SENSIBLE PLANNING KNOWLEDGE NETWORK OF UK: MINING, VISUALIZING AND ANALYSING OF THE ACADEMIC OPEN SOURCE DATA

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Abstract

Planning knowledge network, as the agglomerations of academic outputs and scholars, guides practices to make a better city, educates younger planners and to supports decision making. The research focuses on the planning knowledge network in UK, aiming at making the network more sensible by visualizing, measuring, analysing and discovering the anchor cities of this network. This would be helpful to gain a better understanding of planning intelligence, and to benefit planning schools, scholars, organizations and even navigating young planners in such a planning knowledge ocean. In a word, the most immediate purpose of this research is to make such network sensible, and that is the beginning of a range of benefits.

Regarding planning knowledge society as a cooperative network, with planning scholars contribute academic outputs (publications) in a cooperative way, this research adopted the open source data as resources. Raised conceptual models for the network and methods for visualizing, measuring and analysing the network are innovative, which makes the planning knowledge network sensible for the first time. Additionally, the anchor cities, which represent knowledge produce, exchange and store agglomerations, are also been discussed.

By achieving this, the content is organized in six major parts. The main body is followed by the introduction part, which includes the open data resources introduction, the methods and tools, the visualization and analysis this network, and then the study on anchor cities to complement a more sensible network. Finally, the research draw the conclusion according to the results of important findings.

1 Introduction: A Sensible Network of Planning Knowledge

1.1 Planning Knowledge

Urban Planning as a discipline have developed fast in the past 100 years. Since the first planning principles generated in UK 1909, urban practice, no matter the scale, have been supported by the planning knowledge (from planners, their academic outputs and proposals), along with other disciplines like engineering, Information technologies, politics, etc.

It is high time to discover the inside of the planning knowledge world itself. Such research could be beneficial to planning schools, scholars, organizations and young planners. Without doubt, it is an attempt to make a better understanding of the principles of planning, and the knowledge structure. Meanwhile, this would be instructive to regions like China, India, Southeast Asia, Middle Asia and the Arabic World, where the planning knowledge societies are still growing.

1.2 A Sensible Network

AESOP, along with other organizations has contributed to diverted exchange platforms among different planning entities. This alludes that the planning knowledge society is a network. Planning knowledge network is not only the network of members, exchange students, visiting professors, but the academic intelligence cooperation. Though hard to be visible, since millions of publications bring every scholar into such network, certain approaches could be used to make the network sensible.

As information technology today help to solve problems we couldn't have ever imagined, more and more network become sensible. Through such process, one could gain deeper understanding of the network. The questions such as how the network looks like, what is the attributes, and whether it is location oriented are to answer.

1.3 Major Tasks and Structure

1.3.1 Task 1: Visualize and Measure the Invisible Network: A Sensible Network

In terms of sensible network, such network shall be visualized in the first place. Secondly, the network should have access to get measured through key parameters and proper methods. According to that, having the ideology and methods of networking, the tools to visualize the network shall be adopted. This attempt could be innovative in planning knowledge research or network research field.

1.3.2 Task 2: Discover Physical Anchors of the Network: the Anchor Cities

As to make the network sensible, it is innovative to discover the relationship between invisible network and physical space. Anchor Cities , as a term we used in this research to cities that are outstanding in produce, exchange and store of planning knowledge, open a gate for deepening the sense of the planning knowledge network.

1.3.3 Structure of the Research

The Research are composed by six major parts. First is the concept of planning knowledge network in the instruction phase (First Part).

The next three parts are aimed to achieve the first task. Followed by the data resources (Second Part) and the methods (Third Part) introduction, the UK Sensible Planning Knowledge Network (Forth Part) presents the results of visualization and analysis of the network.

For the second task, this research analyse the relationship between knowledge network and the anchor cities, as well as the clusters of anchor cities. This could be found in the five Anchor Cities of Planning Knowledge Network part (Fifth Part).

Finally, the conclusion (Sixth Part) summarized the findings and analysed results of the Planning Knowledge Network of UK.

1.4 Literature Review

1.4.1 Networking of Planning Knowledge

Planning knowledge had gained its cooperation among scholars global wide. Such kind of networking trends becomes the significant symbol in planning field. In 2001, when the first world planning school congress (WPSC) was held in Shanghai, it collected 600 hundred of papers (Urban Planning Review, 2001). Most importantly, the announcement of Global Planning Education Associations Network was made to enhance the exchange of planning knowledge (Zhiqiang WU, 2001). Such kind of network is not only consisted of the invisible knowledge exchange, but also embodied by massive exchange programs (Harvey A. Goldstein 2006). The globalization promotes the network to grow, and the urban planning knowledge network are changing more global-local at the same time (YuanYUAN, etc. 2004).

Bologna Declaration 1999 had been reached the agreement within 29 European eliminate the obstacle in education resources exchange (Andrea I. Frank, etc., 2014), in that way the knowledge could be shared in an active way. Moreover, as the urban development issues become acceptable worldwide, the knowledge for better life has trans borders (Henian LIANG, 2000).

However, there are some imbalance in planning education, which could be obstacle for knowledge exchanging. Like the incomplete evaluation system (Lei PANG, etc. 2006). 2007 when the AESOP annual conference was held in Napoli, the participants are mostly from the south part of Europe (Yi HUANG, 2007), such case implies that even the trend of networking of planning knowledge, there are still long way to go.

On the other hand, it shows the importance of this research in the perspective of planning knowledge globalization and regionalization.

1.4.2 Development in Visualizing and Analysing

The other important perspective of this research is the methods of visualizing and analysing based on open source data. Until recently, a method of EDEN had been introduced to visualize the simulated geographic data (Chad A.Steed, 2013). By using Hadoop, Song Gao had achieved to visualize the flow of employees in United State. Through the way of Medoids, the data of agglomeration of space could be analysed (Deepak Paramashivan Kaundinya, 2013).

Most importantly, Gephi as a useful social network analysing tool, helped Irene Eleta to cluster twitter customs according to the usage of language (Irene Eleta, 2012). It is obvious that there are many tools to visualize the data, as well as analysing.

For this research, we adopted Gephi as the major tool along with regular data analysis software. It is the model we design and the right research path we think that matters.

2 Data Resources: Open Resources of UK Planning Scholars Academic Data

2.1 Target Group: Academic Scholars as the Main Entities

To establish such visualized knowledge network of UK, question of what kind of target group should be considered is to answer. The target group consists of two parts. First is the academic scholars from the planning schools (main entities), along with the related scholars (complementary entities).

Planning knowledge network, as the basic academic engine that generate intelligence to support practices like the decision making and design, remains the core value of academic outputs, such as articles, books, reports, etc. According to these criteria, the research choose academic scholars as the main entity of the target group. In total, this research focuses on 6 UK planning schools (Cardiff University, University of Manchester, University of Glasgow, University of Liverpool, University College London, and Birmingham City University) from AESOP membership list, which we believe have significant positions in planning knowledge field in UK.

Besides the main entities, the complementary entities should not be ignored. This includes independent scholars and scholars from planning schools out of the list.

2.2 Open Sources: Data of Scholars Academic Information

One of the innovations is to take advantage of the open sources data from the Internet, which on one hand is easy and free to access. On the other hand, the massive information could help to complete or proofread information.

Open source data in this case mainly relies on three resources from the Internet. The first one is the basic information including names, abbreviation, title, and publications from the official website of each university. The second one is google scholar, which could be helpful when some modifications are needed and also the citing information of the publications (Articles, conference papers, reports, editorials, books, book chapters, etc.). The last one is other free publication search engine such as the ResearchGate or ScienceDirect, etc.

In fact, the process of data collection is difficult, especially when some information is not complete on the official website of the planning school. Therefore, it is quite important to have massive open source data to complement each other.

2.3 Raw Data for Measuring the Network

The planning knowledge network is built upon knowledge exchange among the target groups and beyond. In order to capture knowledge exchange , the observation of academic outputs cooperation is essential. Some important factors listed below (more information are captured beyond the items listed). As this research is still ongoing, some raw data is still under testing for this phase, as the research is still on going.

Academic Outputs Cooperation. As the most important indicator in this research, the cooperation of academic outputs contains implies the academic relationship among authors in each article.

Location. The location of the publication shows how the planning knowledge network has an interaction with different places around the globe. With the help of this indicator, the knowledge network would never been floated and untouchable.

Publication Year. The planning knowledge network is never static. Publication year reflects how the knowledge network changing through.

Cited Value. This indicator reflects contribute a certain publication made to the planning knowledge network. If the cited value is high, then it means such publication is more active inside the network.

3 Model, Methods and Tools: Data Mining, Visualizing and Analysing Principles

3.1 Conceptual Model

By visualizing and analysing planning knowledge network of UK, we constructed the conceptual model to set up the rules and also organize the algorithms. Figure 1. The Conceptual Model for Planning Knowledge Network of UK, illustrates the key items.

Scholars (as Node in the Figure 1): Inside the model, each node represents a single scholar (no matter the scholar is main entity or the complementary entity).

Cooperation (as link in the Figure 1): Each link represents the cooperative relationship according to one journal article, one conference paper, one book, one report, etc. The cooperative relationship has no direction, therefore the undirected way of algorithms are chosen. As been put, each link just represent a single cooperative activity, then the model adopt multiple lines if there are more than one cooperative activities between two certain scholars. For example, Scholar 1 and Scholar 2 have 3 cooperative activities, Scholar 3 and Scholar 4 have 2 cooperative activities. Scholar 2 gains totally 9 degrees of cooperation, while scholar 6 just got 1.

Cluster (as modularity): As also showed in the model, the network is consists of diverted groups. However, the main focus is on the major modularity rather than those absolute isolated ones (without any link to major modularity). Furthermore, the research would analyse different groups inside the major modularity.

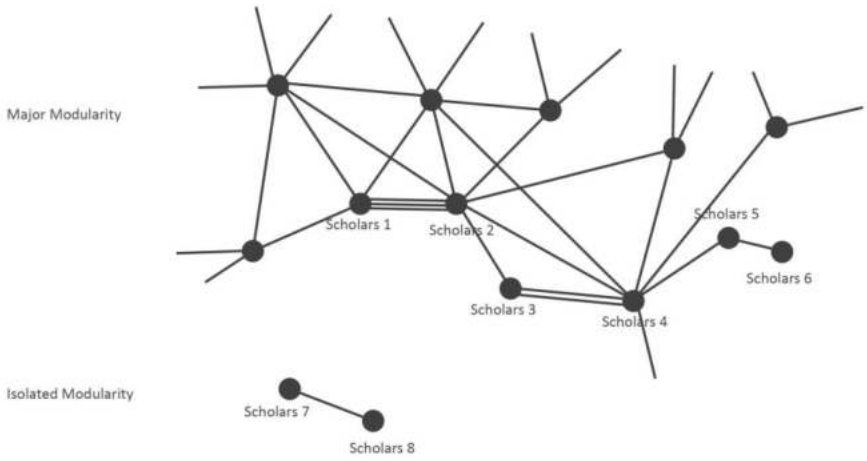

Figure 1. The Conceptual Model for Planning Knowledge Network of UK

3.2 Data Mining and Organizing

During the process of data mining, we adopted a software called Bazhuayu D Machine to assist with the mining process. However, as mentioned before, due to data structural among so many official website, the programing work shall be individually created according to each site structure. Some of the structural data are easy to capture and classify, while the text data could only be filtered afterwards. The final structural of the data pool contains the key factors of each publication.

3.3 Visualizing

To translate data into visualized language, the ideology is to regard each individual scholar as a node in the network, while links between nodes the cooperative academic outputs. The higher value of cooperative degree one node gets, the more cooperation a scholar earns. Similarly, if a link is bolder than others, then the academic relationship between scholars on both sides tighter.

With the help of Gephi, an open source platform of data visualizing software, the planning knowledge network could be visible. Different Force Models were tried to make the layout clearer and defined. Finally, we adopted the Force Atlas2 model which could present the hubs and the centralities of the hubs by the meantime, as showed in Figure 2. Three Stages of Force Atlas2 Models for Visualization.

Force Atlas2 Model obeys the basic algorithm of graph drawing, known as the Force-directed graph drawing. It is originally derived from the physical principle of Hooke s law as be outcome shows the multiple force balanced results among the node connections.

Figure 2. Three Stages of Force Atlas2 Models for Visualization: (a). Raw Stage, (b).Processing Stage, (c). Final Layout (Source: Graph generated through Gephi, 2015)

3.4 Analysing

In this research, some vital indicators for analysis are chosen, including the average degree, the modularity of the network, the local clustering coefficient, the average path length, the graph density, and the connected components. The characteristics and principle for each indicator has been explained below.

3.4.1 Average Degree

Average Degree reflects the entire cooperative degree of each scholar. The higher the value of the average degree get, the more cooperative relationship the network get.

$$a = \frac{1}{N} \sum_{i=1..N} Degree(V_i)$$

a, value of average degree. N, the number of scholars. V, the set of scholars

3.4.2 Modularity

The indicator of Modularity is raised (in 2004) and optimized (in 2006) by Newman, which is used to describe the strength of division of a network into modules (Newman, M. E. J., 2006). According to the indicator of modularity, it could be clear to measure the community structure in large scaled network. (Svr to be 1 if scholar v belongs to group r and 0 otherwise)

$$\delta(v_r, c_i) = \sum_{r} s_{vr} s_{wr}$$

$$Q = \frac{1}{2m} \sum_{vw} \sum_{r} \left[A_{vw} - \frac{k_v k_w}{2m} \right] s_{vr} s_{wr} = \frac{1}{2m} \mathrm{Tr}(S^T B S)$$

$$B_{vw} = A_{vw} - \frac{k_v k_w}{2m}$$

Q, value of modularity of the network. S, Non-square matrix having elements Svr. B, Modularity matrix, which has elements. 2m, Total number of degree among all scholars

3.4.3 Average Clustering Coefficient

This indicator measures the degree of which scholars in a network tend to cluster together. Duncan J. Watts and Steven Strogatz introduced the indicator of local clustering coefficient (both directed and undirected) to determine whether a graph is a small-world network (Duncan J. Watts and Steven Strogatz, 1998). And as for the relationship between scholars has no direction, we adopted the undirected local clustering coefficient to be calculated. Finally an average value of the overall local clustering coefficient values are studied to know the general clustering situation of the whole network.

$$C_i = \frac{2 \left| \{ e_{jk} : v_j, v_k \in N_i, e_{jk} \in E \} \right|}{k_i (k_i - 1)}$$

Ci, value of local clustering coefficient for a certain scholars. V, the set of scholars. E, the set of edges between all the scholars. Ki(Ki-1), possible links exists between all neighborhood scholars

3.4.4 Average Path Length

The average path length is to calculate all paths among scholars, and then dividing by the total number of pairs. It shows the number of steps it takes to get from one scholar to another on average.

3.4.5 Connected Components

This indicator describes how many scholars are strongly connected and weakly connected.

4 UK Planning Knowledge Network

4.1 Visualized Planning Knowledge Network of UK

According to the model and the rules we set up, under the help of Gephi, we achieved the final visualizing work shows in Figure 3. Planning Knowledge Network of UK.

Figure 4. Planning Knowledge Network of UK shows the overview of the planning knowledge network based on the publication cooperation of UK. By using different colours, it is clear to distinguish major clusters. The spatial distance reflects the affinity between clusters in academic relationship, while the links between scholars explain the cooperative attractions.

Statistically, UK s planning knowledge network includes 2169 researchers, with 252 as the counted main entities of the target group. Cardiff University(56 entities scholars), University of Manchester(20), University of Glasgow(33), University of Liverpool(65), University College London(45), Birmingham City University(33).

While, 1917 scholars as the complementary part are discovered by visualizing process. Though been regarded as the complementary one, they also been unveiled in the final visualized work, which on one hand shows their strong impact and active connection in this network. On the other hand it proves that such network is quite tolerant and open.

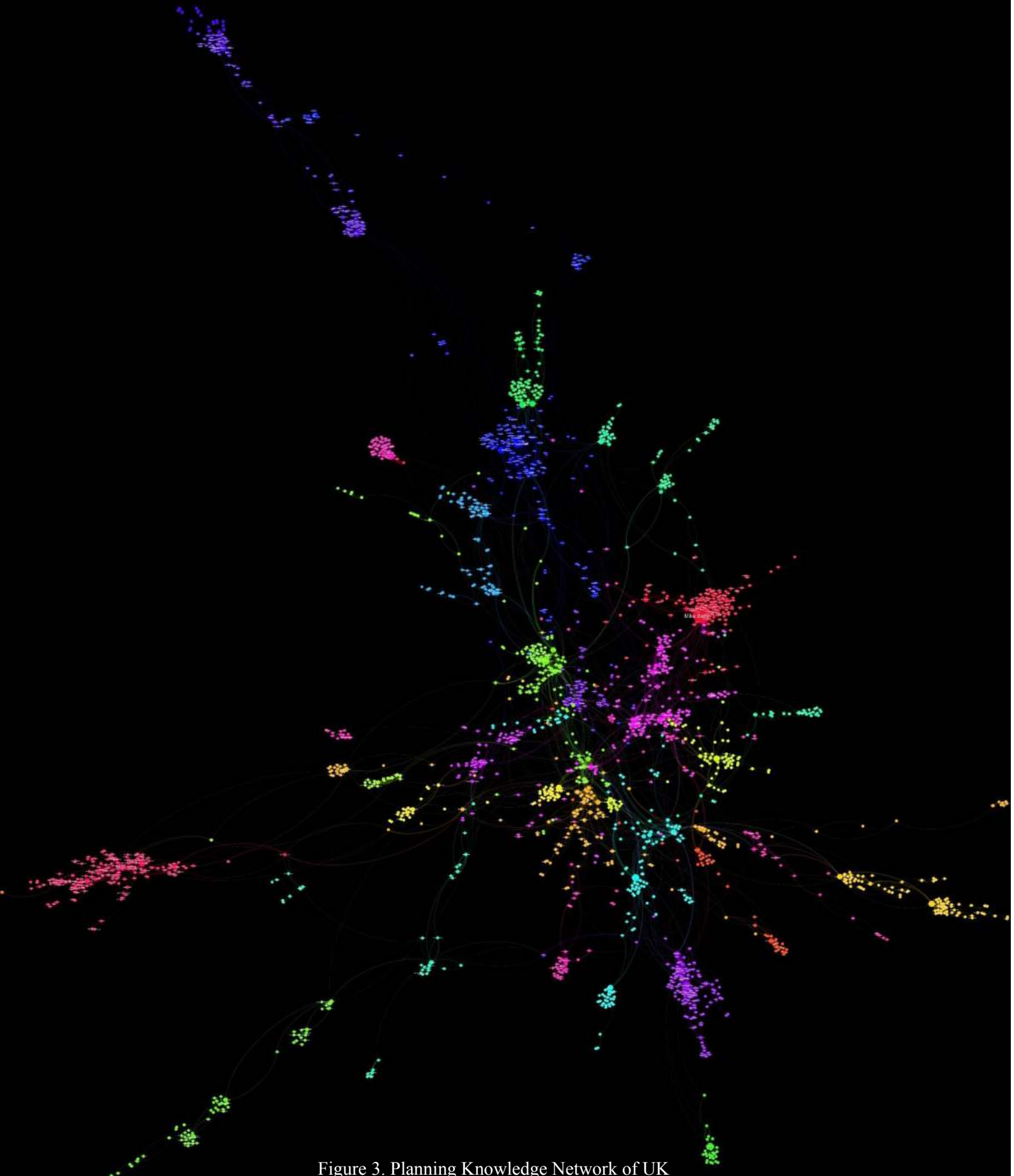

Figure 3. Planning Knowledge Network of UK
(Source: Graph generated through Gephi, 2015)

4.2 Analysis Results of Planning Knowledge Network of UK

4.2.1 High Degree of Involvement in Network (Connected Components, Average Degree)

The degree of involvement in the whole network could be measured according to the indicator of connected components. It implies that the 2055 scholars are highly involved in this network with a strongly connection, while only 114 nodes are less involved with weakly connection. (Robert Tarjan , 1972).

Those who are less involved in UK s planning knowledge network, with less devotion in acade cooperation, might have devoted more into urban practice, or software development, etc. Or because their majority academic outputs belongs other networks. However, this group of scholar are not belong to the 252 main entities we targeted.

4.2.2 Closeness of Scholars (Average Path Length)

Scholars inside the network build the connection through cooperation on publications. While such connectivity could be sensed through the indicator of average path length. And such value for this network is 7.82 with total 1493783 shortest paths. The total diameter for the network is 19 units.

The closeness centrality distribution figure shows all the distances from a given starting node to each other scholars. 1 to 12 extra scholars are needed to build up a connection between two given targeted scholars in majority. According to the algorithms mentioned before (Ulrik Brandes, 2001).

4.2.3 Tendency of Clustering (Clustering Coefficient)

The tendency to form a cluster varies from scholars. Among the relationships, 1789 triangles are created, which implies the tendency to join a cluster for each certain scholar is 0.815 (more than two thirds of total completion), according to the algorithms (Matthieu Latapy, 2008). In general, we could draw a conclusion that, a scholar is relatively close to a certain inside the cluster. On the other hand, it means scholars inside the network have less chance to fight alone.

4.2.4 Modularity of Whole (Modularity)

Under the help of modularity tools, the research found out there are 143 clusters according to the modularity algorithms, while the total modularity is 0.899. Considering the modularity has the default range between [-0.5, 1), it is significantly high in modularity. In other words, it means the entire network shares the same culture of modularity in general. Technically, 4 clusters have the number of more than 150 scholars, while 9 clusters have the number of above 100 scholars.

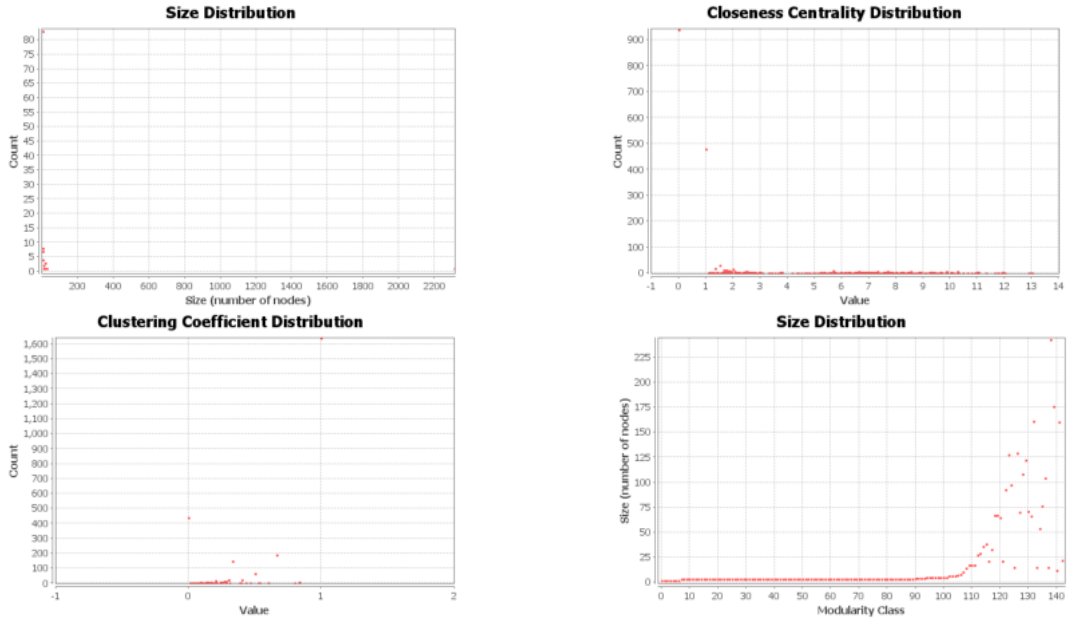

Figure 4. Results of Measuring the Network: (a).Nodes Size Distribution, (b) Closeness Centrality Distribution, (c).Clustering Coefficient Distribution, (d). Cluster Size Distribution (Source: Graph generated through Gephi, 2015)

4.3 Comparison

4.3.1 Ten Major Clusters in UK Planning Knowledge Network

Ten major clusters contribute over half of the cooperative degrees through the entire network, as well as they involve over half of the scholars. The Richard Chiverrell-John Boyle-Andy Plater s cluster ranks the first place, with the total degree of 974 (9.68% in proportion) and 244 scholars (8.78% in proportion).

As implies in Table 1. Ten Major Clusters in UK Planning Knowledge Network implies, all of the ten groups share higher value of degree proportion than scholars number proportion. This means i general, the scholars inside those clusters are more active in cooperation than those outside of these clusters. No matter how many pieces inside each cluster, it is always the degrees that matters.

Table 1. Ten Major Clusters in UK Planning Knowledge Network

Rank	Gephi Code	Total Scholars	Proportion Scholars	Total Degrees	Proportion of Degree	Number of Pieces	Key Figure	Major Background
1	138	244	8.78%	974	9.68%	4	Richard Chiverrell, John Boyle, Andy Plater, Barbara Mauz, Janet Hooke, Neil Macdonald	University of Liverpool
2	139	176	6.36%	729	7.24%	1	Terry Masden, Kevin Morgan, Gillian Bristwo, Mara Miele	Cardiff University
3	132	161	5.82%	638	6.34%	5	Graham Haughton, Mark W Baker, Cecilia Wong,Michael Hebbert, Iain Deas, Ken Gibb	University of Manchester
4	141	160	5.78%	617	6.13%	1	Mike Batty, Alex Singleton	University College London
5	126	130	4.66%	449	4.46%	4	Mark Reed, David Adams, Peter Larkham, Alister Scott	Birmingham City University
6	123	128	4.62%	477	4.74%	2	Richard Bradshaw, Fabienne Marret Davies	University of Liverpool
7	129	122	4.41%	585	5.81%	1	Ade Kearns, Bailey,N, Hastings,A.	University of Glasgow
8	128	108	3.90%	449	4.46%	1	Thomas B Fischer, Sue Kidd, Olivier Sykes	University of Liverpool
9	136	104	3.76%	468	4.65%	3	Nick Gallent, Sir Peter hall, Robin Hickman, Stephen Marshell	University College London
10	124	96	3.50%	359	3.57%	1	Andy Morse	University of Liverpool
Sum		1429	51.59%	5745	57.07%			
Rest		1339	48.41%	4321	42.93%			
Total		2768	100.00%	10066	100.00%			

(Source: Dataset of UK Urban Planning Schools, 2015)

4.3.2 Typical Typologies of Clusters

To gain better understanding of the clusters that formed the whole network, we choose Mike Batty s and Richard Chiverrell-John Boyle-Andy Plate s Cluster to discuss. Representing the one typical typology of clusters, Mike Batty s shows more centrality, while the Richard Chiverrell-John Boyle-Andy Plate s represent the dispersible types. Both of them shows a higher proportion in cooperative degree and the scholar s numbers. The structures and typologies could be found i Typology of Mike Batty s and Richard Chiverrell-John Boyle-Andy Plate s Cluster.

The typology of Mike Batty s cluster implies a strong and attractive academic personality, with over 150 scholars directly owns the cooperation with him. The average degree reaches 3.86, while Batty gains his own degree of 177, which is 45 times of the average value in the cluster. On the other hand, Batty created 91 completed cooperative triangles (Mike Batty - Scholar A - Scholar B), such firm structure guaranteed Mike Batty to have a concrete first degree.

Furthermore, we believe such structure with the growing triangles contribute the development of this cluster. Beyond that, the personality and the openness of this cluster could have contributed to this without doubt.

Richard Chiverrell-John Boyle-Andy Plate s cluster, however, shows another possibility of organizing the cooperative academic relationship. The average cooperative degree among scholars is 3.99, a bit higher that Mike Batty s. While the three major figures inside degree and completed triangles of 70, 54(Richard Chiverrell), 49, 42(John Boyle), 41, 28(Andy Plate). The relative ratio of triangle cooperation among total cooperation is lower. Also the first degree is not relatively high compared with Mike Batty s. However, all the results imply that Ric Chiverrell, John Boyle and Andy Plate together plays the role of Mike Batty s in the cluste

Although the concentration is not that impressive, Richard Chiverrell-John Boyle-Andy Plate s cluster shows the attraction and stability either. The research take a close look at the topics of those two clusters, Both Mike Batty and Richard Chiverrell-John Boyle-Andy Plate are not constrained on few topics, on the contrary, they are open minded and accept different topics in cooperation.

To draw a conclusion, according to the study on the two typical cluster, it is not clear what kind of typology is more sustainable for clusters. However, two things are obviously certain. First, the completed triangle cooperation is the fundamental stabile element for a cluster. Secondly, the wider topic orientation, the more opportunities for clusters to grow, no matter in which typology they adopted.

4.4 Summary of Planning Knowledge Network

In this phase, we visualized the planning knowledge network in UK, which appears the tolerance and openness to scholars knowledge. By adopting five important parameters, we measured the whole network, to have a general understanding of the entire cooperation and the modularity.

Later on, the comparison between major 10 clusters implied the diversity and modularity of the network, with some certain planning schools take the dominoes. The research discovered that the scholars belong to major clusters are more active than those who are not in general.

Finally, in order to find out the philosophy behind the typical typologies of cluster, we discussed about Mike Batty s and Richard Chiverrell-John Boyle-Andy Plate s cluster, the results for this shows no big difference, as the basic structure of completed triangle would contribute to the stability and the openness on topics could gain the development.

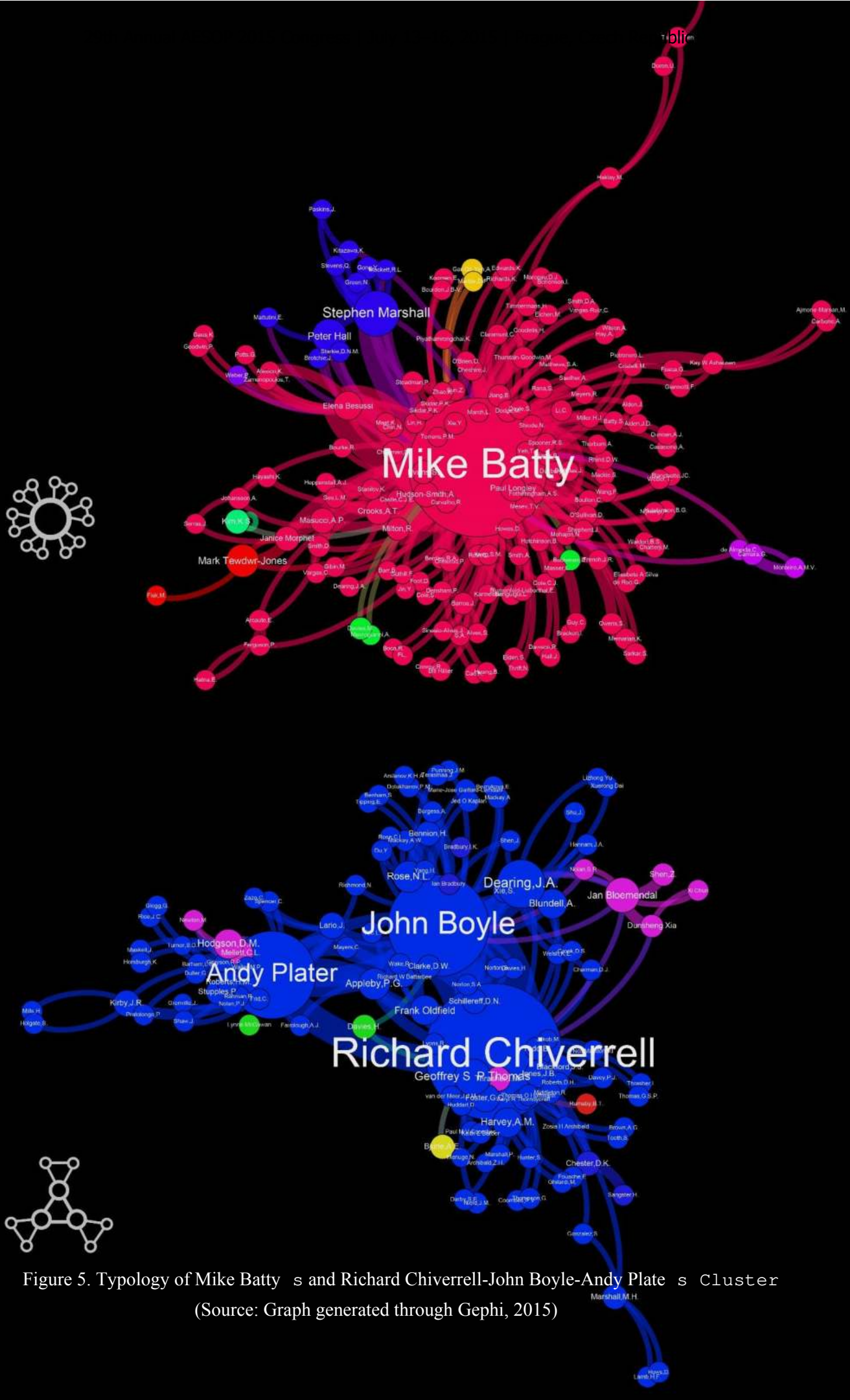

Figure 5. Typology of Mike Batty s and Richard Chiverrell-John Boyle-Andy Plate s Cluster
(Source: Graph generated through Gephi, 2015)

5 Anchor Cities of Planning Knowledge Network

To ensure the knowledge network has more ways to get sensed, the linkage of the network and cities should be unveiled. Anchor cities, as the term to represent such kind of planning knowledge relevant cities are the key element to be discussed in this phase.

In terms of the parameters, the data of academic outputs with location information is key. Somehow, it is possible to rank and group the planning knowledge based cities according to such data. By achieving this, the knowledge network and the cities which produce, exchange and store the knowledge would be obvious share the academic connection. So as to the closeness through the linkage of scholars. In that way, the cities could be grouped according to the closeness exchanging and storing planning knowledge .

5.1 Principle for Anchor Cities and the Network Connection

The simple principle of anchor cities could be described as the relationship between cities through scholars and their academic outposts. Figure 6. Principles for Anchor Cities and the Network Connection shows how the knowledge network anchors the cities. As two main types of nodes (cities, scholars), and links (publications with location information) formed the structure, the differences between scholars and cities could also be clarified from this model.

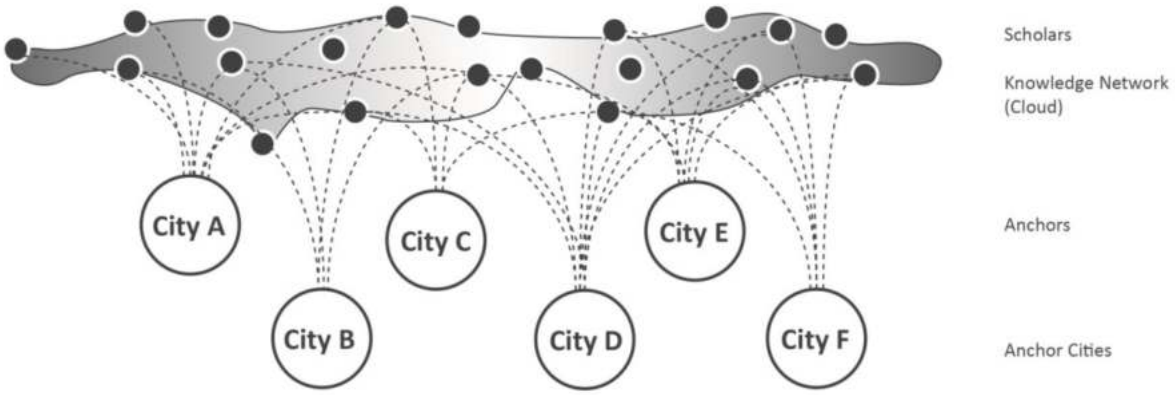

Figure 6. Principles for Anchor Cities and the Network Connection

The data resources for this phase is generate from the same database in the previous phase when analysing the knowledge network, but not all. Somehow, the publications with location information are selected. In that way, most of the conference papers, books, book chapters, reports contribute to the major part of the data source. It is according to those publications, that the anchor cities could be visualized.

As for scholars, one may build the connection between cities through only one publication, or none, or more. As for the cities, the more connection one get, especially from the scholars who have more places to be connected, it is more likely to have close relationship with other cities. In a word, the degree of connection between cities and scholars, and the closeness between each city are concerned in this phase.

5.2 Overview of Anchor Cities

According to such principle, we use Gephi to visualise the anchor cities of the UK s planning knowledge network. The total number of city in such network is 303, with scholars as the links between cities. This implies that the huge knowledge network find its ancho recorded locations information. Among those anchor cities, the power of anchor (degre connections) differs. In Figure 7. Anchor Cities of UK s Planning Knowledge Network visualizing work shows the distribution and clustering of anchor cities.

We filter the less relevant cities, as showed in Table 2. Major Anchor Cities of UK s Planning Knowledge Network, there is major anchor cities. From this table, It is obvious to know that London not only have the largest number of planning scholars counted as the main entities in the network, but also the number of planning schools, scholars.

Another important finding is even the absolute value of the number of scholars is high, the cooperative degree is even higher, which means there are more related scholars that beyond these 104 scholars in London s case. Meanwhile, it could be possible that London attracts not only the local scholars but also scholars from the state. This hypothesis has been proved in the next step.

Table 2. Major Anchor Cities of UK s Planning Knowledge Network

Rank	Anchor City	Degree of Cooperative	Key Planning Schools	Number of Targeted Planning Scholars
1	London	468	University College London London School of Economics and Political Science University of Westminster	104
2	Oxford	88	Oxford Brooks University	31
3	Cardiff	75	Cardiff University	56
4	Liverpool	73	University of Liverpool	65
5	Edinburgh	69	Heriot-Watt University	21
6	Bristol	69	University of West of England	42
7	Manchester	59	University of Manchester	16
8	Glasgow	51	University of Glasgow	33

(Source: Dataset of UK Urban Planning Schools, 2015)

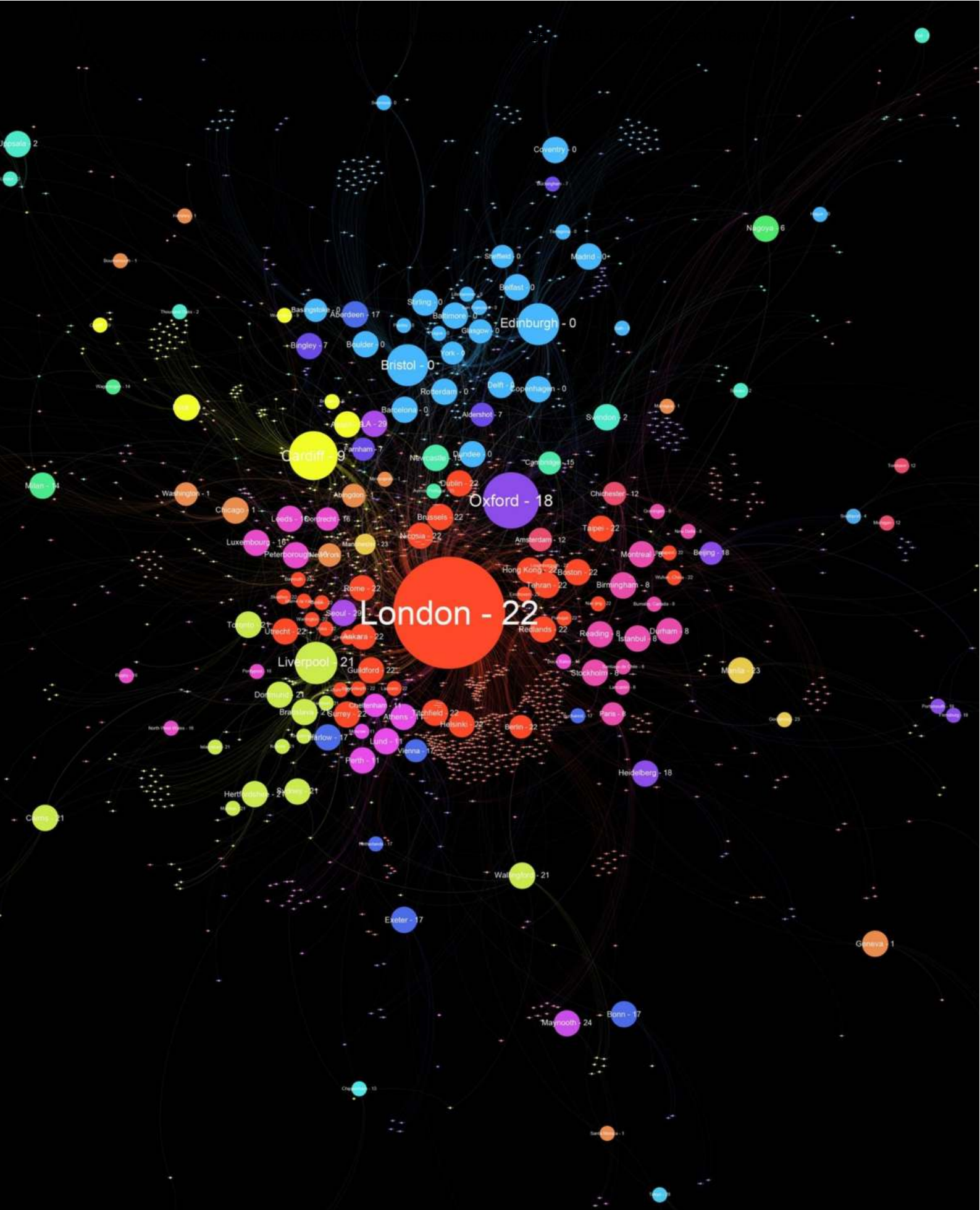

Figure 7. Anchor Cities of UK s Planning Knowledge Network

(Source: Graph generated through Gephi, 2015)

5.3 Clustered Anchor Cities

According to the principle, one city build the connection with another city through common scholars who contribute the academic outputs in both cities. Hence, it is easy to understand that the more common scholars in a group of cities share, the more chance they would form a cluster together. In other words, the scholars along with their academic outputs, makes it possible for cities to be close.

In Table 3. Major Anchor Cities Clusters of UK s Planning Knowledge Network, the ma cities clusters are showed, as the top 8 clusters occupied 78.92% in total proportion of degrees, involving 70.62% of all cities.

Table 3. Major Anchor Cities Clusters of UK s Planning Knowledge Network

Rank	Proportion of Degrees	Anchor Cities Clusters	Number of City	Members	Gephi Code
1	24.04%	London Captial Group	74	London, Dublin, Utrecht, Brussels, Nicosia, Boston, Redlands, Berlin, Helsinki, Titchfield, Surrey, Ankara, Rome, Tehran, Hong Kong, Taipei	22
2	9.62%	Edinburgh-Bristol-Glasgow Group	30	Edinburgh, Bristol, Glasgow, Coventry, Baltimore, Sheffield, Belfast, York, Copenhagen, Rotterdam, Delft, Madrid	0
3	8.33%	Liverpool Group	26	Liverpool, Dortmund, Toronto, Wallingford, Sydney, Hertfordshire, Kingston	21
4	6.09%	Leeds group	19	Leeds, Luxembourg, Peterborough, Dordrecht	16
5	5.77%	Birmingham-Reading Group	18	Birmingham, Reading, Stockholm, Durham, Montreal, Paris, Istanbul	8
5	5.77%	United State Group	18	Chicago, New York, Washington, Abingdon, Minneapolis	1
7	4.81%	Cardiff Group	15	Cardiff, Assen, Frick, Woodstock	9
8	4.49%	Amsterdam Group	14	Amsterdam, Chichester	12
Sum	78.92%	-	214		-
Rest	31.08%	-	89	-	-
Total	100%	-	303		-

(Source: Dataset of UK Urban Planning Schools, 2015)

5.4 Summary of Anchor Cities

As the scholars keep creating planning knowledge in different cities, the records of such academic outputs with location information makes it possible for this research to take advantage of. Anchor cities, play the role of knowledge produce, exchange and store place, are essential to be studied in

order to make the network sensible. As been showed in the visualized work, anchor cities, through the connection by scholars, displayed differently both in degrees of academic cooperation, but also in clustering. In total, five reasons that caused the cities to form clusters, to share common scholars and to play the role of anchor in similar areas in the knowledge network.

First, geographic correlation is important. Inside most of the clusters, key cities in a region share the same cluster. Together, they formed a strong network anchor region, with the local research programs completed by intercity scholars.

Secondly, academic events brought certain types of scholars together, which, on the other hand, build the relationship to their base cities. Usually, both cities always shared certain type of planning issues.

Thirdly, London as a special case, implies not only a strong cooperative relevant with cities in the region, but also shows a relatively high involvement among the capital cities globally. For the reason of its high value of academic mobility and accessibility for planning scholars around the globe, this makes sense. On the other hand, international academic events also make London capital group the most significant and trans-continents one.

Fourthly, the importance of the scholar shall be stressed, as the United State Group shows. The certain group of scholars who are active in both United State and UK, contribute to the strong correlation between certain UK cities and United State cities.

Last but not the least, as the planning knowledge network is an open system, it is impossible to have no connection with other planning knowledge networks, like United State, etc. Once the UK cities been connected to United State cities, it is inevitable to build links with the clusters in United State. Hence, according to the clustering algorithm, a group of cities with high inter correlation but less connections exteriors is tend to be catalogued in an individual cluster, Then Abingdon, rather than London, shares the cluster of Chicago, New York, Washington, and Minneapolis.

6 Conclusions

6.1 Summary of Anchor Cities

The major goal of this research is to gain understanding of the sensible planning knowledge network of UK. Open source data and the models, methods, tools used in the research lead us to the planning knowledge network finally. It is essential to make the network sensible by visualizing the knowledge cooperation among scholars, and also the attempt to find the anchor cities that allows the knowledge network to have physical meanings on a number of cities. By doing so, the planning knowledge network is somehow sensible.

During the process of research, some important findings are discovered. The closeness of scholars inside the network was transformed into clusters, like Mike Batty s Cluster, and Richard Boyle-Andy Plate s cluster, etc. Scholars belong to major clusters are more active in academic cooperation than those who are not, in general. Within the clusters, the typology are different, but share the same ideology that the completed triangle and openness on cooperation could contribute to the development of clusters.

Such closeness also reflect on the physical space, the anchor cities. Like showed in the case of London capital group, Edinburgh-Bristol-Glasgow Group, etc., anchor cities also have the tendency to get clustered. The reason of the anchor cities clustering is complicated. Some due to the geographical correlations, academic events, scholars individual academic activities, even the exterior network interfere the process and results of clustering anchor cities, as the United State Group case implies.

6.2 Inadequate and Extension

However, some problems are still exist in the process and findings of the research. For example, to obtain the data from open sources, it is risky to regard the publications online covers all academic outputs. The same problem also remains in the incomplete UK planning schools taken into consideration, as only

six been studied, and more deep analysis should be added to the measuring part. For the anchor cities study, the results are just proper for UK, instead of even larger territories.

This research still remains a great possibility to be extended in further research. For not only more complete in coverage of knowledge network in UK, but also in depth of data visualization and analysing methods. It is believed that this research just unveiled the corner of a mine , with more applicable and instructive findings are to be discovered and discussed. The devotion on UK s case help us a lot to have meaningful adjustment and thoughts on the whole research program that has a larger horizon of the entire Europe.

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