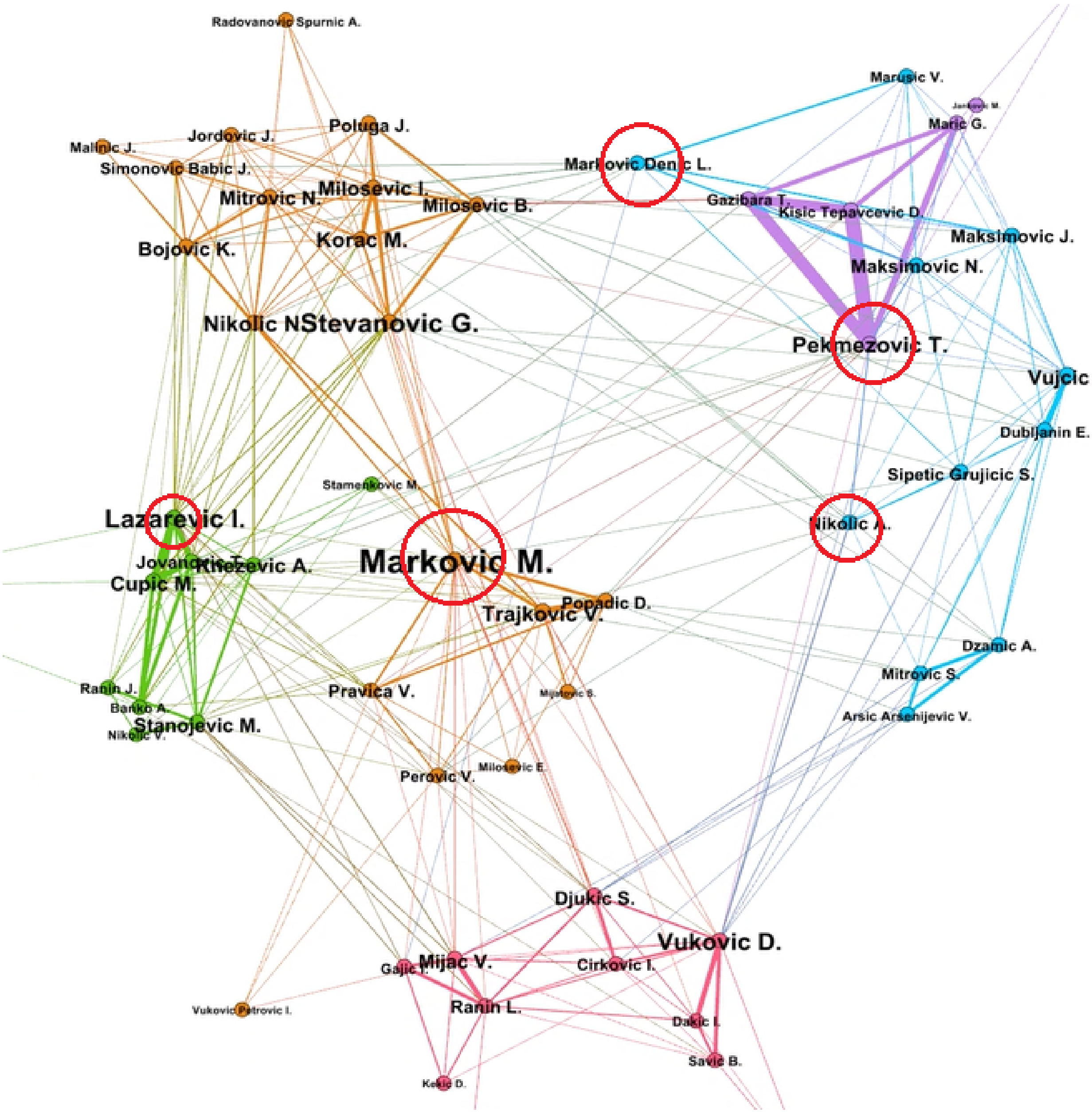
We performed Louvain clustering for four different resolution parameter values *($\boldsymbol{k}$)*. We scaled various values for $\boldsymbol{k}$ and found that at $\boldsymbol{k} \sim \boldsymbol{1.5}$, clusters formed roughly at the department level. The figure shows the average number of authors per cluster.



4.4.2 Question 24

Which communities (clusters) can be observed in the network analysis, and which actors are the key brokers? Is there an explanation for the detected communities?

From Question 23 and the figure below, we can see how the communities are formed. The explanation for these detected communities is that they are mostly formed within corresponding departments. The key brokers are marked.

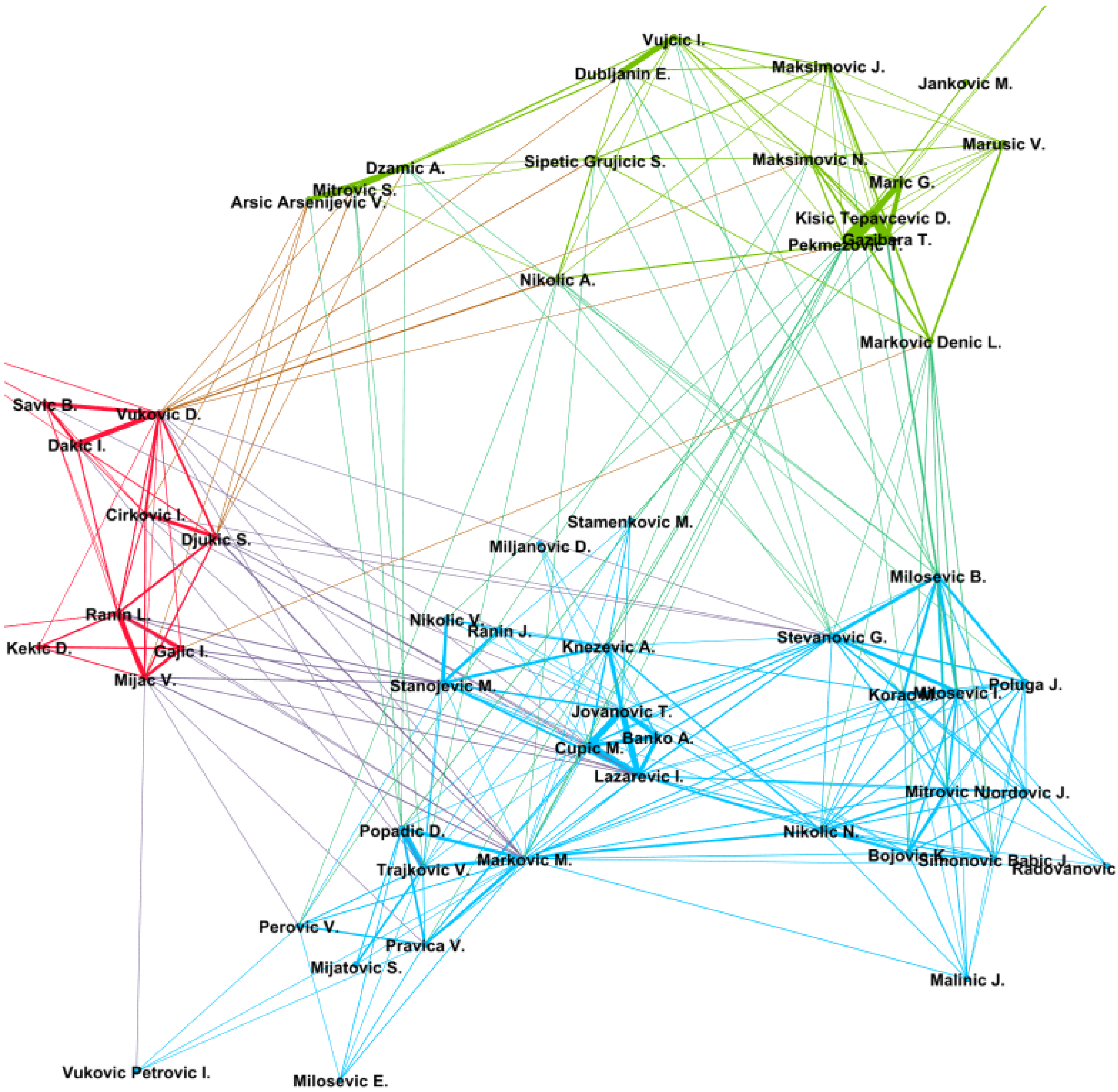


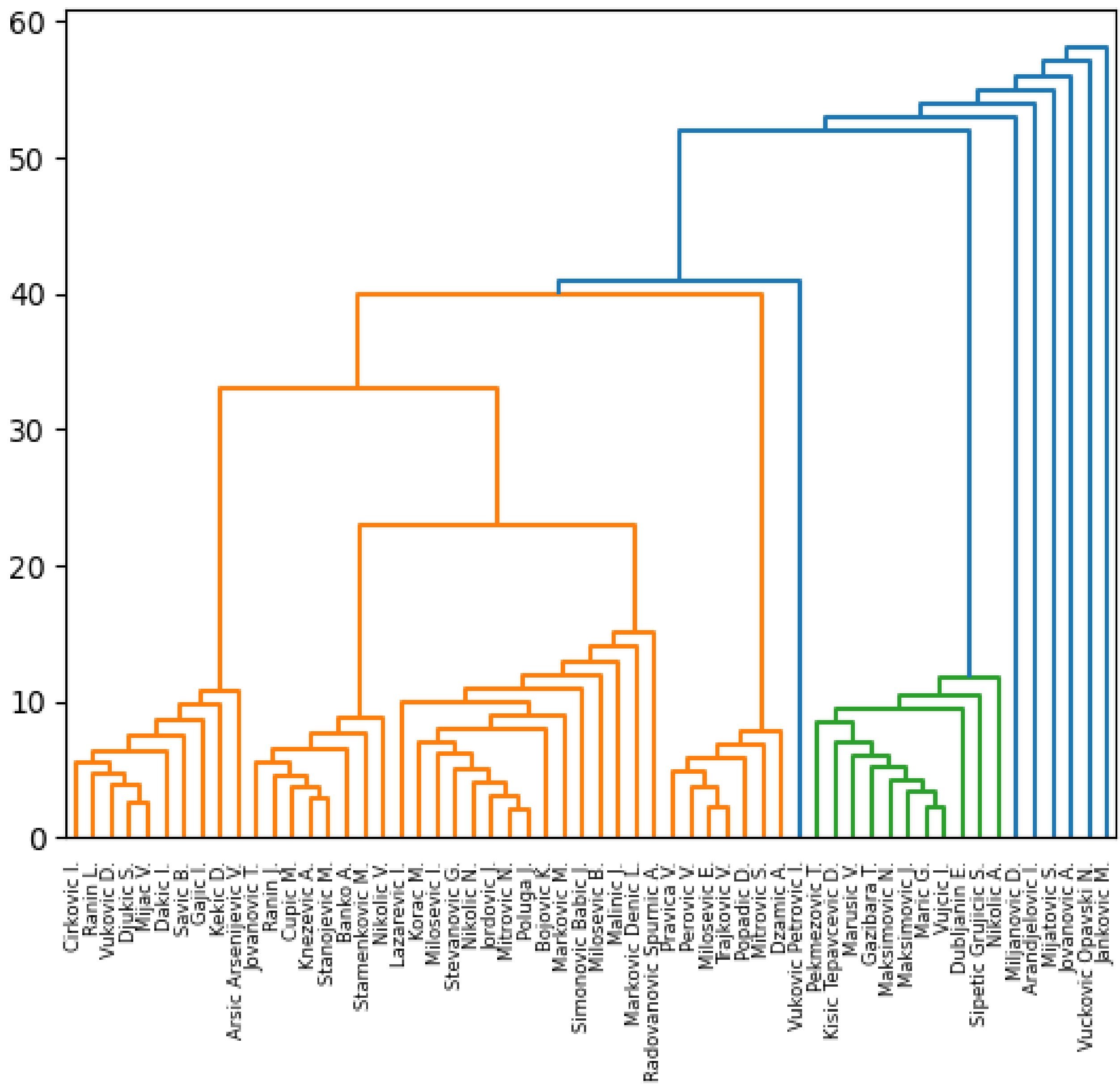
4.5 Community Detection via Spectral Clustering

4.5.1 Question 25

Conduct a spectral analysis and estimate potential candidates for the number of communities in the network. Compare the result with the dendrogram constructed using the Girvan-Newman method, if applicable at the faculty or department level.

For $k = 3$, we conducted a spectral analysis and exported the result to Gephi. From the first image below, we can observe how the communities are colored, followed by the dendrogram which largely matches the previous result.

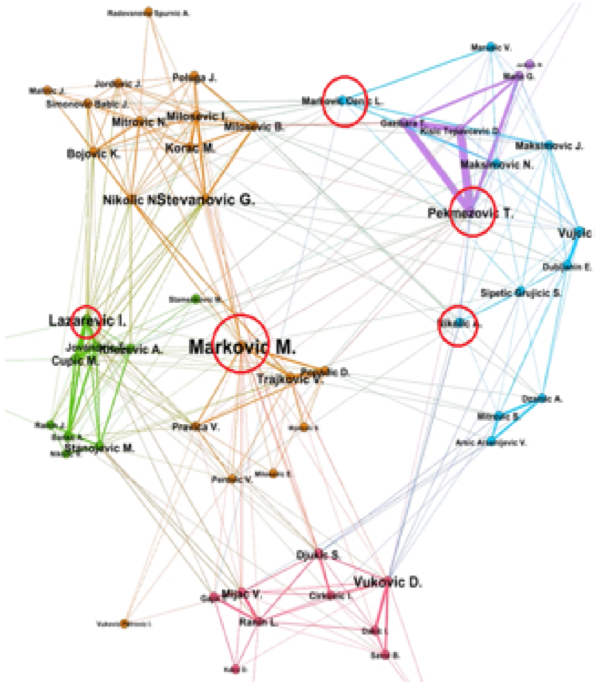




4.5.2 Question 26

Who are the actors that can be characterized as key brokers (bridges) in the network? What makes them brokers? Compare the answer with the brokers identified in Questions 22 and 24.

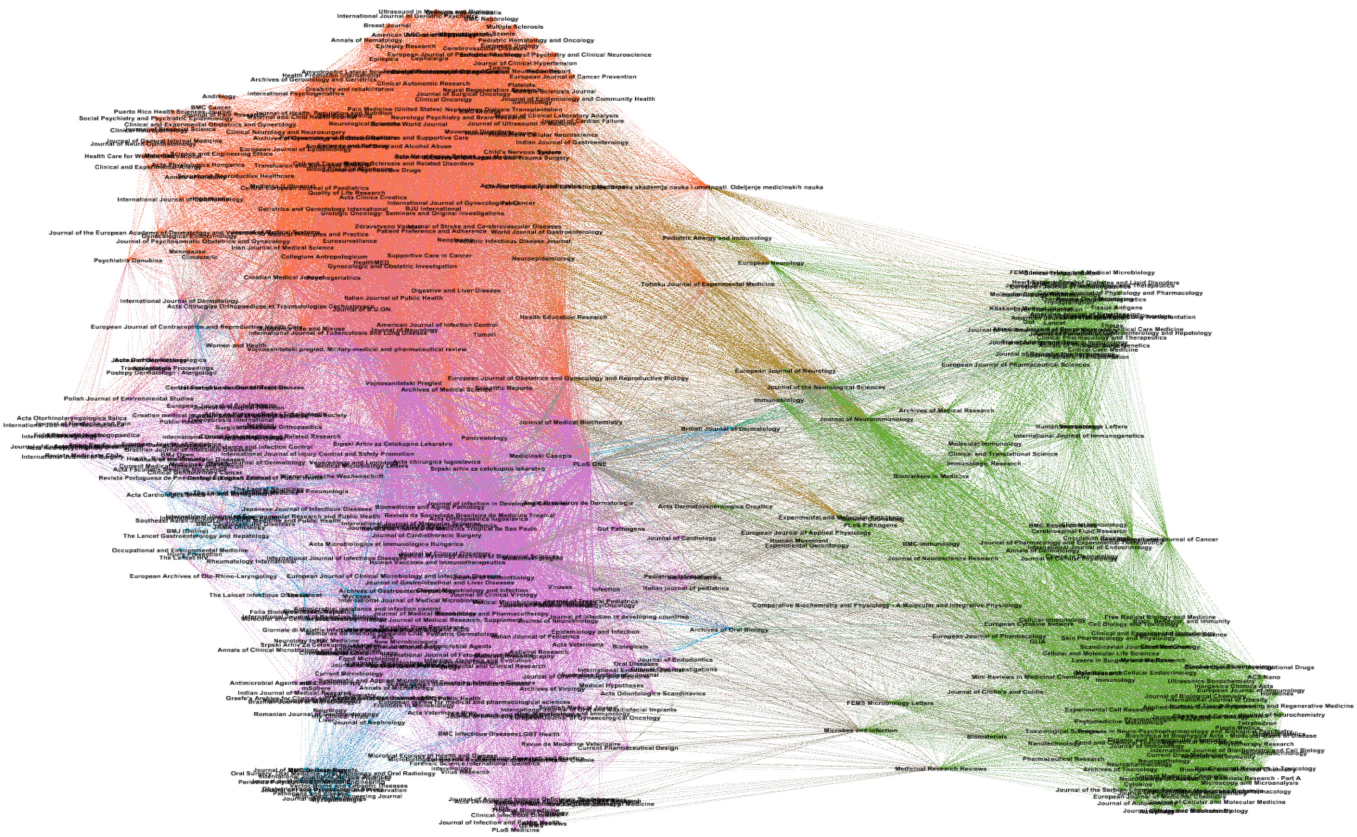
The actors that can be characterized as key brokers are: ***Marković Denić L.*** and ***Nikolić A.***. In the image below, we made a comparison with the previous network, showing that the new set of brokers is a subset of the previous one.


Markovic M.
Lazarevic I.
Pekmezovic T.
Stevanovic G.
Vukovic D.
Mitrovic N.
Milosevic I.
Korac M.
Bojovic K.
Trajkovic V.
Cupic M.
Stanojevic M.
Djukic S.
Ranin L.
Mijac V.
Maksimovic N.
Maksimovic J.
Vujcic I.
Sipetic Grujicic S.
Pravica V.
Milosevic B.
Dubljanin E.
Dzamic A.
Arsic Arsenijevic V.
Vukovic Petrovic I.

Vujcic I.
Dubljanin E.
Maksimovic J.
Jankovic M.
Dzamic A.
Sipetic Grujicic S.
Maksimovic N.
Arsic Arsenijevic V.
Kisic Tepavcevic D.
Nikolic A.
Markovic Denic L.
Vukovic D.
Stamenkovic M.
Milosevic B.
Stevanovic G.
Knezevic A.
Stanojevic M.
Jovanovic T.
Cupic M.
Lazarevic I.
Markovic M.
Trajkovic V.
Pravica V.
Mijatovic S.
Malinic J.
Mijac V.
Vukovic Petrovic I.
Milosevic E.

4.6 Journal Network Analysis

4.6.1 Structure of the Journal Network



4.6.2 Formation of the Journal Network

The network was formed using a secondary dataset in which we observed domestic authors and the journals they publish in. The network contains 536 distinct nodes and 22,495 edges. In this example, the nodes of the network are journals (unique *Source title* values), and the edges represent connections between journals based on authors who have published in both.

4.6.3 Journals and Their Authors

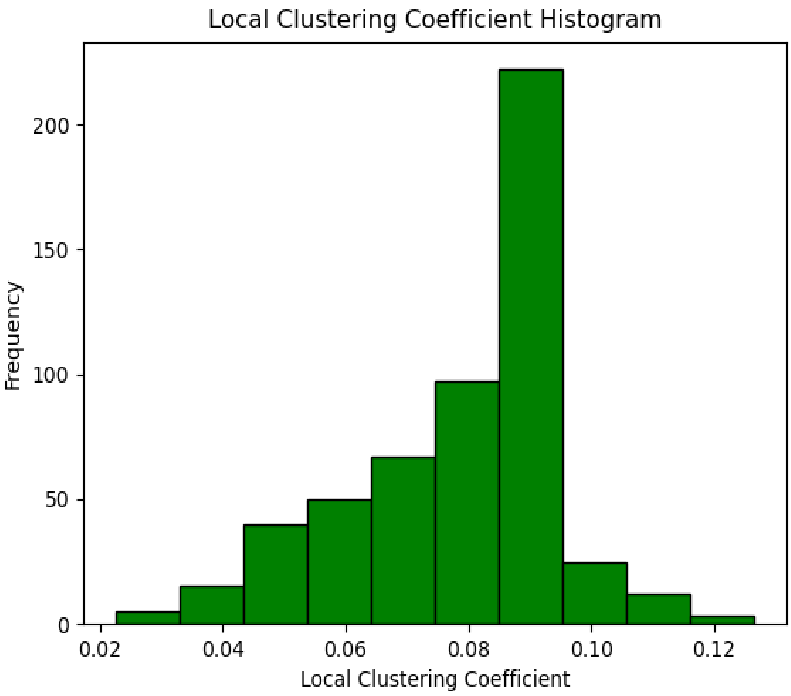
From the figure, it is evident that the journal ***Archives of Biological Sciences*** has the highest number of contributing researchers. The top ten journals and the number of articles in each are shown in descending order.

	Source title	Num of work per Soruce title
47	Archives of Biological Sciences	86
493	Srpski arhiv za celokupno lekarstvo	73
318	Journal of Infection in Developing Countries	59
526	Vojnosanitetski Pregled	58
381	Medicinski pregled	53
492	Srpski Arhiv za Celokupno Lekarstvo	49
434	PLoS ONE	44
322	Journal of Medical Biochemistry	29
527	Vojnosanitetski pregled. Military-medical and ...	28
23	Acta chirurgica Iugoslavica	24

4.6.4 Basic Characterization of the Modeled Network

- ***Network density:*** 0.157
- ***Network diameter:*** 3
- ***Average distance within the network:*** 1.865
- ***Number of connected components:*** 1
- ***Size of the connected component:*** 536
- ***Average clustering coefficient:*** 0.832846235808478
- ***Global clustering coefficient:*** 0.6548100400218044
- ***Local clustering coefficient:*** 0.6548100400218044

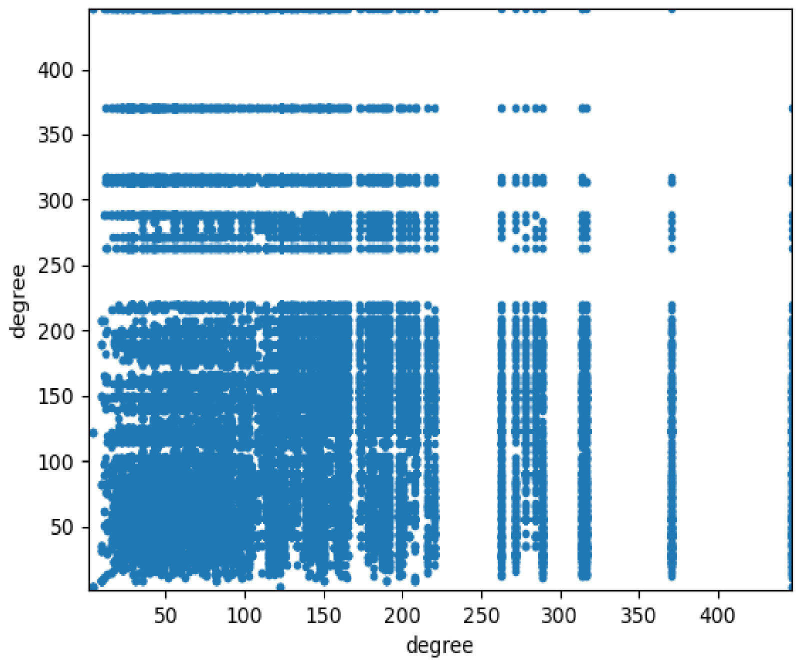
The figure below shows the distribution of the ***local clustering coefficient***. Clustering is not significantly expressed as the coefficient values are close to zero.

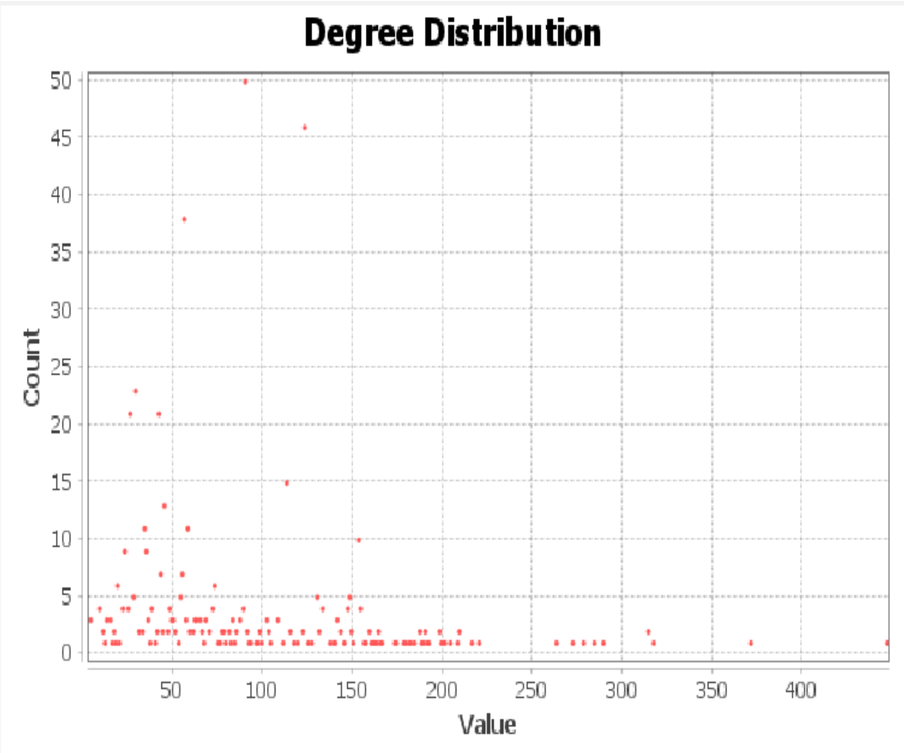


Assortativity coefficient is: -0.012134577741685564
Assortative mixing is not significantly present.

From the figure, it can be concluded that the node degree distribution roughly follows a *power-law* distribution.

When analyzing centrality measures (degree, closeness, betweenness, and eigenvector), it is evident that the journal ***PLoS ONE*** is the most dominant. Authors from different departments collaborated significantly through this journal.

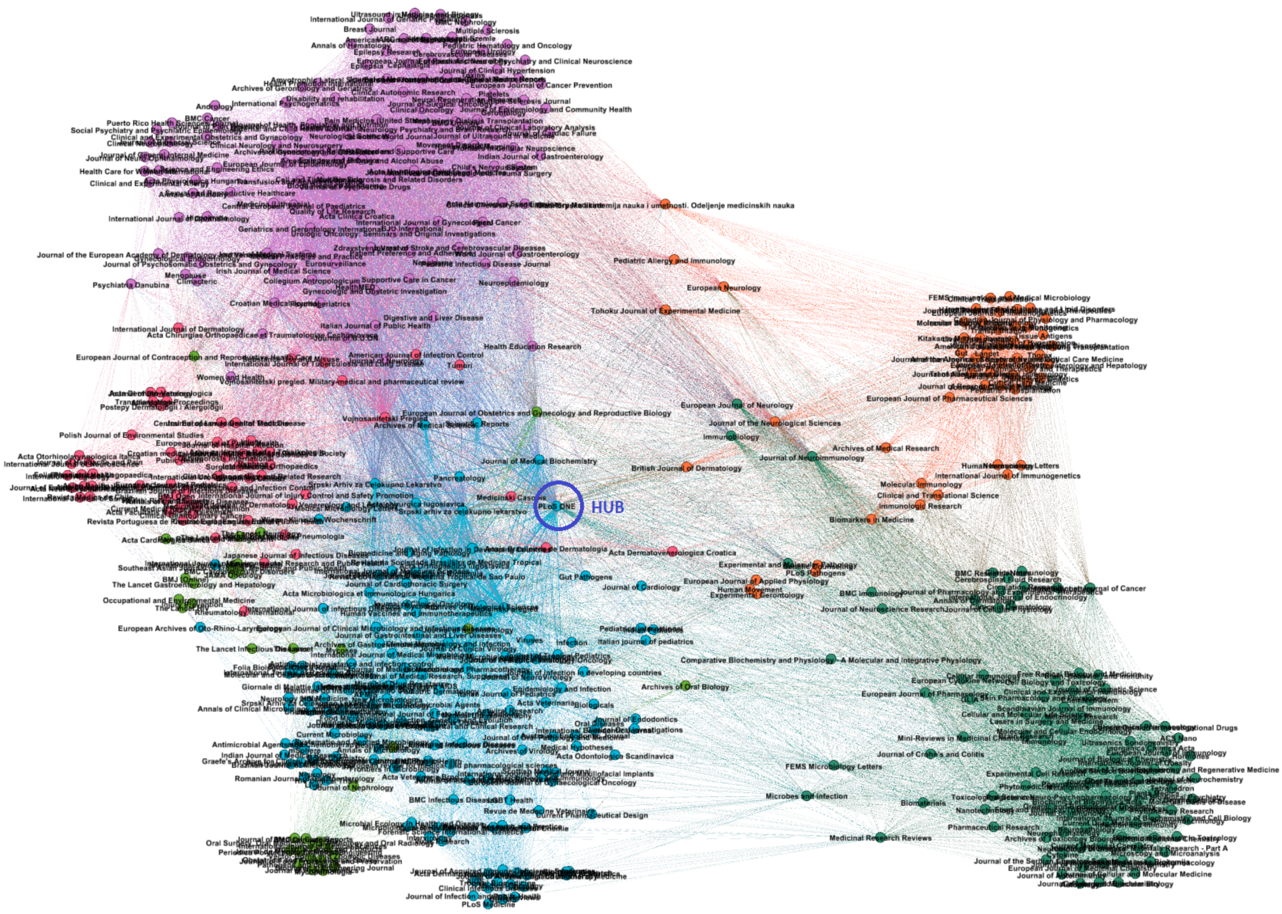




	Source title	Degree centrality	Closeness centrality	Betweenness centrality	Eigenvector centrality
15	PLoS ONE	0.835514	0.858748	0.129459	0.117698
35	Srpski arhiv za celokupno lekarstvo	0.693458	0.765379	0.067631	0.104858
55	Vojnosanitetski Pregled	0.592523	0.710491	0.032207	0.105136
48	Srpski Arhiv za Celokupno Lekarstvo	0.586916	0.707672	0.034729	0.100196
36	Medicinski pregled	0.586916	0.707672	0.074093	0.062765

4.6.5 Community Detection via Louvain Method

For the coefficient value $k = 0.75$, we performed clustering using the Louvain method. We scaled different values of k and found that for $k \sim 0.75$, the clustering was optimal. The figure shows the average number of journals per cluster. It can be noted that journals are not grouped by departments, which is logical as they are the result of collaboration.



4.6.6 Key Brokers in the Journal Network