Structural analysis of European renewable energy R&D Network from 2000 to 2013

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Introduction

Combining the ability of information networks experienced by different involved actors through collaborative alliances in the emerging and multidisciplinary renewable energy (RE) sector is one of the main challenges of SmartCities. Being the innovation networks the union of public or private institutions with the aim of developing technological projects (Hagedoorn et al. 2000, Brockhoff 1992) and according to the collaborative R&D extensive literature, the analysis of these networks starts with understanding their organizational structures (Arranz and Arroyabe 2012) as defined by the actors themselves as well as the existence interconnected links between them (Sakakibara 1997). Most of the R&D collaborative technological RE European projects are financed by The European Union since their slow innovation cycles, long lead time ventures (McCauley and Stephens 2006) and relatively weak position newcomers (Hvelplund 2006).

This paper aims to describe the organizational and evolutionary patterns to be used by European Smartcity policy makers, considering R&D projects as a social networks, using Tech Data Mining Methods (TDM) and Social Network Analysis (SNA) for the period from 2000 to 2013.

Method

Firstly, according to the criteria of amount of information and its availability (Garechana et al 2012), Community Research and Development Information Service database (CORDIS) was chosen due to the fact that it manages and stores all the information related to 97,992 research and development projects financed by European Union Budget.

Secondly, a strategy was defined to be able to obtain the accurate information related to RE sector. Text Data Ming (TDM) techniques were required given its partially structured information. On the one hand, the Subject Index Classification Codes (SID) field was filtered excluding "Nuclear Fussion", "Nuclear Fission" and "Fossil Fuel". And on the other hand, 29,728 projects were identified as a result of combining "Boolean Search Logic" with "Specific Area Classification Sources" for RE specific technological area (Kostoff 2006) as well as using "Keywords", "Title" and "Activity Area" in Vantage Point TDM Software. This strategy was finished by identifying the type of organization (universities, firms, governments, research centres or others) applying the official European organization codes to 66.15% of the 163,664 existing actors and creating a new data base containing 6,703 R&D RE projects including Wind, Solar, Biomass, Geothermal, Tidal/Wave energy, Bioenergy and Hydroelectric areas.

Finally, rearranging firstly the data as 2-mode network data matrix of partners (creating the affiliation relationship as the relationship between partners and projects) and then, transforming into one-mode matrix (Kang and Park 2013), 185,815 relationships were analysed using Social Network Analysis (SNA) indicators.

Results & Discussion

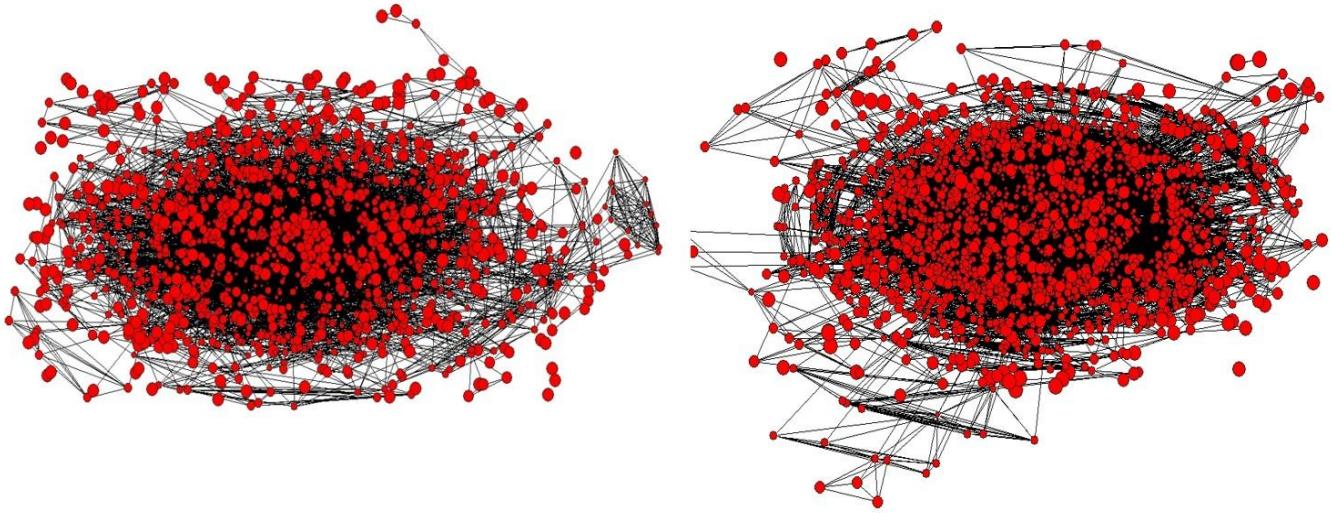
Table 1 shows the network indicators in R&D RE projects from 2000 to 2013 elaborated using Pajek Software.

Table 1. Network indicators in Renewable Energy R&D projects (2000-2013)

Network Indicator	2000	2004	2008	2013
Centrality Degree	0.083	0.157	0.114	0.218
Centrality Betweenness	0.110	0.144	0.137	0.208
Clustering Coefficient	0.378	0.513	0.536	0.394
Nº actors	1356	2240	2580	2094
Nº links	18296	51996	65535	48897
Density	0.018	0.020	0.019	0.021
Average Degree	26.985	46.425	50.802	46.702

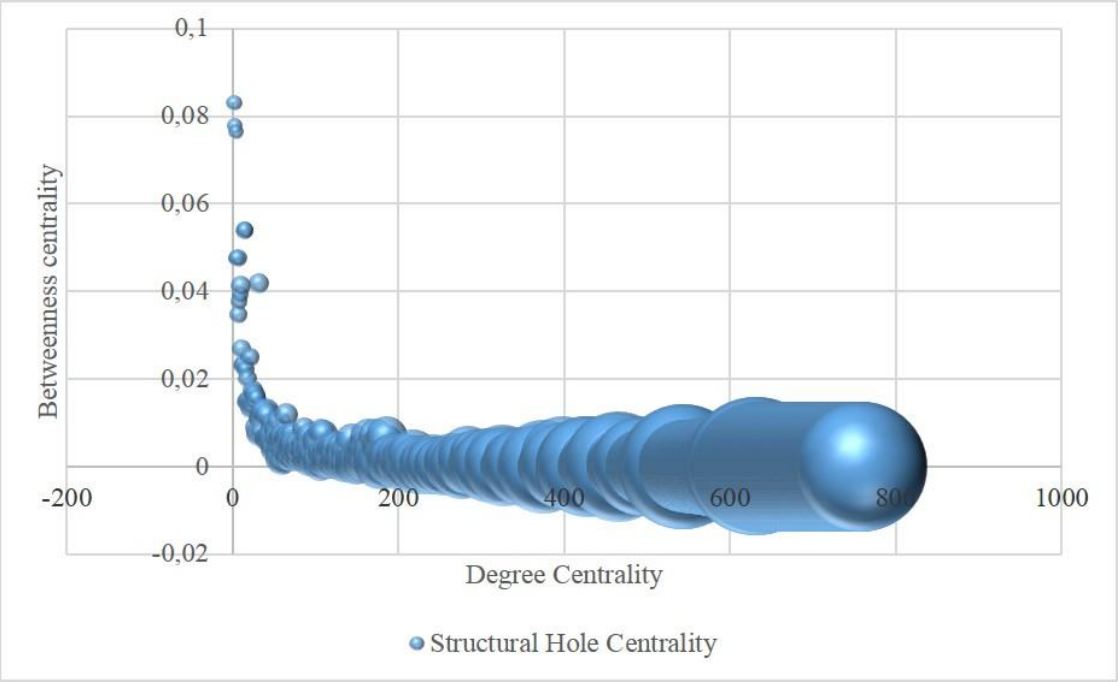
On the one hand, since density indicator measures the average tie strength between any two partners, it remains almost constant during the whole period while the number of collaborating partners tends to rise slightly from 2008 to 2013. According to Kang and Park (2013), this collaboration is concentrated around a few partners due to the fact that the average clustering coefficient remains higher than the overall density. Moreover, rising of the number of links incident upon a node (degree of centrality) and the significance of each actor in the whole network (betweenness centrality) shows that this concentration is strengthened by time.

Fig 1. Evolution of RE Network of R&D in Europe 2000-2013, according to Structural Holes Centrality



On the other hand, representing the efficiency and effectiveness of connections in the collaboration network, the structural holes indicator becomes a key factor of this analysis for 2000-2013 period. In figure 1, each link corresponds to the project collaboration relationship between two partners and the size of the nodes represent the structural holes indicator mean value.

Fig 2. Structural Holes, Betweenness and Degree Centrality values for partners' collaboration links from 2000 to 2013.



In figure 2, structural holes, betweenness and degree centrality values for partners' collaboration links from 2000 to 2013 are represented in an integrated mode.

As shown in figure 2, betweenness centrality tends to descend when degree centrality rises. According to Pajek analysis, from 2000 to 2013, universities represent 46%, research centres 39.67%, firms 11.22% and government 2.57% of the total betweenness centrality sum value. Universities and research centres remain as a key factor in terms of significance for the nertwork. However, regarding the efficiency and effectiveness of connections, firms account for 43.37%, universities for 7.26%, research centres for 11.63% and government for 4.52% of the total structural holes sum value where 88.89% of this sum value correspond to "coordinator of project" actors.

Finally, regarding the nationality of partners and their structural holes indicators, 48.13% of the total structural holes sum value corresponds to the group of partners from Germany (15.07%), Spain (11.32%), 7.95% (Italy), France (7.48%) and Netherlands (6.32%).

Conclusions

The type of organization seems to become a key factor for the R&D networks in RE sector in Europe, more than the period of time, country or their role in the network. In this sense, firms are becoming crucial players as essential, efficient and effective. Due to the fact that organizational networks for this sector appear as a key factor of development for future Smartcities, policy makers should pay more attention to these type of organizations.

References

Hagedoorn, J. & Link, A. & Vonortas, N. (2000). Research partnerships. *Res. Policy*, 29, 567–586.

Brockhoff, K. (1992). R&D cooperation between firms. A perceived transaction cost perspective. *Management Science*, 38, (4), 514–524.

Arranz, N. & Fdez. de Arroyabe, JC. (2012). Can innovation network projects result in efficient performance? *Technological Forecasting & Social Change*, 79, 485–497.

Sakakibara, M. (1997). Evaluating government sponsored R&D consortia in Japan: who benefits and how? *Res. Policy*, 26, (4–5), 447–453.

McCauley, SM. & Stephens, JC. (2006). Green energy clusters and socio-technical transitions: analysis of a sustainable energy cluster for regional economic development in Central Massachusetts, USA. *Sustainability Science*, 1, Sustain Sci DOI 10.1007/s11625-012-0164-6.

Hvelplund, F. (2006). Renewable energy and the need for local energy markets. *Energy*, 31, 2293–2302.

Garechana, G. & Rosa, R. & Cilleruelo, E. (2012). Tracking the evolution of waste recycling research using overlay maps of science. *Waste Management*, 32, 1069–1074.

Kostoff, RN. (2006). Systematic acceleration of radical discovery and innovation in science and technology. *Technol. Forecast. Soc. Change*, 73, (8), 923–936.

Kang, MJ. & Park, J. (2013). Analysis of the partnership network in the clean development mechanism. *Energy Policy*, 52, 543–553.