Introduction

Science, technology and innovation networks gain momentum in the policy agenda of the member states of the European Union. Policies to strengthen research, innovation and deployment activities mainly based on public funding. However, only providing public funding without suggesting strategic policies to strength joint project networks will not be sufficient to create competitive power. In this study, proximity types between participants and network positions of participants in the seventh Framework Programme (FP7) will be explored to suggest strategic network policy to enhance the competitive power of projects in European Commission. Using a large number of data, Social Network Analysis Methodology will be conducted to examine both the structure of FP7 network and explore the relations between participants in the network. The study will be novel in terms of its depth data analysis technique and conducting a research from the key aspects of network performance.

1. Framework 7 Programme

According to European Union's Lisbon strategy, knowledge, research and innovation are the heart of the setting dynamic and competitive power. Therefore, FP7 is built to provide strong networks to facilitate knowledge transfer among participants. The main idea behind FP7 is facilitating effective networks because Networks serve as a locus for innovation, because theyprovide more timely access to external knowledge and resources, represent a test for internal expertise and learning abilities, and give better monitoring and control over fast-moving developments (Powell et al., 1996).

European Research Area (ERA) implement main policy tool which is FP to support research and diffusion, facilitate circulation of information and knowledge, development of transnational organizational forms, definition of common standards, the promotion of shared values.[1] FP7 is different from other first 6

[1]ftp://ftp.cordis.europa.eu/pub/fp7/docs/potential-activity-report_en.pdf

framework programmes in terms of budget and participant types. First five framework programmes provide construction of complex networks with structural properties that facilitate dissemination by constructing recurring patterns of collaboration. In the sixth framework programme Information society technology programmes played an important role in generating and diffusing knowledge as they manage to attract key industry players and boosted network connectivity. Therefore, FP7 is different from other framework programs in terms of including individual teams rather than institutions, universities and private firms. It is crucial to analyze that to investigate social network analysis to detect who are hubs and gatekeepers in knowledge transfer.[2]

1.1. Why Social Network Analysis?

To begin with Social Network Analysis (SNA) is a descriptive social science methodology that maps, measures, and finds patterns in the connections between people and/or organizations.(Johnson, Honnold and Stevens, 2010). Buch-Hansen (2013: 6) criticizes if SNA is detached from positive science and it is mainly used by contemporary scholars in a deductivist manner to test hypotheses derived from theory. Furthermore, it is mainly criticized because of having positivist methodology by including deductive use of theory, reductionist formal models in order to predict and generalize a combination like rational choice theory. (Buch-Hansen, 2013: 16). However, Buch, Hansen (2013) concludes that it is well connected to social world to analyze the unobservable objects (relations) keeping in mind that knowledge is "social and fallible product". As it is well known that social sciences are for criticizing the phenomena and questioning the hidden parts of what is unclear and trying to understand the processes. Therefore, it depends on the researchers' ability to apply SNA in both positivist and non-positivist ways.

[2]ftp://ftp.cordis.europa.eu/pub/fp7/docs/seg-final_en.pdf

In this study, SNA will be used for analyzing connections among participants in 7th Framework Programme. SNA is the most suitable methodology for this study because of following reasons:

- Social network analysis (SNA) is significant when there is no missing data or link in the data. Therefore, the data collection which is done by interview techniques will be less sufficient for SNA. In this study, the data is collected from CORDIS database so the quality of data is appropriate for SNA.
- The probability technique is advanced in SNA, which means it calculates the relationship between actors by coincidence, or not. Therefore in this study, if a country mostly works with a specific participant type, it can be detected it is by coincidence or not.
- SNA methodology is based on relationship between actors not on the actors themselves. Since the FP7 programme is depending on the networking relations of participants, the meaning of ties, connections, and patterns can be analyzed by SNA.
- SNA is a powerful tool for visualizing network. It also has a flexible methodology to change network size, actors and other nodes to create different visualization to make different inferences.

1.2. Aim of this study

The main purpose of this study is to make a policy recommendation to strengthen joint projects between European and non-European countries. According to the results of analysis of this study, it will be found which participant types and countries are crucial in the network. Moreover, it will be analyzed which countries make projects according to which proximity types. After social network analysis of network, it will be depicted that which country choose to work with as a project participant, project coordinator or participant type. Each country's preferences will be different or there can be generalization of preferences. These results will be seen after social network analysis. Their preferences will be examined according to proximity types. Therefore, the purpose of this study is to analyze which countries,

which participant types play crucial role in the framework 7 programme. In addition, with accordance to outcomes the policy recommendation will be suggested by implementing appropriate policy tool to strength network in this programme.

Research questions for this study are declared in the following:

- Exploring network position of project participants how and what can be done to increase network connectedness.
- Exploring proximity types among project participants in the top projects in the 7th Framework Programme.
- Exploring determinants of successful network policy to enhance performance of European Commission projects.

2. Literature Review

2.1. Recent Studies Framework Programmes by Using Social Network Analysis

The whole name of FP7 is 7th Framework Programme for Research and Technological Development. It last for seven years from 2007 until 2013. The programme has a total budget of over € 50 billion which has the highest one compared to other framework programmes in order to show the importance of research in Europe.[3] However, only providing public funding to the participants does not spontaneously result in boosting the strength of European innovation, knowledge and technology triangle. These findings firstly provide benefits to the participants then with the knowledge transfer among firms by making collaborating projects should result in overall success in the network.

Similarly; Breschi, Cassi, Malerba and Vonortas (2009) states that R&D expenditures depend on public funding provides firms input additionality

[3]http://ec.europa.eu/research/fp7/pdf/fp7-inbrief_en.pdf

(resources added to system), output/outcome additionality (extra private and social returns), behavioral additionality (improving the competencies, capabilities, organizational structures and strategies of firm). Most innovations involve collaboration of several different organizations and in these organizations; there are diverse kinds of formal contracts but also informal exchanges of knowledge.

Autant-Bernard and Chalaye (2013) analyzes knowledge diffusion between EU and ENC countries from the important channels such as: IPR Collaboration, student mobility, co-authorship and co-inventorship. These channels are found that they are significant in knowledge diffusion. On the other hand R&D cooperation is an important channel for only ENC countries. Autant-Bernard and Chalaye (2013) stresses that countires have different collobation activities in FP projects, for instance Morrocco, Algeria, Belarus, Moldova have high orientation towards Europe in general but less significant orientation in FPs. ENC countires collaborate with eachother homogenously in FPs and collaboration between EU and ENC is more intense. Additionally, it is found that co-inventor and co-publication networks strongly centered around Israel and Turkey.

Furthermore, Roediger-Schluga and Barber (2006) surprisingly found out that project size does not associate with central project type; the most crucial projects are consisted of different groups in the study covered first six frameworkprogrammes. Moreover, in the large projects there were a few key actors. However, it is stressed that there is a similar pattern of the participants tend to make projects with their previous partners. Thus, the size of project does not play crucial role in the performance of framework programmes, the other significant factors should be analyzed.

There have been several important studies about firms' network position related with organizational performance. For instance, Powell et. al (1999) investigates network of relationships and organizational performance in the human biotechnology industry and found that network position of a firm has significant affect in the firm's performance. Similarly, Farina (2008) conducted a study about the network position of firms and their performance in banking industry and found

that banks enhance performance by having a central position in their network and that specialization reduces bank's benefits of having a central position in the network. Similary, Autant-Bernard and Chalaye (2013) declares that country's position in the network and overal network structure are key determinants of knowledge diffusion.

Therefore, it can be concluded that the actors in the position of hubs and gatekeepers are the most crucial actors in the network. These actors may benefit from their position in order to improve their organizational performance also they provide benefits to the other actors by creating bridges to connect with other actors.

Cassi, Corrocher, Malerba and Vonortas (2009) analyses research network and and deployment networks for IST- RTD Program in 6th Framework Project and it is not surprisingly found that higher education and research institutes are important actors in research networks while industry plays crucial role in deployment networks. Moreover Cassi et. al (2009) stresses the focus of innovation and deployment networks in regional level because it is criticized that existing studies concentrate on the effectiveness of research networks at the European level. As a result, the literature is lack of how research networks affect regional systems and how research and diffusion activities carried out at regional level. Therefore, Social network analysis is conducted to find out interaction and overlaps in the network to detect hubs and gatekeepers in evaluating the links between research and deployment networks of innovation in information society in Europe. (Cassi, et. al (2009). In order to strengthen the links between research and deployment, strengthen regional strategies for deployment of innovations, Cassi et. al (2009: 248) stresses the different roles of multinational companies, SMEs, governments to make more overlaps between research and deployment networks.

2.2. Framework Programmes Studies Related with Proximity Types

Usai, Marrocu and Paci (2013) state that technological and geographical proximities are the most significant type of proximities related to inter-firm knowledge exchanges. On the other hand spatial distance, cultural differences and

institutional and linguistic borders reduce knowledge diffusion between EU and ENC. Labor mobility, overall network structure and individual's position in network affect knowledge diffusion. Knowledge diffusion between EU and ENC can be analyzed by mobility, collaboration, and knowledge networks. Usai, Marrocu and Paci (2013) measured 5 proximity types which are Geographical Proximity, Technological Proximity, Institutional Proximity, Organizational Proximity and Social Proximity. It is stated in the **Table 1** below how they measured these proximity types.

Table1: Proximity types in networks

Proximity Types	How it is measured?
Geographical Proximity	Spatial (geographic) distance
Technological Proximity	Same industry, same sector
Institutional Proximity	Same status
Cognitive Proximity	Not measured in the study
Organizational Proximity	Same group (Participant type, same clique)
Social Proximity	Diverse geodesic distance

Source: Self-interpretation from Usai, Marrocu and Paci (2013)

Geographical proximity is measured by spatial distance between project partners. In my study, it will be done in the same manner by calculating physical distance between countries and between participants. Technological proximity is measured by identifying sector and industry type. Institutional proximity is measured by same status of participants, they give dummy variable if two participants have similar formal and informal rules, regulations and norms. Usai, Marrocu and Paci (2013) did not include cognitive proximity in their study. Organizational proximity

is measured by detecting the quantity of joint connections of participants and also if the participants have been in the same group, the dummy variable is set to 1 in their study. Social proximity is measured by shortest path between actors (nodes) meaning geodesic distance.

3. Data Analysis

Social network analysis is done by using Pajek tool with framework projects' data. The raw data contains all framework project data until the middle of the 2014. I picked energy projects from FP7, ICT projects from FP7 to analyze by social network technique. The raw data are analyzed in excel format and macro codes are written to arrange the data which is suitable for social network analysis. All data and macro codes will be available in the attachments.

3.1. Energy Network in FP7

There are 965 participants and 101 projects about energy project theme in FP7. Network is emerged by putting tie between participants in the same project. Therefore 2 - mode network is emerged between participants and projects. Project type is clustered according contract type which refers to funding type of the project.

Table 2: Contract Type of Projects

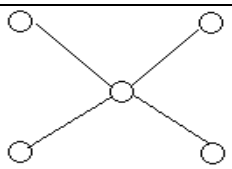
Contract Type	Cluster Number
CP-FP - Small or medium-scale focused research project	1
CP-IP - Large-scale integrating project	2
CSA-C - Coordination (or networking) actions	3
CSA-S - Support actions	4
CSA-SA - Support actions	5
CP - Collaborative project (generic)	6
CP-SICA - Collaborative project for specific cooperation actions dedicated to international cooperation	7
CSA-CA - Coordination (or networking) actions	8
BSG-SME - Research for SMEs	9
BSG-SME-AG - Research for SME associations/ groupings	10
Cooperative - SMEs-Co-operative research contracts	11
Collective - SMEs-Collective research projects	12

Participants are clustered according to country code and each country is represented as different color in Pajek visualization. Participants are clustered according to being coordinator or participant. There are two vector files for projects which are cost and funding. These vectors represent the size of nodes in the network. As the size of the node is big, it means the project has higher funding or cost. Therefore the whole energy data consists of 3 cluster files: country code of participants, contract type of projects, participant type of participants; 2 vector files: project cost, project funding.

3.1.1. Network Analysis

Metrics related to information flow and power in a network is examined in terms of degree centrality, degree centralization, closeness centrality, closeness centralization, betweenness centrality and betweenness centralization in social network analysis. In the following table, each metric is described what it means for the analysis and how it relates with network.

Table 3: Metrics related to information flow and power in a network

Metrics related to information flow and power in a network	Description	What does mean for analysis?
Degree centrality	Positions of individual vertices within the network (how many degree=ties has)	Information can reach vertices with high degree centrality easily
Degree centralization	Refers to networks (degrees of vertices divided by the maximum degree variation)	in highly centralized network information spreads easily and the vertices at the center have high importance for the transmission of information
Closeness centrality	refers to the number of other vertices divided by the sum of all distances between that vertex and all others	Vertex is distant to other vertices or not in the network
Closeness centralization	Closeness centrality of vertices divided by the maximum variation in closeness centrality scores possible in a network of same size	 This star network has highest closeness centralization=1 , equal distances to reach center vertex.
Betweenness centrality	Proportation of all geodesics(distance) between pairs of other vertices that include this vertex	How important a vertex is for transformission of information rather than how reachable it is.
Betweenness centralization	Betweenness centrality of vertices divided by the maximum variation of possible network in the same size.	Star network has the possible greatestbetweenness centrality (N-1). How much bigger betweenness centrality means that network has high possibility for transmission.

Source: Self-Interpretation (De Nooy, Mrvar and Batagelj, 2011)

Metrics' calculation of FP7 Energy Network is stated in the **Table 3** in terms of both project network and participant network. Closeness centralization cannot be calculated which means the all energy network has not homogenous distance to the center of the node. Betweenness centralization of participant network has the highest value which means there is high possibility for knowledge transmission between participants.

Table 4: Metrics' calculation of FP7 Energy Network

Metrics related to information flow and power in a network	FP7 Energy Network (All Network)
Degree centralization	0.0226 (project network = 0.07963, participants network= 0.16061)
Closeness centralization	Network is weakly connected, cannot be computed. (So I will investigate different partitions in the next section 1.1.2)
Betweenness centralization	0.20164 (project network = 0.0784, participants network= 0.20624)

Average degree of participant and project network is 2.0863039. Generally, vertices have 2 ties with each other. If we separate projects and participant network (transform 2 mode network to 1 mode network) then All Degree centralization of participant network is 0.07963. If we emerge 1 mode network of only projects and then calculate the all degree centralization then it is 0.16061.

All degree centralization refers to the network density. Project network is denser than participant network. Overall, this network is not a dense network; nodes make a few connections to each other.

To analyze deeply we need to look closely to participant network. Since closeness centralization of the whole FP7 energy network cannot be calculated, there is another measure called All Closeness Centralization Calculation (which analyze to

measure more strong ties between partitions and relatedness) is applied. In order to calculate all closeness centralization of network, 2 mode network should be separated into project and participant network. In order to test the connection between participant type and country clusters we need to calculate all closeness centralization. There are two types of cluster files which are country of participant and participant type (coordinator or just participant). The relation between these two types of cluster will be measuredby all closeness centralization and its calculated 0.31837. If the participant network closeness centralization is higher than energy network then we can make assumptions that in those networks country type and participant type is more significant than energy network.

3.1.2. In Dept Analysis of Project Network

Project network visualization is provided below in **Figure 1** according to contract type and funding. Vertices represent projects, different colors represent different contract type and size of vertices represent funding amount.

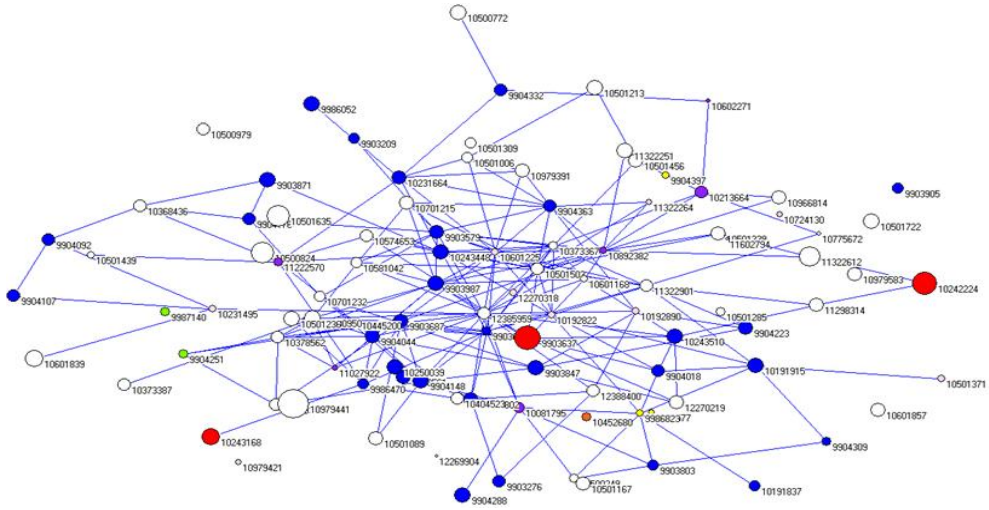


Figure 1: Representation of project network in terms of contract type and funding

The colours of different contract type is stated in the following:

- Red Vertices type: CP-IP - Large-scale integrating project
- Blue Vertices type: CP-FP - Small or medium-scale focused research project
- White Vertices type: CP - Collaborative project (generic)
- Pink Vertices type: CSA-SA - Support actions
- Green Vertices type: CSA-C - Coordination (or networking) actions
- Yellow Vertices type: CSA-S - Support actions

CSA-C - Coordination (or networking) actions projects are in the periphery of the network. Generally CP-FP - Small or medium-scale focused research project are in the center of the network thus they have high degrees compared to other types of projects. Only one CP-IP - Large-scale integrating project is located near to the center of the network.

3.1.2.1. Testing Similarities of Project Network in terms of Different Clusters and Vectors

Spearman Correlation index is used to measure different similarity of different partitions. Firstly, similarity between contract type and degree of projects is measured and Spearman Correlation index is calculated as -0.01575 which means there is no similarity between these partitions. Likely, there is no similarity between betweenness centrality of projects and funding, degrees of projects and funding and contract type and project cost because their spearmen correlation index is calculated as negatively as it is given in the table below. On the other hand there is similarity between closeness centrality of projects and funding which has highest spearman correlation index. Similar funding amount causevertices located homogenous distance to each other. There is not significant similarity result between degrees and project cost.

Table 5: Spearman Correlation Index Results

Similarity Comparison between Partitions	Spearman Correlation Index
contract type and degree of projects	-0.01575
betweenness centrality of projects and funding	-0.12168
closeness centrality of projects and funding	0.02198
degrees of projects and funding	-0.05451
contract type and project cost	-0.16766
degree and project cost	0.00814

3.1.2.2 Important Roles in the Project Network:

Bi-components of project network is found to see the projects that receives information from different two channels. Therefore obtaining bi-components of network provides to see the projects in which transmission of information most likely to be occurred. Representation of bi-components of project network is shown in **Figure 2** below.

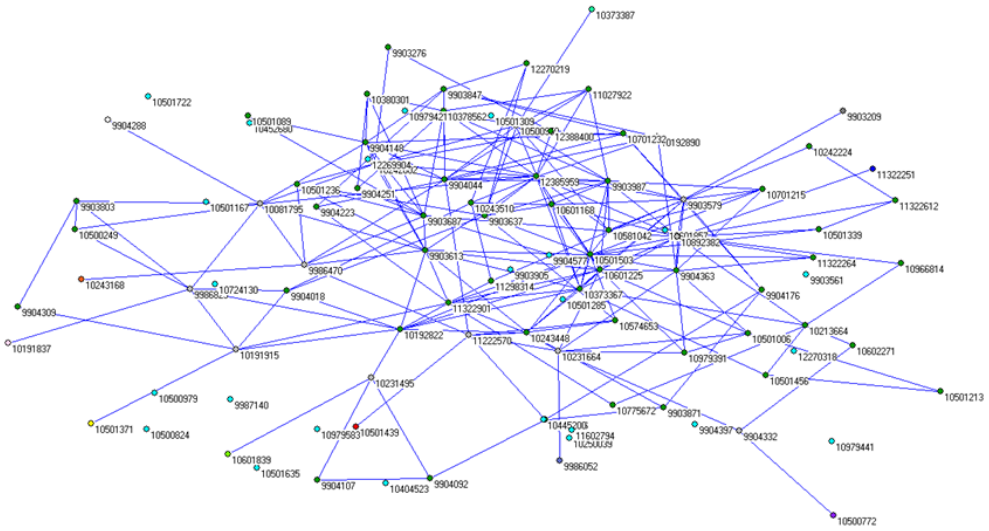


Figure 2: Representation of Bi-components

After detecting bi-component network, the projects that belongs two or more bridges or bi componentscan be found. These projects are shown with respect to contract type in the following **Figure 3**.

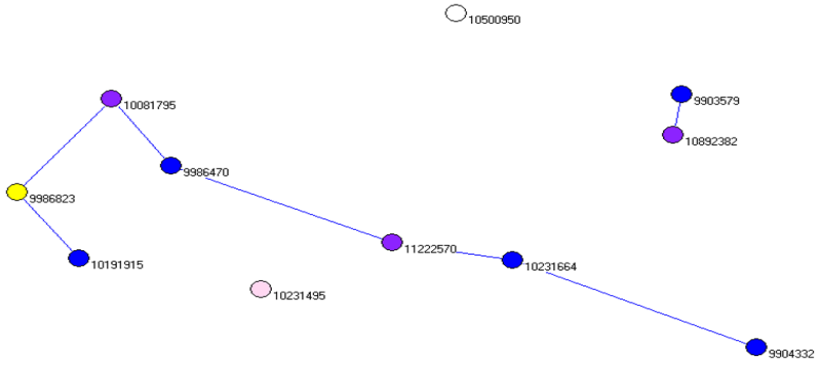


Figure 3: Representation of projects belongs two or more bridges

In the center there is CSA-CA - Coordination (or networking) actions (purple color). Yellow color project(CSA-S - Support actions type) can play brokerage role for blue project and there is structural hole between purple and blue project.

3.1.3. In-Depth Analysis of Participant Network

Participants of FP7 Energy programme with smaller and same size emerge different components which can be seen in the whole representation of network in the **Figure 4**. There are also small degrees of vertices connected to central network but they are also staying in the periphery of the network. Participant network is drawn in the below with respect to country and degree. The separate components are visualized as follows. The size of vertices represents the degree of participants (different colours shows different countries and size of vertices show degree of participant).

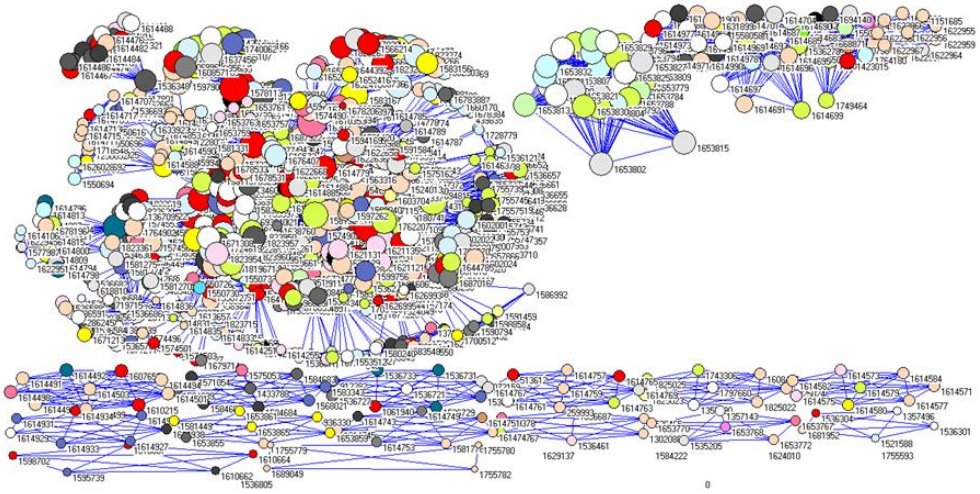


Figure 4: Representation of participant network in terms of countries and degrees

Participants with smaller size degrees are dense in the below part of network and they are separate from the center. Small size degree participants are collaborating among each other generally.

3.1.3.1 Testing similarity between country type and degree of participants:

Cramer's V. Rajskiis used to measure different similarity of different partitions.In order to investigate whether there is similarity or not between county type and degree of participants in participant network**.**Cramer's V. Rajskiindex is calculated. Cramer's V. Rajski index is significant if the index is greater or equal to 0.5 in making concrete assumptions. Index is calculated as in the following and all indexes are less than 0.5 to make a concrete assumption. However the highest index is the third one which is Rajski(C1 <- C2): 0.2410. This means there is a probability in which degree of participants is most likely similar in the participants of same county.

Chi-Square: 2774.4897
Cramer's V: 0.2351

Rajski(C1 <-> C2): 0.1351
Rajski(C1 -> C2): 0.2351
Rajski(C1 <- C2): 0.2410

3.1.3.2 Analysis of Important Roles in The Network

If there is structural hole, it means there is to tie between participants to make interaction. Larger space between vertices indicates that there is a structural hole in the network in that place. High constraint ties are drawn shorter, low constraint ties are drawn longer. In the participant network there are no bridges. The structural holes of participant network is shown in the **Figure 5** below.

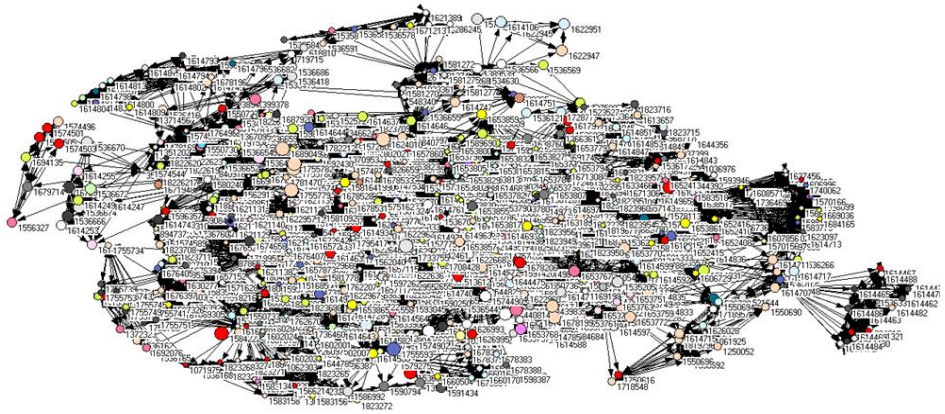


Figure 5: Representation of Structural Holes

3.2. ICT Projects in FP7

Metrics related to information flow and power in a network of FP7 ICT network is calculated as in the following **Table 6**.

Table 6: Metrics related to information flow and power in a network of ICT network

Metrics related to information flow and power in a network	FP7 ICT Network (All Network)
Degree centralization	0.00803(project network = 0.11531, participants network= 0.04412)
Closeness centralization	Closeness Centralization cannot be computed since the network is not weakly connected like in FP7 energy network
Betweenness centralization	0.08529(project network =0.04946, participants network= 0.08052)

Average degree of participant and project network is 13.6915720. All Closeness Centralization of projects cannot be calculated because it is not a dense network the ties are so weak. All Closeness Centralization of participants is 0.1406.

All Closeness Centralization between country partition and participant type partition is calculated as 0.21426 which is lower than FP7 energy network. Since the calculation of ICT network shows that this network is not dense as energy network, we do not need other calculations. In order to see analyze more deeply this network, hubs can be found. If the network is not dense, there is high probability that hubs play crucial roles in the network. Therefore, the knowledge transfer is occured among hubs.

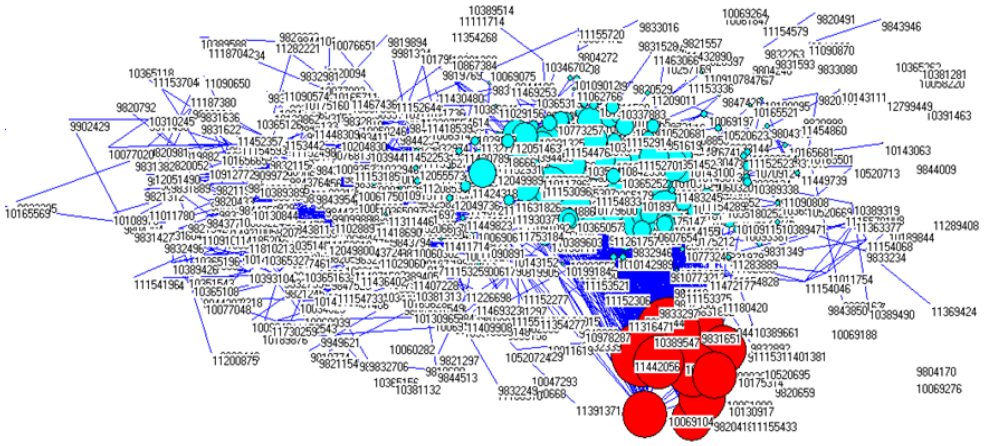


Figure 6: Hubs in the FP7 ICT Network

The colours of different contract type is stated in the following:

- Red Vertices type: CP-IP - Large-scale integrating project
- Blue Vertices type: CP-FP - Small or medium-scale focused research project

- White Vertices type: CP - Collaborative project (generic)
- Pink Vertices type: CSA-SA - Support actions
- Green Vertices type: CSA-C - Coordination (or networking) actions
- Yellow Vertices type: CSA-S - Support actions

Therefore, there is the biggest hub in the CP-IP - Large-scale integrating project also these projects has the highest funding. The second hub occurs within CP-FP - Small or medium-scale focused research project represented as blue color. There hub is also located as in the center of the network and has moderate level of funding.

Conclusion

The most significant comparison between FP7 energy and ICT networks can be summarized in terms of density of the networks, location of structural holes and hubs and project type.

Participant network closeness centralization of energy network is higher than that of ICT network so we can make assumptions that in energy participant networks country type and participant type is more significant than those of ICT network. CP-IP - Large-scale integrating projects is the center of energy network which has highest finding. However, CP-IP - Large-scale integrating projects in ICT network emerge hub among each other there is no knowledge transfer possibility with other projects. CSA-S - Support actions type projects can play brokerage role for blue project and there is structural hole between CSA-SA - Support actions and CP-FP - Small or medium-scale focused research project.

Participants with smaller size degress are dense in the below part of energy network and they are separate from the center. Small size degree participants are collaborating among each other generally.

The aim of policy recommendation will be attracting key (crucial, popular) actors to the programme network, strengthen connectivity among actors, suggesting

organizational setting, and institutional settings to the weakest actors in the network and small funding projects. Furthermore, the strategy aims to strengthen the scientific and technological network of European projects by proposing strategic suggestions in the global competitive world.

As a further study, this flexible and novel study may also be conducted to Horizon2020. Moreover, there will be comparison between framework and horizon 2020 projects and future recommendation will be drawn for further knowledge, research and innovation related programmes.

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