DBBA Coursework 1

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Instructions

Academic Misconduct

Please remember the good scholarly practice requirements of the University regarding work for credit. You can find guidance at the School page

https://web.inf.ed.ac.uk/infweb/admin/policies/academic-misconduct

This also has links to the relevant University pages.

You are not allowed to collaborate with other students on this assignment or to ask or answer questions about the contents of the assignment. If you do not understand a specific question, ask Valerio and Ogy on Piazza.

Submission Instructions

All the analysis must be done in this Jupyter Notebook and you should have a separate written report (without code) saved in PDF. Please fill out the fields bellow with the necessary code(remember to comment your code well) and discussion where needed. Code will generally not be marked, but it will be checked by the markers to ensure that all the analysis is properly done and the work is yours (i.e. there was no plagiarism). Focus on analysing the results you obtain as this is the main part that will be marked. Report your findings in a PDF file where you do not include any code but just the figures obtained and the conclusions you draw, i.e. plots and analysis. You will have to submit your files (final Jupyter Notebook and PDF) on Learn. Name your files with your student number. For instance, if your student number is S123456789, you must submit a file S123456789.zip containing the python source code and answers to the questions (PDF).

General Instructions

In this coursework, you will analyse a real-world temporal network based on what you have learned in class. Many exercises will require you to discuss the results of your analysis, some other will leave you the choice of which algorithm to use for a particular task. This is by design because this coursework assesses whether you understand network science and whether you can apply it to real-world networks. For this reason, if you realise you need to make assumptions to answer a question, do so and always, always motivate your assumptions and answers!

Warning: Some network metrics might require some time to compute. Please consider this when doing the coursework and allow enough time to perform the required

computations. Also remember that you can use the School's DICE machines, which can be let to run!

Assignment Premises

You have been hired as a data analyst in the newly founded investment company DBBA Capital and have been tasked with the analysis of the investment patterns of one of our major competitors: Fairholme Capital, managed by Bruce Berkowitz.

DBBA Capital wants you to evaluate the investment patterns of Fairholme Capital in relation to other superinvestors and evaluate the change in investment patterns during the pandemic. They have provided you with data about different superinvestors and the companies they invested in for each quarter spanning from quarter 1 (Q1) of 2019 to quarter 2 (Q2) of 2023 (that you can find in the folder named "Assignment Data").

The first column of each file represents the investors and the remaining columns represent the companies each investor invested in. First, familiarlise yourself with the data, and then, follow the steps bellow to perform the necessary analysis.

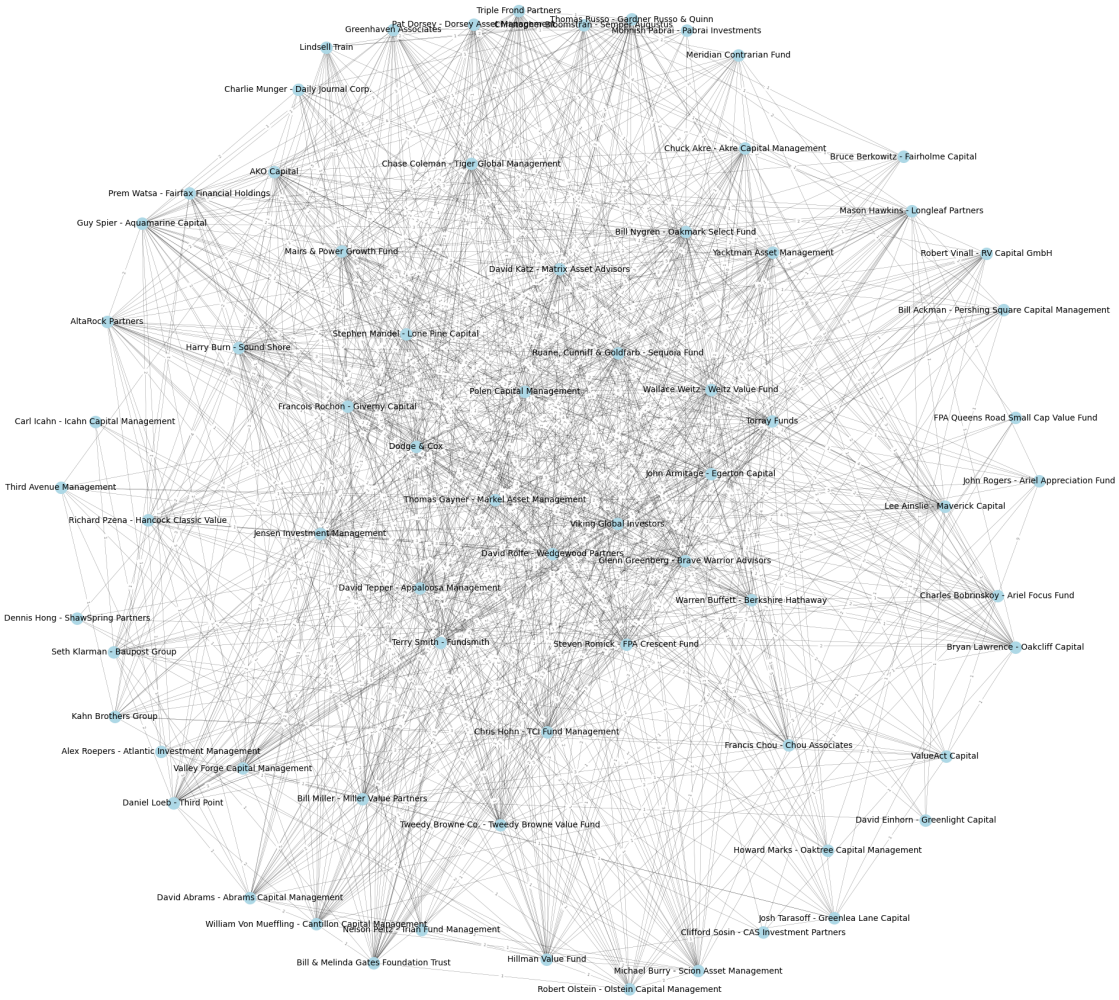
TIP When you believe it might help, make use of the information you have on the portfolio composition to comment and discuss your results.

Part 1: Network Creation

Task 1.1 (7 marks)
In the field below, load the first Excel dataset ("2019_Q1.xlsx") and create a network out of the investors and companies in the following manner:

- the nodes of the network are all the investors in the first column of the dataset
- two investors (nodes) are connected with an edge if they have invested in the same company (e.g. Christopher Bloomstran - Semper Augustus and David Abrams - Abrams Capital Management will be connected because they both invested in GOOGL).
- if two investors have invested in more than one common comapny, do *not* assign multiple edges between them. Instead, assign the number of common companies they have invested in as a weight to the edge connecting them.

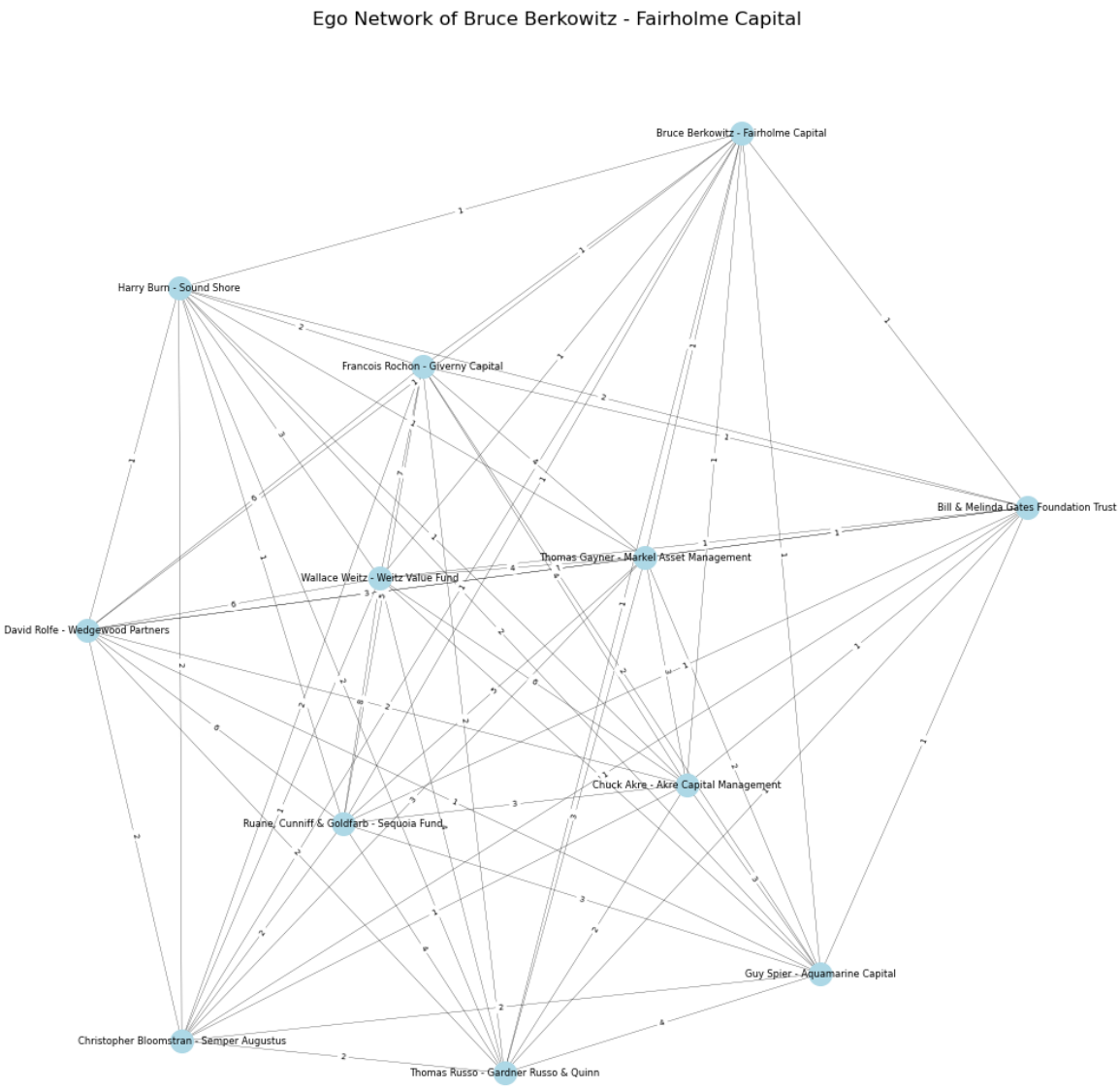
After you built the network, extract the largest connected component and plot it. Remember to add the edge weights in your plot.



Note that the whole network here and hereafter represents the largest connected component of the network

Task 1.2 (3 marks)

Obtain the ego-network of 'Bruce Berkowitz - Fairholme Capital' and plot it.



Part 2: Basic Network Analysis

Task 2.1 (15 marks)
Now that you know how to build the network for a single quarter and get its largest connected component, repeat the procedure for all the other quarters. For both the whole network and the ego-network, produce a table with the summary statistics (i.e. mean, max, min, and standard deviation) of the following network quantities:

- Number of nodes
- Number of links
- Density
- Average clustering coefficient
- Average degrees
- Average strength
- Assortativity

If you need to make any assumption or decision regarding the metric to use to compute any of these quantities, clearly motivate it.

Whole Network Summary Statistics

Quarter	Num Nodes	Num Links	Density	Avg Clustering Coefficient	Avg Degrees	Avg Strength	Assortativity
2019_Q1	71	1070	0.430584	0.645887	30.140845	57.661972	0.039387
2019_Q2	72	1086	0.424883	0.656897	30.166667	57.111111	-0.002711
2019_Q3	74	1064	0.393928	0.635414	28.756757	53.351351	0.027168
2019_Q4	77	1187	0.405673	0.649873	30.831169	56.649351	0.010834
2020_Q1	77	1378	0.470950	0.694655	35.792208	71.012987	0.019800
2020_Q2	77	1360	0.464798	0.717500	35.324675	72.311688	0.013681
2020_Q3	77	1383	0.472659	0.711723	35.922078	73.662338	0.022120
2020_Q4	77	1367	0.467191	0.710125	35.506494	72.233766	0.012836
2021_Q1	77	1361	0.465140	0.711671	35.350649	69.922078	0.031967
2021_Q2	77	1350	0.461381	0.717407	35.064935	70.285714	0.061560
2021_Q3	77	1337	0.456938	0.693127	34.727273	70.077922	0.104740
2021_Q4	77	1330	0.454545	0.692923	34.545455	69.012987	0.106451
2022_Q1	76	1346	0.472281	0.714746	35.421053	68.526316	0.087454
2022_Q2	76	1267	0.444561	0.682278	33.342105	64.315789	0.090014
2022_Q3	77	1291	0.441217	0.693347	33.532468	64.129870	0.059744
2022_Q4	77	1307	0.446685	0.687974	33.948052	62.649351	0.081434
2023_Q1	77	1377	0.470608	0.705381	35.766234	69.116883	0.046820
2023_Q2	72	1212	0.474178	0.701804	33.666667	66.888889	0.079506

	Num Nodes	Num Links	Density	Avg Clustering Coefficient	Avg Degrees	Avg Strength	Assortativity
mean	75.833333	1281.833333	0.451011	0.690152	33.766988	66.051131	0.049600
std	2.065116	110.554884	0.023784	0.026109	2.259138	6.194663	0.035099
min	71.000000	1064.000000	0.393928	0.635414	28.756757	53.351351	-0.002711
max	77.000000	1383.000000	0.474178	0.717500	35.922078	73.662338	0.106451

Ego Network Summary Statistics

Quarter	Num Nodes	Num Links	Density	Avg Clustering Coefficient	Avg Degrees	Avg Strength	Assortativity
2019_Q1	12	66	1.000000	1.000000	11.000000	26.333333	-0.090909
2019_Q2	14	91	1.000000	1.000000	13.000000	31.428571	-0.076923
2019_Q3	16	108	0.900000	0.954029	13.500000	30.125000	-0.083761
2019_Q4	15	105	1.000000	1.000000	14.000000	34.133333	-0.071429
2020_Q1	18	129	0.843137	0.895962	14.333333	35.111111	-0.040679
2020_Q2	21	173	0.823810	0.927166	16.476190	42.000000	-0.043481
2020_Q3	29	309	0.761084	0.837963	21.310345	50.689655	-0.060394
2020_Q4	33	378	0.715909	0.825026	22.909091	50.606061	-0.043574
2021_Q1	30	292	0.671264	0.802458	19.466667	40.066667	0.004545
2021_Q2	36	412	0.653968	0.799240	22.888889	45.944444	-0.041516
2021_Q3	33	358	0.678030	0.820919	21.696970	43.575758	-0.043945
2021_Q4	38	424	0.603129	0.765489	22.315789	42.473684	0.003081
2022_Q1	37	438	0.657658	0.755714	23.675676	43.081081	-0.007976
2022_Q2	37	439	0.659159	0.768976	23.729730	44.972973	0.009002
2022_Q3	36	408	0.647619	0.789977	22.666667	42.111111	-0.066669
2022_Q4	35	385	0.647059	0.775476	22.000000	40.171429	-0.056282
2023_Q1	33	391	0.740530	0.827109	23.696970	48.787879	-0.002481
2023_Q2	27	267	0.760684	0.863614	19.777778	43.629630	0.004224

	Num Nodes	Num Links	Density	Avg Clustering Coefficient	Avg Degrees	Avg Strength	Assortativity
mean	27.777778	287.388889	0.764613	0.856062	19.358005	40.846762	-0.039398
std	9.181539	137.192496	0.133240	0.085626	4.370096	6.933676	0.033358
min	12.000000	66.000000	0.603129	0.755714	11.000000	26.333333	-0.090909
max	38.000000	439.000000	1.000000	1.000000	23.729730	50.689655	0.009002

Task 2.2 (10 marks) </br> Discuss why ego networks are useful for exploring the importance of singular nodes. Then, comment on the statistics you computed above and what information they give you about the investment patterns of Bruce Berkowitz - Fairholme Capital. Briefly discuss how the ego network statistics differ from the statistics obtained for the whole network, explaining whether the differences or similarities are expected or not. Motivate your answers.

Discuss:

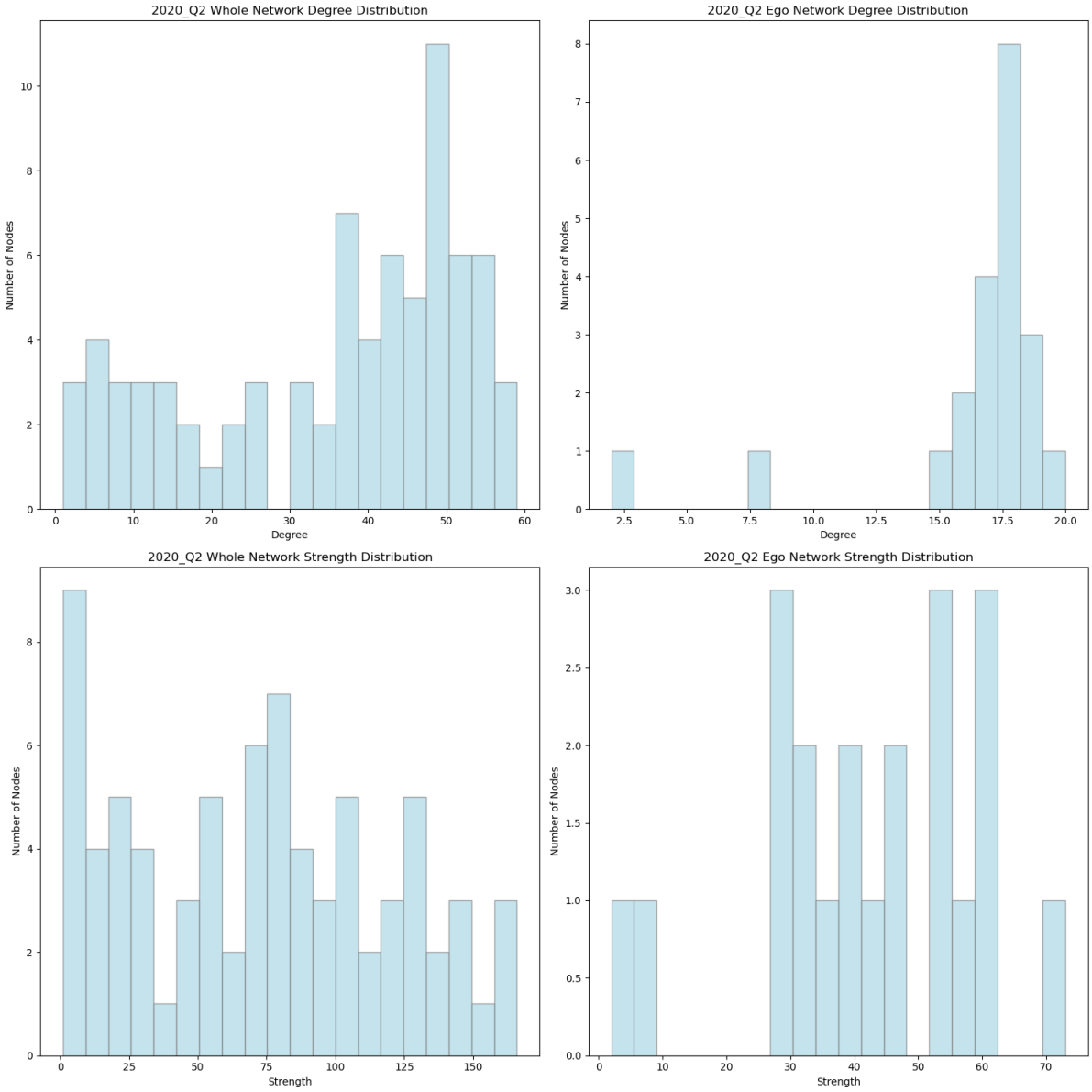
1. As you can see in the first network of a single quarter, the network is too complex due to the number of nodes. It is very difficult to see the relationships of a singular node from it. So the ego-network provide a simple view of the networks that only

contains the node needed to be focused. It can help to understand the role and impact of the node in its local environment. In addition to this if we want to find information about a particular node in the network, analyzing the ego network can also remove some useless interfering information and make the results more informative.

2. Because we focus on Bruce Berkowitz - Fairholme Capital, based on the data from the ego Network Summary Statistics above. First of all, it can be noticed that the number of nodes, the number of links and the average strength of the ego network has increased over time. This indicates that the number of companies invested by Bruce Berkowitz - Fairholme Capital is increasing. Secondly, it can also be noticed that the average clustering coefficient from 2019 Q1 to 2023 Q2 is overall large, but has a tendency to become smaller. This indicates that overall there is strong aggregation between nodes and nodes tend to connect to each other, but this tendency is getting weaker. In addition to this, Assortativity does not change from start to finish and stays around 0. This also shows that the connections between nodes are relatively random, are not affected by node attributes, connections are independent of the similarity between nodes. So overall from 2019 Q1 to 2023 Q2, Bruce Berkowitz - Fairholme Capital has been investing in more companies, but there is no strong similarity in the investment style of the companies with the same investment targets. Bruce Berkowitz - Fairholme Capital is still in a period of growth and the primary direction of its investments may be undetermined. Or perhaps the current strategy of his company is not to focus on specific types of companies, but to invest in all types of companies.
3. If compare the data of ego network with whole network. First of all the number of nodes and the number of links will definitely decrease and the density could become larger because only neighbors of the specified nodes are shown, these changes are compatible with the actual data. Secondly due to focusing on only one particular node and neighbors, the nodes will be more connected to each other than whole network, so the clustering coefficient could increase. In addition to this, according to the average degree and average intensity in the table, it can be noticed that so Bruce Berkowitz - Fairholme Capital invests in a small number of companies, maybe even less than average, thus its average degree and average intensity have decreased. As for the assortativity, which represents the similarity between nodes, the value of assortativity in a large whole network is very low and tends to be close to 0, which means that the similarity between nodes is very low, thus, it is normal that assortativity is also very low in ego network. So overall these changes are to be expected if it is realized that Bruce Berkowitz - Fairholme Capital is not a very important node in the whole network.

Part 3: Comparing Degree Distributions

Task 3.1 (8 marks) </br> Choose a single temporal slice (i.e. quarter) and plot and analyse the total degree and strength distributions of both the whole network and the ego-network. Comment on the similarities/differences between these networks.



Task 3.2 (7 marks) </br> Based on degree distributions and the results you obtained, what type of network would you say the whole network and ego-network are (e.g scale free, random, etc)? Could have they been generated by any of the models discussed in class? Motivate your answer.

	Network Type	Clustering Coefficient	Average Shortest Path Length
0	Random Whole Network	0.466285	1.535202
1	Random Ego Network	0.818921	1.176190
2	Whole Network	0.717500	1.584074
3	Ego Network	0.927166	1.176190

Discuss:

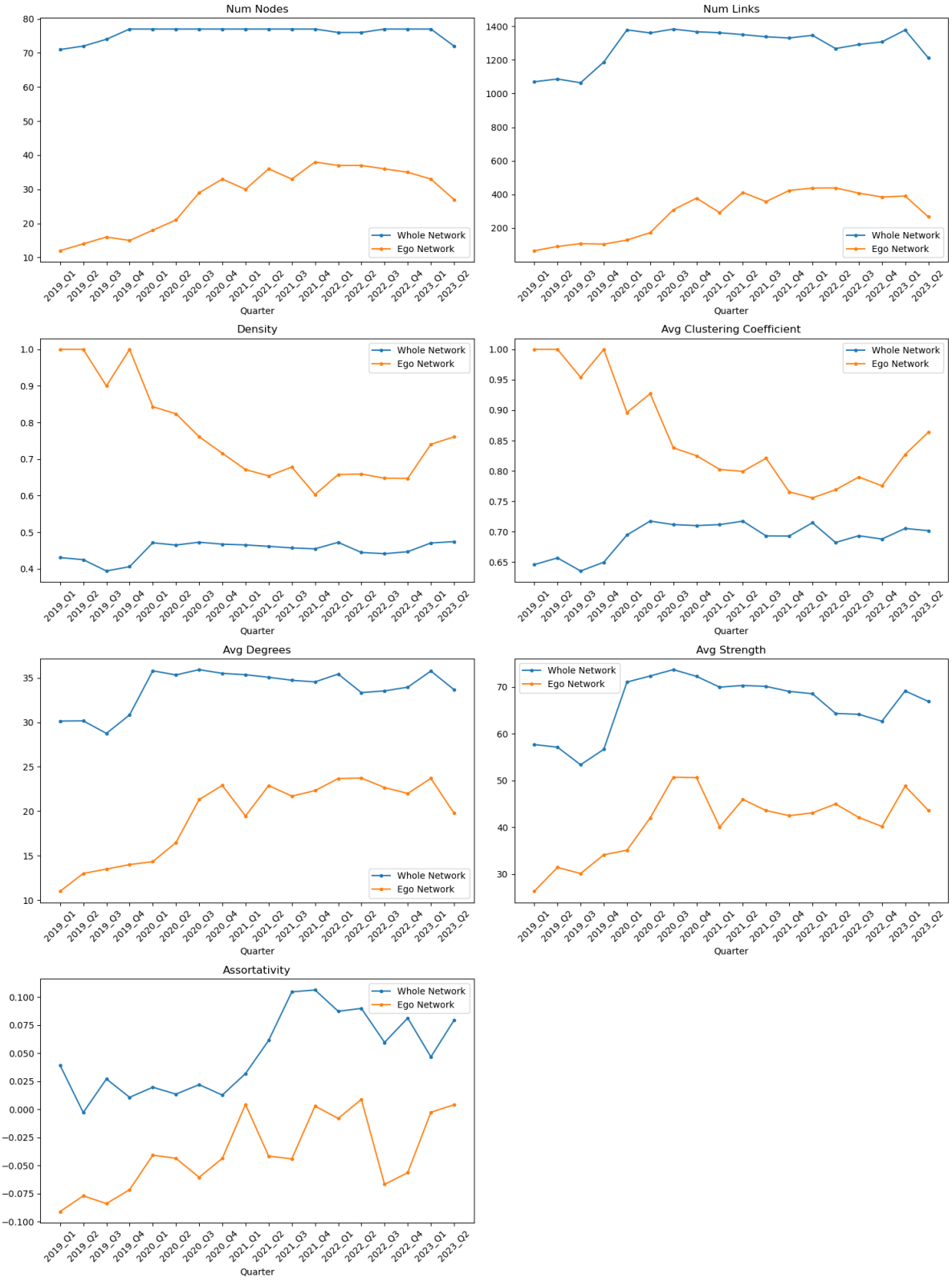
1. We can see from the degree distributions drawn above that the distributions are not linear so it is clear that both whole network and ego network are not scale free networks.
2. Then we should determine if the network is a small world network or random network.

- First, generate two random networks using the same number of degrees and number of edges as in the whole network and ego network. According to the database, a company can invest up to 20 companies, so the weights in the random networks are also set to random numbers between 1 and 20. Then calculate the clustering coefficient and average path length of whole network, Ego network and these two random networks.
- According to the final calculation results, it can be found that for whole network. The Clustering Coefficient of whole network is much larger than the random network, while for Average path length, the value of whole network is a little bit smaller than the random network but the difference is not significant. It can be found that the whole network has a larger Clustering Coefficient than the random network, which means that the nodes of the whole network are more connected to each other so the whole network is closer to the small world netwrok.
- As for the ego network, the Clustering Coefficient of the ego network is slightly larger than the random network with the same size, while the Average path length is basically no difference. The ego network has a larger Clustering Coefficient than the random network, but the difference is not big as the whole network, so the network should still belong to the small world network, but it is very close to the random network.

Overall, the whole network is a small world network, and I would prefer to classify the ego network as a small world network but it's status is very close to a random network.

Part 4: Changes of the network statistics during the pandemic

Task 4.1 (15 marks) </br> Plot the temporal evolution of the quantities you computed in Part 2 for the ego network and the whole network compare the difference between the networks. For each quantity, discuss if it can be used for analysing the investment patterns of Bruce Berkowitz - Fairholme Capital over time. Based on your discussion, choose the quantities that you find important. What information you can draw about the change of those network statistics during the pandemic?

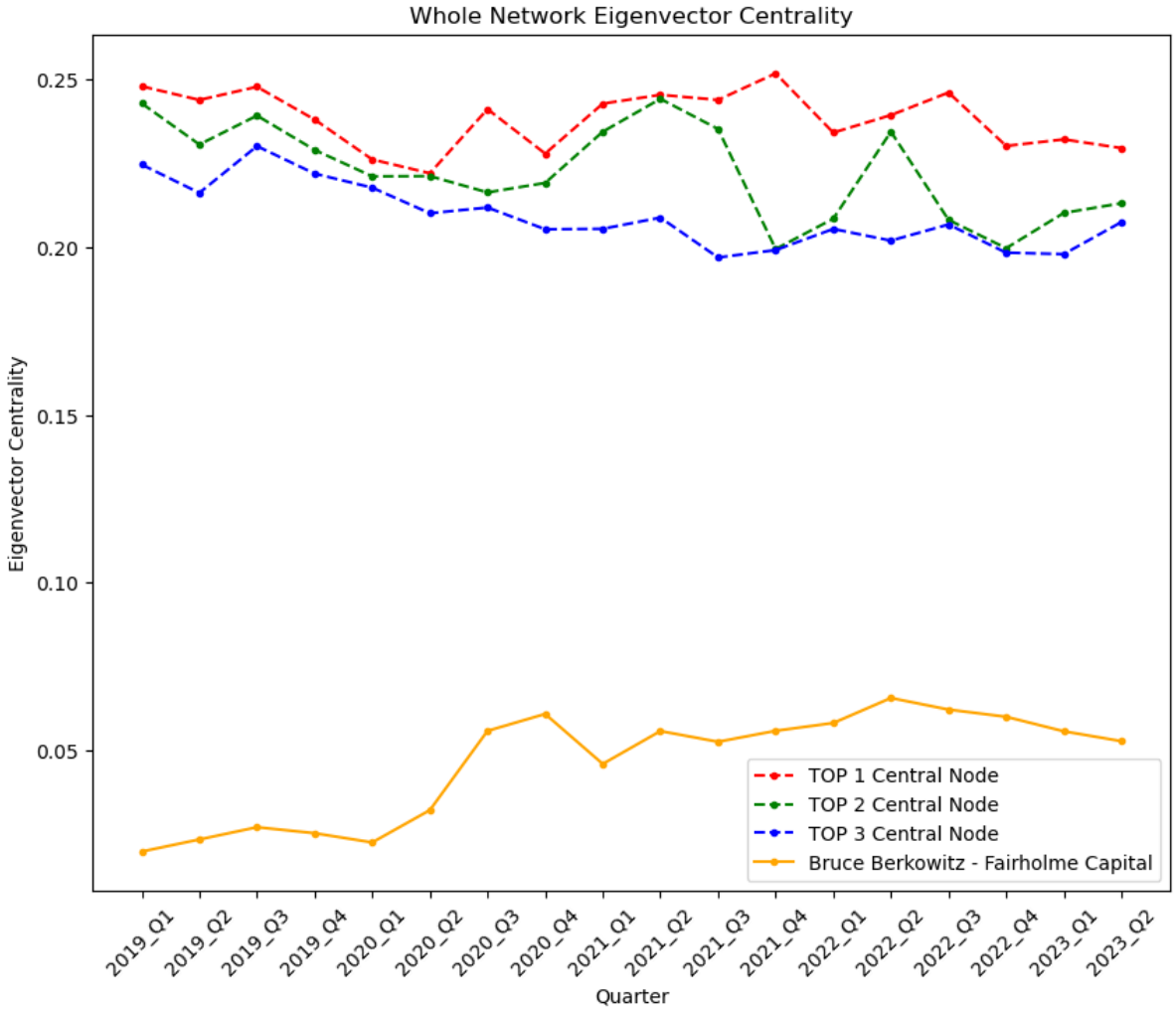


Tasks 4.2 (10 marks) </br> Choose a suitable centrality measure that would give us imporatnt information about the nodes in the whole network, and clearly motivate your choice. Use this measure to find the 3 most central nodes for each quarter. Compare the centrality of Bruce Berkowitz - Fairholme Capital overtime with that of the most central nodes. What can you conclude from this?

Whole Network

	Quarter	TOP 1 Node Name	TOP 1 Node Centrality	TOP 2 Node Name	TOP 2 Node Centrality	TOP 3 Node Name	TOP 3 Node Centrality	B Berk Fairh Ca
0	2019_Q1	Wallace Weitz - Weitz Value Fund	0.247998	Polen Capital Management	0.242915	Stephen Mandel - Lone Pine Capital	0.224650	0.0
1	2019_Q2	Wallace Weitz - Weitz Value Fund	0.243926	Polen Capital Management	0.230649	Glenn Greenberg - Brave Warrior Advisors	0.216225	0.02
2	2019_Q3	Wallace Weitz - Weitz Value Fund	0.247853	Polen Capital Management	0.239261	Steven Romick - FPA Crescent Fund	0.230165	0.02
3	2019_Q4	Christopher Davis - Davis Advisors	0.238087	Wallace Weitz - Weitz Value Fund	0.229034	Steven Romick - FPA Crescent Fund	0.221963	0.02
4	2020_Q1	John Armitage - Egerton Capital	0.226178	Wallace Weitz - Weitz Value Fund	0.221153	Chris Hohn - TCI Fund Management	0.217779	0.02
5	2020_Q2	David Tepper - Appaloosa Management	0.222075	Wallace Weitz - Weitz Value Fund	0.221228	Chris Hohn - TCI Fund Management	0.210153	0.03
6	2020_Q3	John Armitage - Egerton Capital	0.241186	David Tepper - Appaloosa Management	0.216368	Wallace Weitz - Weitz Value Fund	0.211861	0.05
7	2020_Q4	David Tepper - Appaloosa Management	0.227937	John Armitage - Egerton Capital	0.219185	Daniel Loeb - Third Point	0.205384	0.06
8	2021_Q1	Polen Capital Management	0.242826	John Armitage - Egerton Capital	0.234461	Wallace Weitz - Weitz Value Fund	0.205514	0.04
9	2021_Q2	Polen Capital Management	0.245467	John Armitage - Egerton Capital	0.244261	Wallace Weitz - Weitz Value Fund	0.208847	0.05
10	2021_Q3	Polen Capital Management	0.243936	John Armitage - Egerton Capital	0.235273	Christopher Davis - Davis Advisors	0.196961	0.05
11	2021_Q4	Polen Capital Management	0.251862	Christopher Davis - Davis Advisors	0.199482	Terry Smith - Fundsmith	0.199167	0.05

	Quarter	TOP 1 Node Name	TOP 1 Node Centrality	TOP 2 Node Name	TOP 2 Node Centrality	TOP 3 Node Name	TOP 3 Node Centrality	Berk Fairh Ca
12	2022_Q1	Polen Capital Management	0.234184	John Armitage - Egerton Capital	0.208516	Wallace Weitz - Weitz Value Fund	0.205465	0.05
13	2022_Q2	Polen Capital Management	0.239420	Stephen Mandel - Lone Pine Capital	0.234466	Christopher Davis - Davis Advisors	0.201983	0.06
14	2022_Q3	Polen Capital Management	0.246142	Stephen Mandel - Lone Pine Capital	0.208168	John Armitage - Egerton Capital	0.206809	0.06
15	2022_Q4	Polen Capital Management	0.230218	Wallace Weitz - Weitz Value Fund	0.199738	John Armitage - Egerton Capital	0.198381	0.06
16	2023_Q1	David Rolfe - Wedgewood Partners	0.232165	Polen Capital Management	0.210244	Thomas Gayner - Markel Asset Management	0.197978	0.05
17	2023_Q2	David Rolfe - Wedgewood Partners	0.229577	Wallace Weitz - Weitz Value Fund	0.213141	Polen Capital Management	0.207515	0.05



Discuss:

- For the figure, I would like to explain that the companies represented by the TOP central nodes are always changing, and for a better visualization I have connected the TOP central nodes with a dotted line. This does not mean that the points on the same line represent the same company, the specific company names can be viewed in the table.

1. First we need to consider which centrality calculation method to use.

    - Degree Centrality considers degree only , and does not take into account the weights between nodes, so it is not chosen here.
    - Betweenness Centrality focuses more on the intermediary role between nodes connecting to other nodes and has no significance in our network so it is not considered.
    - Closeness Centrality focuses on the closeness of nodes to each other, in our network if we consider the weights as the distance between nodes. If two companies have invested together in many same companies, then it can be judged that they are close. But there is a issue with this, the closeness does not actually indicate the similarity of these two companies because this closeness does not take into account how much money these two companies have invested. If there is a company that invests in all companies, but invests a small amount of money in each company, that this company is close to all of the companies, then using Closeness Centrality can't give good results.
    - Eigenvector Centrality considers the centrality of other nodes connected to a node, and the importance of a node is influenced by the importance of the nodes connected to it. So for our investment network, the connections of companies that have the same investment object are getting calculated, which I think is relevant to our goal.
    - And Katz Centrality mainly focuses on the transmission between the nodes but in our network the transmission between the nodes is not important so Katz Centrality can't be used.

    So finally I chose to use Eigenvector Centrality for the computation.

2. For the final result, it can be found that:
    - Overall, it can be observed that the centrality of the most central nodes has been decreasing from 2019 Q1 to 2023 Q2, while the centrality of Bruce Berkowitz - Fairholme Capital has instead increased, which can also be seen in the centrality differences between Bruce Berkowitz - Fairholme Capital closing with the Top 1 central node.
    - Although overall Bruce Berkowitz - Fairholme Capital has increased in importance, it is also necessary to note that Bruce Berkowitz - Fairholme Capital has been falling since 2022 Q2. At the same time the Top 1 central node has also fallen a bit, which should indicate that at this time the market has made some changes and companies have fallen in importance slightly, I can't say for sure if this is related to the Russo-Ukrainian war that started in February 2022, but this is worth noticing in this part.

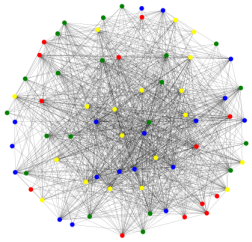
- Apart from that, it is also noticeable that Bruce Berkowitz - Fairholme Capital didn't shine in 2019, but in 2020 Q1, when the pandemic started, Bruce Berkowitz - Fairholme Capital got a very rapid increase in importance. In my opinion Bruce Berkowitz - Fairholme Capital could be a very opportunistic company that sees the huge change in society when the pandemic starts, and the rich opportunities in that, and uses this period to get itself promoted.

So all in all Bruce Berkowitz - Fairholme Capital is supposed to be a very risk averse and speculative company that is able to quickly take opportunities to improve at particular times and withstand the overall downward market environment. But its decline in recent quarters needs to be noted, and it's not a good sign if it keeps going down like this.

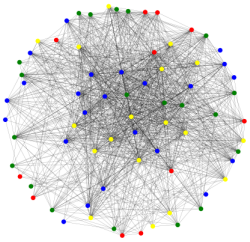
Part 5: Clustering and Modularity

Task 5.1 (15 marks) </br> Find the communities in each quarter in the whole network. To do so, use an algorithm of your choice, and justify your decision. Analyse how the communities evolve overtime, focussing on the membership of Bruce Berkowitz - Fairholme Capital. Does this node fall in the same community with the same superinvestors across different quarters? What conclusions can you draw from this?

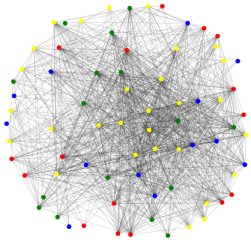
2019_Q1 Network



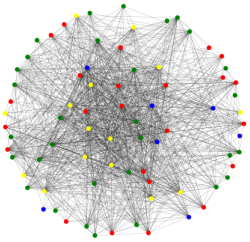
2019_Q2 Network



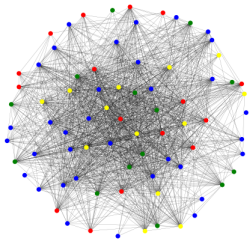
2019_Q3 Network



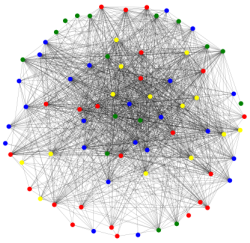
2019_Q4 Network



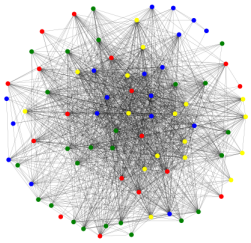
2020_Q1 Network



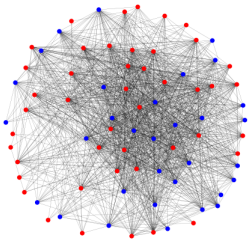
2020_Q2 Network



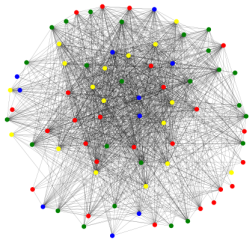
2020_Q3 Network



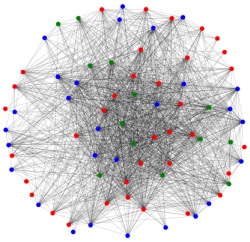
2020_Q4 Network



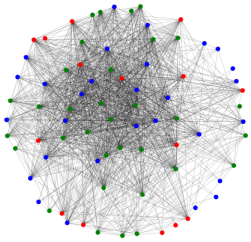
2021_Q1 Network



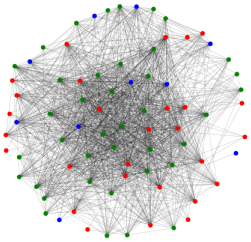
2021_Q2 Network



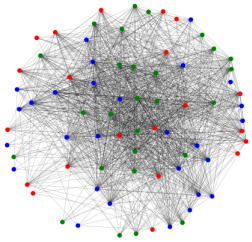
2021_Q3 Network



2021_Q4 Network



2022_Q1 Network



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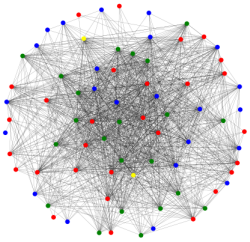
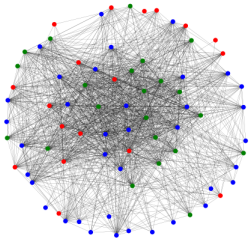
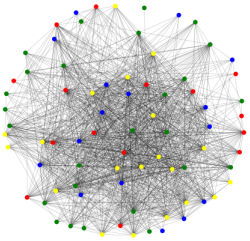


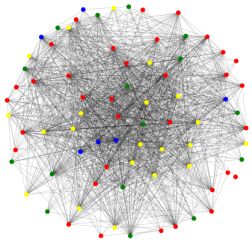
2022_Q3 Network



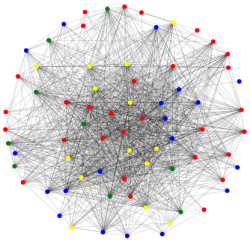
2022_Q4 Network



2023_Q1 Network

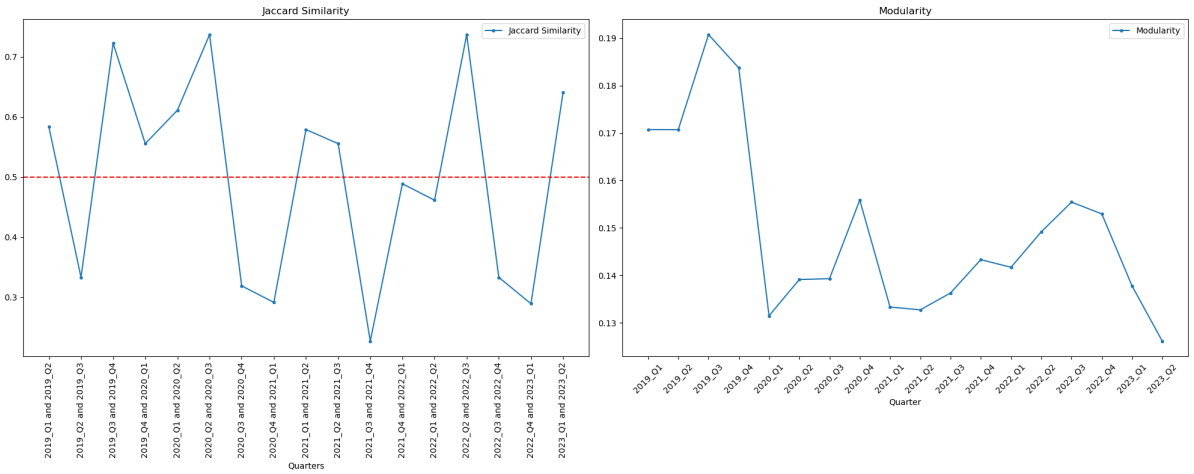


2023_Q2 Network



	Quarter	Modularity	TOP 1 Node Name	TOP 1 Node in Same Community	TOP 2 Node Name	TOP 2 Node in Same Community	TOP 3 Node Name	C
0	2019_Q1	0.170727	Wallace Weitz - Weitz Value Fund	True	Polen Capital Management	True	Stephen Mandel - Lone Pine Capital	
1	2019_Q2	0.170708	Wallace Weitz - Weitz Value Fund	True	Polen Capital Management	True	Glenn Greenberg - Brave Warrior Advisors	
2	2019_Q3	0.190751	Wallace Weitz - Weitz Value Fund	True	Polen Capital Management	False	Steven Romick - FPA Crescent Fund	
3	2019_Q4	0.183712	Christopher Davis - Davis Advisors	True	Wallace Weitz - Weitz Value Fund	True	Steven Romick - FPA Crescent Fund	
4	2020_Q1	0.131474	John Armitage - Egerton Capital	False	Wallace Weitz - Weitz Value Fund	False	Chris Hohn - TCI Fund Management	
5	2020_Q2	0.139117	David Tepper - Appaloosa Management	False	Wallace Weitz - Weitz Value Fund	False	Chris Hohn - TCI Fund Management	
6	2020_Q3	0.139305	John Armitage - Egerton Capital	False	David Tepper - Appaloosa Management	False	Wallace Weitz - Weitz Value Fund	
7	2020_Q4	0.155867	David Tepper - Appaloosa Management	False	John Armitage - Egerton Capital	False	Daniel Loeb - Third Point	
8	2021_Q1	0.133323	Polen Capital Management	False	John Armitage - Egerton Capital	False	Wallace Weitz - Weitz Value Fund	
9	2021_Q2	0.132729	Polen Capital Management	False	John Armitage - Egerton Capital	False	Wallace Weitz - Weitz Value Fund	
10	2021_Q3	0.136286	Polen Capital Management	False	John Armitage - Egerton Capital	False	Christopher Davis - Davis Advisors	
11	2021_Q4	0.143308	Polen Capital Management	False	Christopher Davis - Davis Advisors	True	Terry Smith - Fundsmith	
12	2022_Q1	0.141700	Polen Capital Management	False	John Armitage -	False	Wallace Weitz -	

	Quarter	Modularity	TOP 1 Node Name	TOP 1 Node in Same Community	TOP 2 Node Name	TOP 2 Node in Same Community	TOP 3 Node Name	C
					Egerton Capital		Weitz Value Fund	
13	2022_Q2	0.149179	Polen Capital Management	False	Stephen Mandel - Lone Pine Capital	False	Christopher Davis - Davis Advisors	
14	2022_Q3	0.155436	Polen Capital Management	False	Stephen Mandel - Lone Pine Capital	False	John Armitage - Egerton Capital	
15	2022_Q4	0.152959	Polen Capital Management	False	Wallace Weitz - Weitz Value Fund	False	John Armitage - Egerton Capital	
16	2023_Q1	0.137783	David Rolfe - Wedgewood Partners	False	Polen Capital Management	False	Thomas Gayner - Markel Asset Management	
17	2023_Q2	0.126129	David Rolfe - Wedgewood Partners	False	Wallace Weitz - Weitz Value Fund	False	Polen Capital Management	



Discuss:

1. In select the algorithm to find the communities, I used Louvain algorithm. Because I don't know the current number or structure of communities and Louvain algorithm can find the community structure automatically. Secondly Louvain algorithm is able to identify the community structure quickly in large scale networks, which is what we need. So I decided to use Louvain algorithm.
2. In the results, I extracted all the communities containing Bruce Berkowitz - Fairholme Capital and compared the communities to the previous quarter by using Jaccrd Similarity to get a graph that can represent the difference between the communities and the previous quarter's communities. The principle of Jaccrd Similarity is to compare the difference between two sets of communities, if the difference between the two communities is small then the value of Jaccrd Similarity will tend to be 1. Here we consider that when Jaccrd Similarity is less than 0.5 then

the two communities are not very relevant. In addition to this, I have also tabulated the modularity of these communities in order to observe the quality of the community.

- Firstly, it can be seen that the values of modularity are small, and the highest value does not reach 0.2, which indicates that the whole network does not have a high quality of community, showing that the network does not have a clear community structure, and the current distribution of community division is very uniform.
- Between 2019 Q3 and 2020 Q3 it can be seen that Jaccrd Similarity has held up well, and there is very little differentiation between members within the community, but on the other hand modularity has changed a lot during this time, which shows that there is a lot of change in the community across the whole network. According to Centrality, it's also the period where Bruce Berkowitz - Fairholme Capital has gained a lot of importance. In 2020 Q4 its community has changed a lot, but its importance has still increased, which shows that Bruce Berkowitz - Fairholme Capital has strong management skills at a special time.
- Overall, from 2019 Q1 to 2023 Q2 Jaccrd Similarity and modularity have been changing without much pattern. This means that the community where Bruce Berkowitz - Fairholme Capital is located is always changing, and the community divisions across the network have also changed significantly. In conclusion, it is possible that Bruce Berkowitz - Fairholme Capital's investment direction has been changing and that it has not yet found an exact investment direction. Moreover, according to the Centrality results above, Bruce Berkowitz - Fairholme Capital has also decreased in importance recently. Of course all investors or companies might have changed a lot, so I think the whole network is still in a state of chaos.

Part 6: Report your findings

Task 6.1 (10 marks) </br> As any good DBBA Capital data analyst, at the end of your analysis you need to present your fidnings. Please write a brief (~250 words) report discussing how the portfolio of Fairholme Capital has changed compared with the rest of the funds in the dataset.

REPORT

Bruce Berkowitz - Fairholme Capital has not been a shining star among all the companies. It has not invested in a large number of companies compared to the top players, but it has shown a very good resilience to risk and the ability to take advantage of particular external circumstances to improve itself. It was able to take advantage of the current situation during the pandemic and quickly raise its importance. In addition to this it was also able to boost its importance against the backdrop of an overall market downturn, which left me very impressed. But portfolio of Fairholme Capital is not static in general, Bruce Berkowitz - Fairholme Capital is more like an opportunist who takes advantage of opportunities to improve himself in a certain period of time, but doesn't have a stable investment direction. The companies which it invests with change all the

time, which is not good news for the stability of the investment, and in addition to that its decline in recent quarters is worth keeping an eye on. Overall Bruce Berkowitz - Fairholme Capital is a very noteworthy competitor.The importance has been rising and it has grown very impressively fast during the pandemic.Though it's not the most impressive of all investors right now, but who knows what it could become if it takes another chance.