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# Social network analysis of Eureka project partnership in Central and South-Eastern European regions

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**Abstract**

In this article we present research on the social network structure of project partnership in the Eureka network in order to understand country performance in the network. The main method used in our research is the Social Network Analysis (SNA). Research questions were set and examined on the set of the Central and South-Eastern European countries. We investigated regionally based partnerships, relation between central position in the network and country's level of development and, finally, in order to analyze relation between number of project partners and project success, Eureka success stories were investigated as well.
**Keywords:** social network analysis, Eureka projects, project partnership

## 1. Introduction

Eureka is a European research initiative with the goal of motivating cross-border co-operation between industry and research institutions in the area of technological research and development. There are no calls for individual Eureka projects. Projects within this initiative are co-operations of independent partners representing at least two Eureka member states [9].

The main objective of the paper is to investigate performance of countries from Central and South-Eastern Europe in Eureka projects. To analyze project partnerships in the Eureka network the Social Network Analysis (SNA) was used. We implemented the SNA to investigate the involvement of Eureka members in Eureka projects as well as their networking and characteristics of project partnership.

The SNA provides both a visual and a mathematical analysis of human or organizational relationships. There are many measures that can be implemented through SNA. In our analysis we use centrality measures such as degree centrality, betweenness and closeness centrality [11].

The research was organized around the following research questions:

> **RQ1:** Are the central countries in the social network of partnership in Eureka projects most developed countries? If not, which characteristics of a country lead to the central position in the network?
>
> **RQ2:** Is there any evidence that partnership in Eureka projects is based on geographical closeness? Is cooperation in Eureka projects regionally based?

**RQ3:** Most Eureka projects are bilateral. Do bilateral projects achieve more significant success comparing to multilateral projects?

Research questions were investigated on the set of the Central and South-Eastern European countries. The results of this research are presented in our paper. Based on the obtained results, the research hypotheses were formulated and will be tested in further research on network level including all Eureka member countries.

At the beginning of this paper, the state of the art is given and the research method (SNA) is introduced. Secondly, the Eureka network is briefly presented, followed by the description and results of the research. Finally, the conclusion is given along with the directions for further research.

## 2. Using SNA in project management research: State of the art

The application of the SNA method in project management, especially in research on the social network structure of project partnership, has not received extensive attention in recent literature.

Hossain (2008) explored the effect of the employee's organizational position and network centrality on project based coordination from a real-world dataset of complex multi-million dollar projects with hundreds of people working together. He investigated whether centrally 'well-connected' people are able to exercise greater project based coordination within the network structure [2].

Hossain and Wu (2009) investigated the correlation between actor centrality and project-based coordination. They developed and presented multi-layered test designs to explore this relationship at the project-based (macro) and cross-project (micro) level [3].

Smith-Doerr, Manev and Rizova (2004) analyzed the social networks of project managers in an R&D lab of a Fortune 500 company. The aim of the research was to find out how the extent and type of centrality shapes managers' perceptions of the success or failure of six technologically innovative projects [7].

Applying the social network analysis approach to refine, classify and prioritize the requirements for collaboration and information management in an organization, Pereira and Soares (2007) presented a practical case of application of SNetCol method to an R&D institution in their paper [6].

Mote (2005) examined the impact of complexity in an R&D setting and adopted the approach that collaborative research involves a range of specialties and skills, which can be viewed separately from individuals involved in the collaboration process. He used a 2-mode network analysis which allowed an examination of the interrelationships of these competencies within a cluster of R&D projects in a large multi-disciplinary national laboratory [5].

According to our best knowledge, the SNA method has not been used so far in analyzing project networking in pan-European market-oriented programs.

## 3. Social Network Analysis (SNA)

Social network analysis (SNA) is considered as the mapping and measuring of relationships and flows between people, groups, organizations, computers, web sites and other information/knowledge processing entities. The nodes in the network are people, groups or some other items, with links showing relationships or flows between the nodes. The SNA has arisen as a key technique in sociology, but it also plays a significant role in information and organizational sciences. This research attempts to contribute to exploiting its potential in the area of project management. The SNA provides both a visual and a mathematical analysis of human or organizational relationships. The resulting structure has a structure of a mathematical graph and these graph-based structures are often very complex [11].

Let us now introduce a few definitions from the graph theory. The (undirected) graph is ordered pair $G = (V, E)$, where $V = V(G) \neq \emptyset$ is an non-empty set of nodes and $E = E(G)$ a set of edges where $E \cap V = \emptyset$ and every edge $e \in E$ connects two nodes $u, v \in V$ that are called the ends of the edge $e$.

A *walk* is any sequence of adjacent nodes and a path is a walk in which all nodes are distinct. It is possible that there are several paths between a given pair of nodes and that these paths differ in length. A graph is *connected* if there is a path between every pair of nodes in the graph. A shortest path between two nodes is called a geodesic. The length $max_{u,v} d_g(u, v)$ of the 'longest shortest path' (i.e. the longest graph geodesic) between any two graph vertices $(u, v)$ of a graph, where $d_g(u, v)$ is the shortest distance between two nodes, is called graph *diameter*

$$diam\ G = max\{d_g(u, v) : u, v \in V(G)\} \quad (1)$$

It means that the diameter of a connected graph is the length of the longest geodesics between any pair of nodes [8].

There are many measures that can be defined for the SNA, including centrality measures (degree centrality, betweenness and closeness centrality) [11], which were also used in our analysis.

*Degree* of a node is the count of the number of ties to other actors in the network i.e. the number of lines that are incident with it. It is given by

$$C_D(n_i) = d(n_i) = \sum_{\forall j \neq i} x_{ij}\ , \quad (2)$$

where

| | |
|---|---|
| $C_D(n_i)$ | Degree centrality of actor $i$ |
| $d(n_i)$ | Degree of node $i$ |
| $x_{ij}$ | $\begin{cases} 1, if\ i\ is\ indicent\ to\ j \\ 0, if\ i\ is\ not\ indicent\ to\ j \end{cases}$ |
| $n$ | Number of nodes in the network |

*Betweenness* refers to the extent to which a node lies between other nodes on their geodesics in the network. This measure takes into account the connectivity of the node's neighbors, giving a higher value to nodes which bridge clusters. The measure reflects the number of nodes that an item connecting indirectly through their direct links. It is defined as

$$C_B(n_i) = \frac{\sum_{j<k, i \neq j, i \neq k} \frac{g_{jk}(n_i)}{g_{jk}}}{\frac{((n-2)(n-1))}{2}}, \quad (3)$$

where

| | |
|---|---|
| $C_B(n_i)$ | Standardized betweenness centrality of node $i$ |
| $g_{jk}(n_i)$ | Number of geodesic linking $j$ and $k$ that contains $i$ in between |
| $g_{jk}$ | Total number of geodesic linking $j$ and $k$ |

*Closeness* is the degree to which an item is positioned near all the other items in a network (directly or indirectly). It reflects the ability to access information through network members.

$$C_c(n_i) = \frac{n-1}{(\sum_{j=1, i \neq j}^{n} d(n_i, n_j))}, \quad (4)$$

where

| | |
|---|---|
| $C_c(n_i)$ | Standardized closeness centrality of node $i$ |
| $d(n_i, n_j)$ | Geodesic between $i$ and $j$ |

*Density* is a measure of group cohesion and mathematically, the density is the average standardized degree. Network or global-level density is the proportion of ties in a network relative to the total number possible (sparse versus dense networks) [8]. If we indicate the number of nodes in the network as $n$ and number of present lines in the network as $e$, the possible number of lines in the network is equal to $\frac{n*(n-1)}{2}$ and the density of the network is equal to $\frac{2*e}{n(n-1)}$.

## 4. Eureka network

Eureka is a pan-European network for market-oriented, industrial R&D created as an intergovernmental initiative in 1985 and currently counts 40 members (the majority of which are European countries), two national information points (Albania and Bosnia-Herzegovina) and South Korea as an associated country. At the time this research was performed (2009) Eureka counted 39 members since Bulgaria was national information point and not full Eureka member.

Eureka aims to enhance European competitiveness through its support to businesses, research centers and universities that carry out pan-European projects to develop innovative products, processes and services. Through a Eureka project, partners develop new technologies, for which they agree on the Intellectual Property Rights, and build partnerships to penetrate new markets.

There are three different kind of partnership (projects) in Eureka. Most projects are individual projects initiated by European companies, SMEs, research institutions and universities. Further, Eureka Clusters are longer-term, strategically significant industrial initiatives. They usually have a large number of participants, and their aim is to develop generic technologies of key importance for European competitiveness, primarily in ICT and, more recently, energy and biotechnology. Finally, the Eureka Umbrellas are thematic networks which focus on a specific technology area or business sector. The main goal of an Umbrella is to facilitate the generation of Eureka projects in its own target area. Projects are categorized into ten technical areas: 1. Electronics and ICT, 2. Industrial Manufacturing, Material and Transport, 3. Other Industrial Technologies, 4. Energy Technology, 5. Chemistry, Physical and Exact Sciences, 6. Biological Sciences, 7. Agriculture and Marine Resources, 8. Agrofood Technology, 9. Measurements and Standards and 10. Technology for protecting humankind and the environment.

The network is governed by High-Level Group (HLG), Executive Group (EG) and National Project Coordinator (NPC). The Ministerial Conference (MC) is the political body of Eureka where the ministers lay down political guidelines decides on further developments, approval/dismissal of members and officially announces the new Eureka projects endorsed during the Chairmanship year [9]. HLG is the key decision-making body of Eureka. The ministry responsible for Eureka in each member country names its High-Level Representative (HLR) which in turn endorses new Eureka projects, takes decisions on the management of Eureka and prepares new Eureka policy discussions for the MC. Public authorities provide the funding necessary to make a project idea a reality and therefore it is justified to research on particular country performance as well as its position in the network.

From the pool of all Eureka projects, Eureka national offices nominate projects to be featured as success stories, based on the strength of the project and the final completed innovation. These success stories are published on the Eureka website, with an accompanying press release being distributed to several international press syndication sites. Success stories form a solid foundation for international media exposure, highlighting the outstanding work and innovations created by the network projects [9].

## 5. Research description

### 5.1. Sample

In our research on Eureka partnerships, project participation of seven countries from the Central European and South-Eastern European regions were analyzed. The research was performed on the following countries: Austria, Croatia, Czech Republic, Hungary, Serbia, Slovak Republic and Slovenia.

The projects included in the research are umbrellas and individual projects, which were started no earlier than 2007 and involve the above-mentioned countries. A total of 131 projects were taken into consideration. Austria is involved in 25 projects, Croatia in 11, Czech Republic in 47, Hungary in 13, Serbia in 26, Slovak Republic in 20 and Slovenia in 62 projects.

### 5.2. Social network analysis of Eureka project partnership in Central and South-Eastern European regions

First we formed a network for social network analysis as evident from Figure 1. In our research, we consider all partners from the same country as only one node. Therefore, the observed network consists of Eureka members, so there are 38 nodes in the social network of partnership in Eureka projects (European Union as the 39$^{th}$ member is excluded from the network and Bulgaria as the 40$^{th}$ member was still national information point), but only partnerships that include partner from Central and South-Eastern Europe are taken into consideration. The edges represent partnerships in projects. Regarding the type of interaction (partnership), the graph of this social network is undirected. We analyzed both models: an un-weighted network model and a weighted network model.

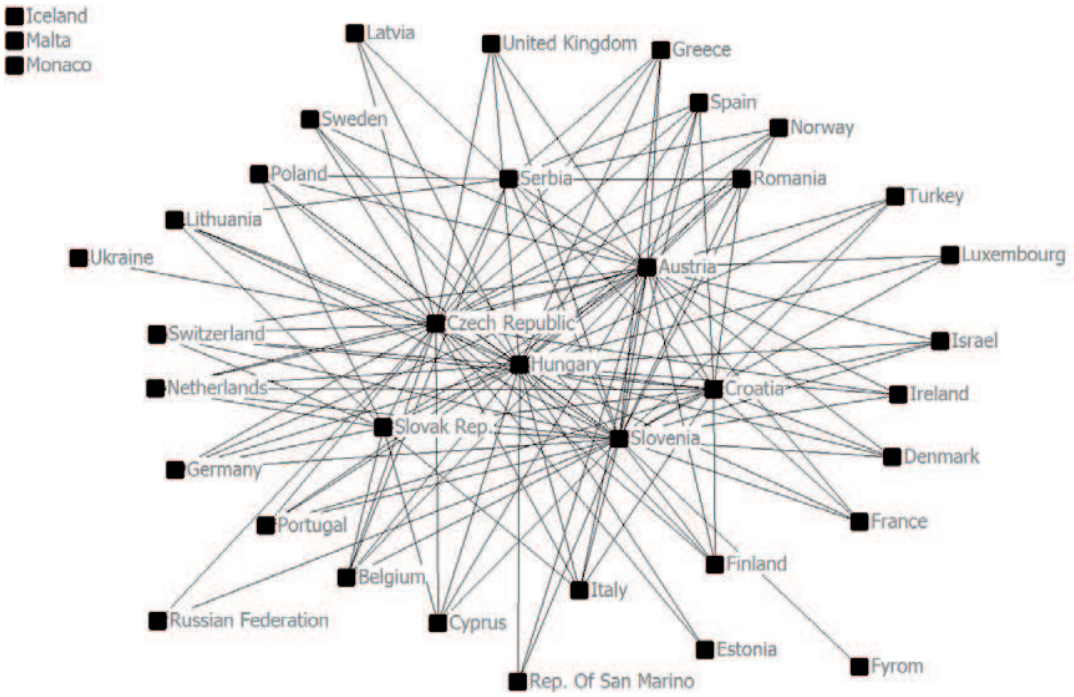


Figure 1. Social network of Eureka project partnership in Central and South-Eastern European regions

### Degree centrality

The position of the countries was tested by means of centrality measures: degree, closeness and betweenness. The highest degree centrality was obtained for Slovenia (31), followed by Hungary (30) and Austria (28). Each of these countries cooperates with more than 70% of Eureka members. Considering undirected graph, degree centrality can be explained as a reflection of a country's interests in innovation and market-oriented R&D as well as that of its engagement in Eureka projects and its attractiveness as a partner in Eureka projects. In other words, degree centrality is an indicator of a country's activity in a network.

### Closeness centrality

According to closeness centrality, the central position among countries is again held by Slovenia, Hungary and Austria, which means that these countries from Central and South-Eastern Europe have the lowest mean geodesic distance from all other countries in the network reachable from the point of their position. Closeness centrality affects the speed of access of one node to the other nodes in the network so these countries can successfully and quickly establish contacts with other Eureka members (Table 1).

### Betweenness centrality

Finally, a high betweenness centrality was obtained for Slovenia, Hungary and Czech Republic, which means that they control information, communication, diffusion innovation and other flows since they are intermediaries. They are also in a position to block those flows and therefore other countries might be forced to find alternative ways for project networking. Centrality measures are represented in Table 1.

| | Degree | Betweenness | Closeness |
|---|---|---|---|
| **Austria** | 28 | 77.826 | 235.000 |
| **Czech Republic** | 26 | 103.276 | 237.000 |
| **Hungary** | 30 | 113.450 | 233.000 |
| **Slovenia** | 31 | 136.093 | 232.000 |

Table 1. Centrality measures

### Weighted network

If we consider weighted graph of partnerships in Eureka project partnership in Central and South-Eastern European regions, the results are not significantly different. Slovenia has established the highest number of partnerships with other Eureka members (total 116) and it is followed by Czech Republic (97) and Austria (69).

## 5.3. Social network analysis of partnerships in success Eureka stories in Central and South-Eastern European regions

Among Eureka success stories, we have analyzed individual projects, umbrellas and sub-umbrellas published from January 2002 until September 2009. There are 188 Eureka success stories published on the Eureka web site in the abovementioned period. In this research only Eureka full members from Central and South-Eastern European regions and success stories published from January 2007 until September 2009 were taken into consideration. There are 66 Eureka success stories published from January 2007 until September 2009 and in 19 of them were included countries from Central and South-Eastern European regions.

As we can see from Figure 2 there are 18 Eureka members in social network of partnerships in Eureka success stories in Central and South-Eastern European regions. Only Serbia has not been included in any Eureka success story in observed period. Other Eureka members from Central and South-Eastern European region have been cooperated in success projects with 11 Eureka members outside the observed regions.

If we analyze social network of partnerships in Eureka success stories in Central and South-Eastern European regions (Figure 2) the central country is Hungary according to all centrality measures (Table 2). Further, in 10 Eureka success stories Hungary has established 22 partnerships with Eureka members. Therefore, Hungary is the most successful Eureka member from Central and South-Eastern European regions when success stories were analyzed.

| | Degree | Betweenness | Closeness |
|---|---|---|---|
| **Hungary** | 15 | 27.245 | 817.000 |

Table 2. Centrality measures for Hungary

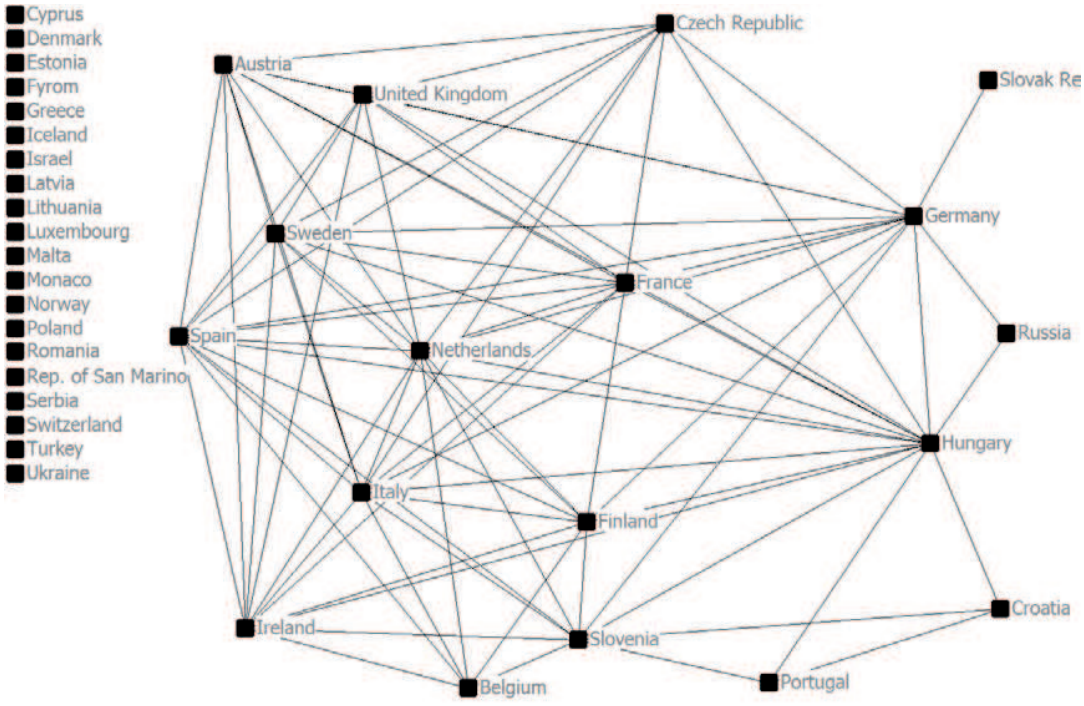


Figure 2. Social network of partnerships in Eureka success stories in Central and South-Eastern European regions

## 6. Interpretation of the results

According to the centrality measures the leader in Eureka projects among the observed countries from the Central European region and the South-Eastern region is *Slovenia*, although *Hungary* and *Austria* do not lag behind considerably, while Czech Republic is one of the central countries only according to the betweenness centrality. Further, Slovenia had established the highest number of partnerships with number of Eureka members so its ego network is the biggest (Figure 3). Owing to this position, Slovenia gains a lot of opportunities for exploiting new and innovative project ideas and penetrating regional markets. Beyond the formal aspect of project there is an informal aspect that includes informal communication and

friendship between partners providing a platform for future projects in Eureka or another cooperation framework.

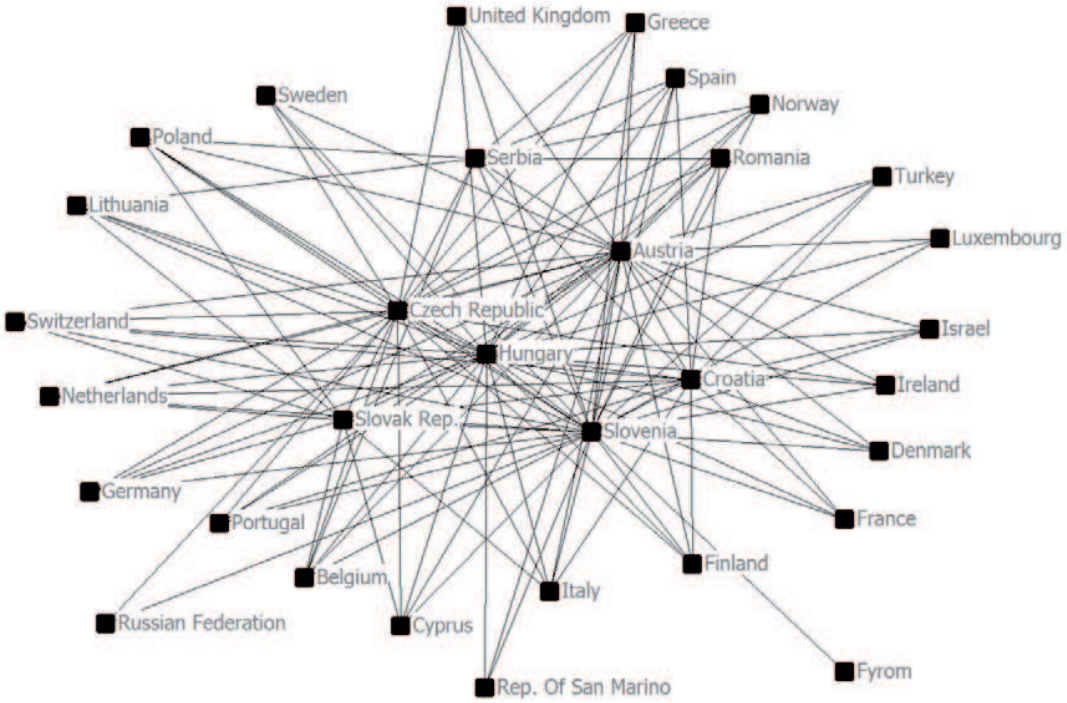


Figure 3. Ego network of Slovenia

In order to investigate the first research question, Eureka members were classified into developed countries and advanced economies according to the following indicators: Human Development Index (statistical measure that gauges a country's level of human development) [13], IMF's advanced economy list [10], High-income OECD members [15], World Bank high-income economies (Gross National Income per capita of $12,169 or more in 2009) [14] and Quality of life index [12]. In this paper we will refer, for the sake of simplicity, to developed countries and advanced economies as developed countries.

As we can see from Table 2, Austria, Slovenia and Czech Republic are developed countries according to all mentioned indicators. They also have central position in a social network of partnership in Eureka projects in Central and South-Eastern European regions. However, Hungary is a central country but not developed according to all observed development indicators. That means that the level of a country's development is not necessarily guarantee for a central position in a social network of partnership in Eureka projects.

Based on these results hypothesis 1 is formulated:

> **H1** *Central countries in the social network of partnership in Eureka projects are developed countries.*

If the hypothesis H1 will not be confirmed, then we need to answer the question *which characteristics of a country lead to the central position in the network?*

This hypothesis must be tested on the network level including all Eureka member countries. Further, we can consider some other indicators of development and connect them with the centrality position. In further research this issue will be investigated more thoroughly.

| | Human Development Index (2009) | IMF's advanced economy list (2009) | High-income OECD members (2009) | World Bank high-income economies (2009) | Quality of life index (2010) |
|---|---|---|---|---|---|
| **Austria** | Yes | Yes | Yes | Yes | Yes |
| **Croatia** | No | No | No | Yes | Yes |
| **Czech Republic** | Yes | Yes | Yes | Yes | Yes |
| **Hungary** | No | No | Yes | Yes | No |
| **Serbia** | No | No | No | No | No |
| **Slovak Republic** | No | Yes | Yes | Yes | No |
| **Slovenia** | Yes | Yes | Yes | Yes | Yes |

Table 2. Development indicators for countries

The Czech Republic differs from other countries in the social network of Eureka project partnership in Central and South-Eastern European region. It is developed country according to observed development indicators, it has been involved in 47 projects (Slovenia has been involved in highest number of projects (62) followed by Czech Republic), it has establish 97 partnerships, but influence of established partnerships in this 47 projects is evident only in high betweenness centrality of Czech Republic. If we analyze partners of Czech Republic in Eureka projects, in 19 projects partner was Slovak Republic and with 12 Eureka members Czech Republic did not establish any partnership which is a reason for lower degree and closeness centrality. Based on this results we could say that the structure of project partners of Czech Republic is too narrow to have more significant impact on position of Czech Republic in social network of Eureka project partnership in Central and South-Eastern European regions. As we can see in Table 1, Austria has higher degree and closeness centrality than Czech Republic, but lower betweenness centrality. In accordance with this, we can conclude that higher number of project partners (that is degree centrality) and closeness to other nodes in the network do not necessarily result with higher betweenness centrality. It seems that Czech Republic has established good mediating relations at global level although it did not cooperate with high number of project partners as Austria, Hungary and Slovenia.

Further, the Czech Republic and Slovenia are cut-points in the network, which means that they act as bridging countries. This is a very important role since they can use their position for their own benefit. If we remove them from the network, the network is divided into three components of connectivity.

The greatest influence on the observed countries from the Central European region and the South-Eastern region, among the countries outside of the observed region, is exerted by Germany. This can be seen in the highest number of partnerships (realized connections) with the observed countries and the fact that within a total of 66 "Eureka success stories" from January 2007 until September 2009, 19 of them include countries from the Central European region and it can indicate that the region is better than average. It is interesting that countries from the Central and South-Eastern European region in 11 from 19 Eureka success stories cooperated with Germany and this could be considered as influence of Germany on the region.

The density of the social network of partnership in Eureka projects in Central and South-Eastern European regions is 0.1963, which is an indicator of un-decentralized international cooperation in Eureka projects. It can be also interpreted as the speed of Eureka projects innovations diffusion. Further, there are three isolated countries in the network: Iceland, Malta and Monaco. Therefore, it seems that these countries are uninviting as project partners

for countries from observed regions so they did not establish any partnership with those countries.

As we already mentioned, 131 projects were observed, 73 of which are bilateral. In 26 of these bilateral projects the partners are neighboring countries. If we observe all 131 projects, in 74 of them there are at least two partners from neighboring countries. Further, in 40 of the 131 projects all the partners are countries from the observed region. Therefore in further research the following hypothesis will be investigated:

> **H2** *In Eureka projects, countries from the same region cooperate more among themselves than with the countries from any other region.*

Additionally, there are 19 Eureka success stories including countries from Central and South-Eastern Europe and 8 of them are bilateral projects. Therefore, it seems that the number of partners in the project is negatively correlated with project success and it can be explained in the way that market-oriented innovative project has to be developed in a short time and effectively managed in order to gain a chance to be as soon as possible with a product on a market.

Finally, based on the obtained results we formulated the following hypothesis for further research:

> **H3** *Among market-oriented innovative Eureka projects for a successful project is important to have small number of consortium members.*

This hypothesis will be also investigated in further research.

## 7. Conclusion

In this article we presented research on the social network of Eureka project partnerships in Central and South-Eastern European region that can be viewed as a pilot research for a broader case that will cover all Eureka countries. According to the centrality measures, central country in Eureka network in Central and South-Eastern European region is Slovenia, while Austria, Hungary and Czech Republic do not lag much behind. Further, the results of conducted social network analysis indicate that in Eureka projects countries from the same region cooperate more among themselves than with the countries from any other region. Further it is indicated that country's level of development does not necessarily guarantee central position in the network and that bilateral partnership are the most successful partnerships. Based on these results three hypotheses were formulated and they will be tested on the network level including all Eureka member countries in further research.

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