**Joint and Open REsearch Programmes:
features and potentialities of the JOREP database**

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NETWORK ANALYSIS ON THE JOREP DATASET
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Aim of the study

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- The aim is to study the collaboration network of the countries (with network analysis technique) in ERA-net (FP6) and bilateral programmes.

- We have chosen the ERA-net and Bilateral programmes because they are smaller programmes and also because are national initiatives.

- We are focusing on the relationship of eleven JOREP countries and the relationship with the other countries within the programme.

Research questions

- How have the scientific collaboration networks of the eleven countries changed (ERAnet/Bilateral)? Which countries occupy a central role in the network?

- Does the high connection of a node coincide with high funding within the programmes?

Why Network Analysis?

- The network analysis techniques are important tools to assess the country performance in the European research, for example to understand:

  - if the bilateral projects achieve more significant success compared to the multilateral projects (Divjak, 2010).

  - how the network position can influence the performance of joint R&D projects (Arranz, 2012).

What is Social Network Analysis?

- Network analysis is the mapping and measuring of relationships and flows between people, groups, organizations etc.

  - Countries are represented as *nodes (or vertices).*
  - Relationships are represented as *edges (or links).*

- The networked environment provides a great opportunity to understand:

  - how these relationships are made;
  - which are the main countries and their role within the system;
  - how the network operates improving the European R&D system.

Main scientific literature

- Arranz N. and Fdez. de Arroyabe J. C. (2012), Effect of Formal Contracts, Relational Norms and Trust on Performance of Joint Research and Development Projects Issue, British Journal of Management, Volume 23, Issue 4, pages 575–588

- Divjak, (2010). Social network analysis of Eureka project partnership in Central and South-Eastern European regions, JIOs, Vol. 34, No. 2

- European Commision (2008). FP6 Final Review: Subscription, Implementation, Participation, Research Directorate-General,Brussels (http://ec.europa.eu/research/reports/2008/pdf/fp6-final-review.pdf).

- Freeman, L. C. (1979). Centrality in Social Networks: Conceptual Clarification, Social Networks 1:215-39.

- Zeev Maoz (2011), Networks of Nations: The Evolution, Structure, and Impact of International Networks, Cambridge University Press, New York.

Methodology

- The data used in this study are taken from the JOREP dataset. In the following, we focus our attention on ERA-net (we have extrapolated only programmes that are part of the FP6) and bilateral programmes between countries and do not take into account the integrated programmes.

- We considered in the analysis 35 countries involved in 22 ERA-net programmes and 54 countries involved in 53 bilateral programmes.

- We have calculated the degree, closeness and betweenness of each node (country) and the general cluster coefficient for each network.

Centrality measures

In this study we have used the following indicators in order to describe and assess the research activity of the participant countries:

Degree centrality

$$C_D(p_k) = \sum_{i=1}^{n} a(p_i + p_k)$$

where n is the number of nodes and $a(p_1+p_2)=1$ if and only if node i and k are connected, and $a(p_1+p_2)=0$ otherwise

Closeness centrality

$$C_C(p_k) = \left[\sum_{j=1}^{g} d(p_i, p_j) \right]^{-1}$$

where $d(p_i, p_j)$ is the geodesic distance (the shortest paths) linking p_i and p_j

Betweenness centrality

$$C_B(p_k) = \sum_{i<j} g_{ij}(p_k) / g_{ij}$$

Number that represents how frequently an actor is between other nodes' geodesic paths

where g_{ij} is the geodesic distance linking p_i and p_j and $g_{ij}(p_k)$ is the geodesic distance linking p_i and p_j that contains p_k

Clustering coefficient

$$C = \frac{1}{N} \sum_{i \in N} c_i \text{ with } c_i = \frac{\sum_{j,m} \alpha_{ij}\alpha_{jm}\alpha_{mi}}{k_i(k_i - 1)}$$

is a measure of the degree to which nodes in a graph tend to cluster together

(FP6) ERA-net programmes

```
Variable      |   Obs     Mean   Std. Dev.    Min      Max
--------------+--------------------------------------------------
Degree        |    35    25.429     6.88       11       34
Betweennes    |    35     4.286     4.07        0      12.95
Closeness     |    35     0.024     0.004      0.018    0.029
Clustering C. |    35     0.874     0.091      0.733     1
```
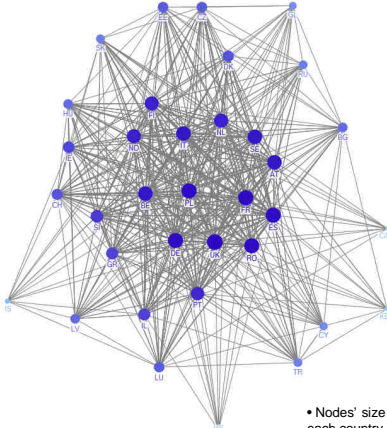
Bilateral programmes

```
Variable      |   Obs     Mean   Std. Dev.    Min      Max
--------------+--------------------------------------------------
Degree        |    54    13.889     8           1       34
Betweennes    |    54    28.296    63.559       0      263.882
Closeness     |    54     0.009     0.002      0.005    0.013
Clustering C. |    54     0.712     0.332878    0        1
```
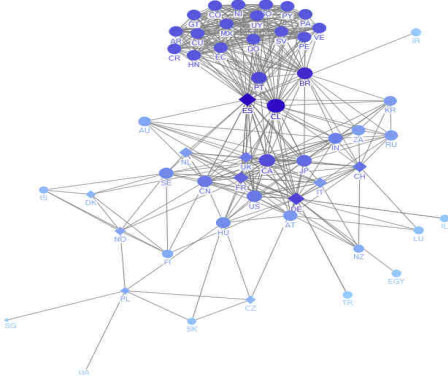

ERA-net programmes
Graph density 0.7478

Bilateral programmes
Graph density 0.2620

• Nodes' size shows the closeness centrality of each country.

• Color gradation shows the degree of each country.

Network analysis results

- The main countries in the ERA-net programmes network according to their centrality degree are the United Kingdom (k=34), followed by Germany, France, Spain and Poland (k=33).

- The main countries in the bilateral programmes network according to their centrality degree are Spain (k=34) Germany (k=24), France (k=18).

- Spain and Germany are the countries with the highest betweenness in bilateral programmes (countries that attract more partners to the research programmes).

- Finally, the average clustering coefficient in the ERA-net (C=0.874) is higher than in the bilateral programmes (C=0.712), thus the countries in the ERA-net tend to cluster more than the other program.

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Index of centrality

- Understanding participation and mobilization (amount of funding/number of collaborations)

- We have calculated an index of degree, closeness and betweenness for each node (country).

$$I_{(d,c,b)} = \frac{x_i - x_{min}}{x_{max} - x_{min}}$$

- We have added the three indexes created (combination)

$$I = I_d + I_{c+}I_b$$

- After, we have analyzed the Index with the total funding by country in the two types of programmes.

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Amount(€) and Index of centrality

Results

- Substantial differentiation between ERA-net programmes and bilateral programmes as to the network structure of research.

- Some countries play a prominent role in one program and a marginal one in the other (the UK and Poland for example).

- The high number of connections of a node does not always correspond with the amount of funding (the UK, Italy and Poland for example). Italy has a network that is smaller than the UK, but with more funding. One possible explanation is that Italy has a greater specialization in fields where the cost of research activity is higher than other fields.