Evaluating Patterns of Co-operation: Application of a bibliometric visualisation tool to the 4th Framework Programme and the Transport Research Programme

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published at *Research Evaluation*, vol. **10**, no 2, pp 129-140, Aug 2001

Abstract

The article will focus on the analysis of networks of collaboration that were set up within the European Union's Fourth Framework Programme (4th FP) by applying co-occurrence analysis and visualisation in 2-dimensional knowledge maps. The ability to generate research networks was one of the key objectives of the Framework Programmes in order to foster the long-term competitiveness of the European economy. Therefore the focus of the analysis is on the patterns of co-operations and collaboration in research networks within FP4, involving the industrial, research and education sectors of all EU-member states. It will look both at the aggregate situation of FP4 as a whole, but also at the situation in one of the specific programmes, namely the Transport Research Programme. The objective is to identify specific features within the patterns of co-operation which are of particular relevance to European research, such as the respective roles of universities, industry and non-university research institutions, the balance of countries, and the role of key centres of excellence. The article will also summarise the methodology and assess its potential for future research evaluation within the European Research Area.

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1. Introduction

In the field of research and technological development the intention of EU policy has been to strengthen "the scientific and technological bases of Community industry and encouraging it to become more competitive at international level, while promoting all the research activities..."[4] In pursuing these objectives, "...the Community shall carry out ...research, technological development and demonstration programmes, by promoting co-operation with and between undertakings, research centres and universities."[5]

Looking at EU activities in the field of technology and research policy, the *Framework Programmes for Research, Technological Development and Demonstration* (FP) are the central instrument to foster and to strengthen RTD at a European level. Since the early Eighties, when the first Framework Programme was designed, they have become more important, as expressed in the financial means that were attributed to the FPs. The total budget of the 4th FP is more than three times that of the first in nominal value, with a doubling of ressources after the 3rd FP. The currently running 5th FP has further grown by about 10%. It was also with the 4th FP that for the first time all 15 current EU-Member States fully participated, and it also covered a great variety of different scientific and technological areas by thematic and horizontal programmes.

The importance of collaborative efforts in research has also been reassessed in recent years. Due to the faster pace of change in key technology areas and the growing complexity of research, single entities can hardly cover all the different disciplines and phases of the innovation process. The early involvement of users and a networking type of research organisations have become more important features of the innovation process. A fundamental change in RTD has been identified which some researchers have tried to capture in notions such as Mode 2 of knowledge production (Gibbons et al 1994), or the triple helix (Leydesdorff 2000). These findings have also influenced the current policy debates about the further development of the Framework Programme, and even more the plans for establishing a European Research Area (European Commission 2000). Finally, research cooperation is also regarded as a means to improve cohesion within the Union and thus contribute also

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[4] Maastricht Treaty (1992), Article 130f; Amsterdam Treaty (1999), Article 163

[5] Maastricht Treaty, Article 130g; Amsterdam Treaty, Article 164

from this side to improving the competitiveness of the EU. In fact, a central requirement for submitting a successful funding proposal is a well structured consortium consisting of partners from different countries as well as from different (organisational) sectors.

In each country one can identify some lead firms, institutes, etc. which are able to co-operate internationally in RTD, irrespective of the underlying industry and research structure. In other words, RTD at European level is thus carried out by transnational research joint ventures. These joint ventures are made up of business firms, research centres and universities that have the necessary special, and often tacit, skills to engage in pre-competitive research. The emergence of specific patterns of co-operation can therefore be addressed at several levels of industrial and spatial aggregation. This article will analyse two levels, namely the aggregate level of the Fourth Framework Programme, and as an example of a specific programme within FP4 the Transport Research Programme.

Therefore our analysis of the participation in the EU R&TD Framework Programmes concentrates on identifying specific features within the patterns of co-operation and collaborative networking within FP4 which are of particular relevance to the ongoing European Research Area debate. It will focus on the respective roles of industrial, university and non-university research, and on the participation of different Member States. We will also look at the central players in European research, i.e. the candidate “centres of excellence” of the European Research Area. This kind of evaluation of cognitive entities has a number of particular difficulties, especially an appropriate delimitation of a research field (van Raan 2000). This is why we apply it only to the individual programme level with respect to the role of an organisation in this specific programme.

The characteristics / special features of our analysis is that we take both a macro and a micro view on the most intensive co-operative links between participants from all EU member countries within the FP. Furthermore we focus upon the single partners and their patterns of participation, as well as the overall patterns of participation. And above all we observe partners from all EU member states to give a comprehensive picture of EU-funded research instead of taking the perspective on only one country’s participants and their partners.

Although the Framework Programmes as the core of the European research and technology policy only represents a comparatively small share of research spending in Europe, it has a strong structuring effect on the national industry and research structures, by pointing strategically to new and emerging routes of scientific and technological knowledge creation.[6] However, it needs to be carefully examined whether this also leads to dissemination in European industry their relevance for creating sustained co-operation effects beyond the duration of EU-funding, and whether it has an impact on other policy areas and framework conditions (Peterson/Sharp 1998, Grande 1996).

Several analyses use graph-theoretical mapping techniques to visualise R&D collaborations of a few selected countries and specific sectors (Dumont / Meussen 1997). Evaluations of participation of several countries in the FPs use mainly statistics and look at numbers of participations and collaborative links to find indicators to describe co-operation and participation patterns (Lukkonen 1999, Gusmao 2000). An interesting technique of mapping the participation of the different Member States in the FPs has been presented by Removille and Clarysse (1999), but they do not go down to the level of individual collaboration networks for visualising their results.

The analytical tool that has been used to produce the collaboration maps in this paper supplements and goes far beyond conventional statistics. On a descriptive level the visualised networks allow to identify different types of collaborative R&D patterns between countries, sectors, organisations etc. and to use these observations as a basis for further investigations.

The methodology and visualisation tool will be introduced and discussed in the next section. In the following two sections, some example results on the patterns of collaboration in FP4 and the Transport Research Programme will be presented. First of all, this should allow to demonstrate the application potential of the analytical tool for evaluation purposes. It is to be expected that future research evaluation will be in need of new tools to assess networking and collaboration patterns in Europe. Secondly, the results of our analysis, although exemplary in nature, tend to enrich the

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6 The EU spending on research accounted for about 4% in 1994 to 1998 (Research and Technological Development Activities of the European Union – 1999 , European Commission (COM 99) 284, Table 10 and 11, page 78f). The FP equalled only a very small share of total government spending on RTD in member states and a very much smaller percentage of all RTD expenditures (public and private).

current debate on the role of collaborative research and innovation and the discussion about evaluation methods for the European research programmes. It provides detailed information on the role of different countries and types of research organisations, as well as on the key position of a few “centres of excellence” in European research.

2. Database

Information on data

For this analysis we used data of the CORDIS database of the European Commission. Due to the high amount of projects we restricted the dataset to projects financed by the EU within 4th FP (1995-1998). At that time (December 1998) more than 10.000 projects with over 47.000 participations across all the thematic and horizontal programmes of 4th FP were listed in the CORDIS database. One has to bear in mind that CORDIS only contains projects that are in execution or that are already completed. The projects are filed when contracts are signed and when CORDIS receives the data from the Commission. In selected programmes there is a considerable delay and the data are not always up to date. Nevertheless, for the time being the CORDIS data base is the only source provided by the European Commission that gives comprehensive information on projects and participants involved in the FPs.

Selection of the data

At a first step all categories of projects were taken into consideration. Finally a sample of partners were selected. About three quarters of the participations happened in the so-called *Cost-sharing Actions*[7], the most frequent type of projects. Another 10% were involved in projects with a co-ordinating agenda (*Co-ordination of research actions, Thematic Network Contracts*). The remaining projects were exploratory awards for SMEs, study contracts etc., each one in only minor proportions.

Within the whole Program partners from more than 200 countries were involved in projects. We selected only partners from the 15 European Union’s Member States for the analysis.

To have a more efficient representation of the partners, we added some information to the names. The name was first extended by the **organisational type** to describe the institutional setting of each partner. The most important organisational types were industry (with the abbreviation IND), higher education and university institutes (EDU) and (non-university) research organisations (ROR) (institutes, laboratories). Additionally we found consulting firms (CON), public organisations (OTH), non commercial (NCL), international organisations (INT).[8] Secondly we added the country[9] as a **regional** (geographical) extension. At the end the description of a partner consisted of an acronym of the name and the mentioned two extensions: for example: siemens.ind.de).

The visualisation was also performed with the help of some additional attributes to representate a time dependend evolution of networks we used the date of the first appearance of the partner in the 4th FP, i.e. the starting date of the project, this actor was envolved in. Thematic landscapes were drawn on the basis of the specific programmes, the partner was participating in, the industrial sector, the region of origin, or the main research field of a participant.

Standardisation of data

There are also some limitations and weaknesses of the data, that prevented more detailed analysis. For example, it was not possible to distinguish between small / medium enterprises and big enterprises. Furthermore, the data had to be harmonised in order to diminish and eliminate the discrepancies in the database in order to apply the methodology in a consistent way.

For example, frequently the name of one and the same partner was spelled differently in the CORDIS database. In order to be able to apply the bibliometric analysis with the software BibTechMon™ for the network analysis all the data had to be unified, i.e. each partner had to be identified by one acronym, organisational type and country. Due to this procedure more then 47.000 supposed acteurs were identified as only 13.598 different organisations.

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7 The European Commission finances up to 50% of the costs for industrial partners and 100% of the additional costs for universities in the – mostly - research or demonstration projects.

8 For those we were not able to identify the appropriate organisational type we used "x".

9 As mentioned above we concentrated on the EU 15.

Data set

For our analysis we distinguished between a partner, i.e. a single institution / organisation who participated in one or more projects. Each time a partner participated in a project was counted as a participation. One partner could have several participations in different projects. The collaboration with another partner in a project created a collaborative link. Co-operative relationships occurring in the RTD projects executed within the European Union's Framework Programmes were mapped, encompassing the 13.598 partners with a rich set of variables on each.

For the network analysis we selected those organisations, that participated in three or more projects (9.403 of the partners participated in only one project, 1.767 in just two and therefore were not considered to be a part of a network). Furthermore in many cases the organisational code was incorrect or missing and had to be supplemented.

This restriction led to 2.428 partners , who participated 30.000 times in 8.800 projects. Altogether the network showed about 58.963 collaborative links. Partners from the 15 EU member states across all sectors (industry, universities, research institutes etc.) were included.

3. Methodology

Bibliometrics

Bibliometric methods can be applied for the analysis of specific fields of technology or for identification of experts and institutions leading in technology by surveying literature and patent information from databases. Relations between technological developments, different fields of application and leading experts can be determined using bibliometrics (Grupp et al., 1990). Due to the manifold possibilities of analysing large amounts of information and documents the importance of bibliometric analysis increased also for other fields of application, like competitive analysis of companies and their products, structuring of internal documents for knowledge management, patent analysis and management or analysis of co-operation behaviour of institutions or persons (Noll and Schiebel, 2000).

Bibliometric methods go for structuring of electronically stored information in internal or external databases. The structuring is based on the calculation and often visualisation of relations between objects, such as documents, keywords, authors or institutions. The relations are derived from indicators that can be defined through different models (Van Raan, 1992).

Co-occurrences

Since the question of interest is co-operation between institutions, one dimensional statistics alone like total frequencies do not deliver sufficient information. What is needed is a method taking into account relations between the institutions. The kind of relation we are looking at is co-operation defined as common participation (one partner can have several participations in different projects) in projects found in the CORDIS-database. The role of the participant in a project (e.g. co-ordinator, researcher) is not taken into consideration at the study on hand. To measure the relation, simply the number of co-operations between each couple of institutions had to be counted in the sense of a co-occurrence analysis (compare Callon et al. 1983, Rip and Courtial 1984, Turner et al. 1988, Leyersdorf 1989, Kostoff.1993). A detail of the respective matrix is shown at fig. 1 The numbers in the main diagonal correspond to the total number of participations of a single partner in the 4^{th} FP.

Name of partner	csic.ror.es	uni cam.edu.gb	ntua.edu.gr	icstm.edu.gb	vtt.ror.fi	cnr.ror.it	uni lund.edu.se	max_planck.ror.de	fu brux.edu.be	siemens.ind.de	uni_saloniki.edu.gr	uni_utrecht.edu.nl	tu_delft.edu.nl
csic.ror.es	266	5	5	4	7	19	14	12	8	1	6	9	2
uni cam.edu.gb	5	226	1	2	2	9	2	7	7	1	5	2	4
ntua.edu.gr	5	1	207	14	13	5	4	0	5	5	4	0	5
icstm.edu.gb	4	2	14	184	10	4	3	8	0	6	3	1	11
vtt.ror.fi	7	2	13	10	181	3	6	1	0	2	3	1	5
cnr.ror.it	19	9	5	4	3	179	3	4	3	2	10	4	1
uni lund.edu.se	14	2	4	3	6	3	158	3	1	3	4	7	9
max_planck.ror.de	12	7	0	8	1	4	3	157	4	1	0	5	1
fu brux.edu.be	8	7	5	0	0	3	1	4	150	1	3	15	3
siemens.ind.de	1	1	5	6	2	2	3	1	1	131	3	1	6
uni_saloniki.edu.gr	6	5	4	3	3	10	4	0	3	3	129	2	6
uni_utrecht.edu.nl	9	2	0	1	1	4	7	5	15	1	2	129	7
tu_delft.edu.nl	2	4	5	11	5	1	9	1	3	6	6	7	128

Fig. 1: Table of co-occurrences (small section of the original matrix with a dimension of 2.428 rows and columns) indicates for any pair of institutions the number of common projects where they participated together: The numbers in the main diagonal correspond to the total number of participations of a single partner in the 4th FP.

The Jaccard Index was used to normalise the elements of the co-occurrence matrix. This index gives a better information about the "intensity" of the co-operation of partners:

$$J_{ij} = \frac{c_{ij}}{c_{ii} + c_{jj} - c_{ij}}$$

, where c_{ii} is the co-occurrence of partners *i* and *j*, c_{ii} is the total number of participations of partner *i*. J_{ij} therefore is a normalised measure for the intensity of co-operation.

Visualisation

The above matrix contains information about co-operational behaviour, nevertheless it is not easy to interpret it. For this reason a visualisation method had to be carried out that is capable of transforming the matrix into a intuitive readable 2-dimensional map. For this purpose a mechanical spring model is applied (Kopcsa and Schiebel

1998) as follows. Institutions in this model are mass points with a mass and size proportional to the total frequency J_{ii}. The masspoints are connected with each other by forces (springs) correlated to J_{ij}. The masspoints are positioned randomly as a starting position and then will move driven by the forces defined above. This is done by iteration of the respective n-dimensional differential equation system. So the masspoints will be positioned on a 2-dimensional map in correlation to their co-operational relation to each other as defined by the Jaccard matrix. Through this model the partners are positioned according to their co-operations, intensively co-operating institutions will be found in a close neighbourhood.

Thus the map gives information through the size of the objects (correlated to the total frequency) and the relative position to each other (see also Van Raan, A. F. J., 1992). To enrich the content of such maps additional information is appended by colouring the objects to visualise other parameters of interest as for instance the organisational type (see fig. 2).

4. Evaluating patterns of collaboration in the Fourth Framework Programme

In the frame of this paper only a selection of possible interpretations of the calculated co-operation maps can presented in order to demonstrate the possibilities offered by this method which exceeds traditional ways of analysis. In this section, we will look at aggregate patterns of co-operation that can be discerned for the Framework Programme as a whole. Moreover, we will “zoom” into one specific area of research field within FP4 (aeronautics).

Industries, universities and non-university research organisations

In Figures 2.1 to 2.3, educational, industrial and non-academic institutions are highlighted. A clear division can be noticed between industrial institutions on the one hand, and universities/higher education on the other. This indicates a preference of institutions of these two types to co-operate with partners of the same organisational type and to form more steady networks.[10]

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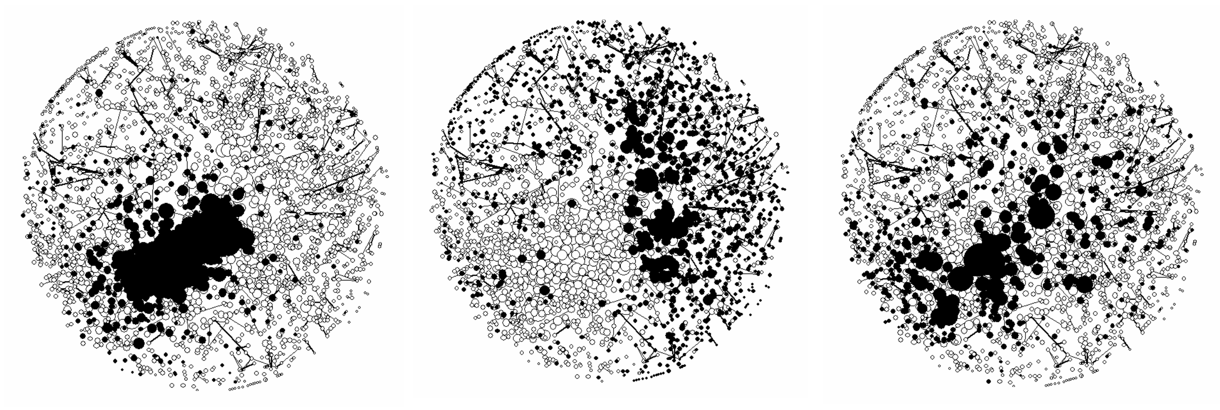
[10] That does not mean that they do not co-operate with other partners at all but just that their collaborative links are more intense with partners of their own kind. If we would look just at the sheer number of participations



university sector | industry sector | non-university research sector

Fig. 2.1 to 2.3: Co-operation network of 4th FP. Series of three identical networks, where educational, industrial and non-university research institutions are highlighted (in black) respectively.

When looking at the non-university research organisations (ror), it can easily be observed, that quite often they do co-operate with partners from other organisational types because they are evenly spread across the figure and do not form a sector by their own. To all appearances non-university organisations fulfil an intermediary function between educational and industrial institutions. This is a quite trivial result but demonstrates the kind of visualisation of this relationship.

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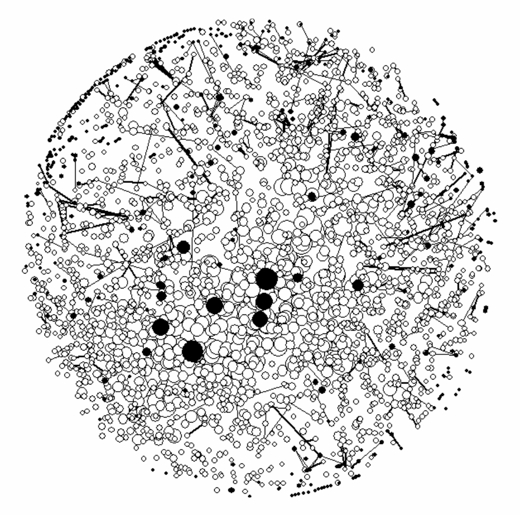
we would not be able to see this specific pattern, on the contrary we would presume that the co-operation is quite balanced.

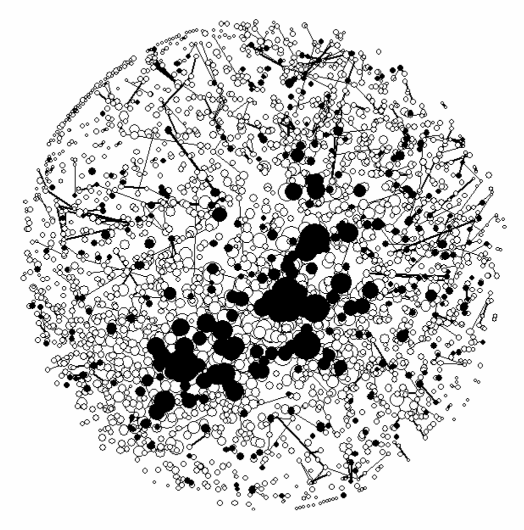
The participation of Member States

To demonstrate the possibility to generate research hypothesis we have a closer look on the participations of different countries to FP4.

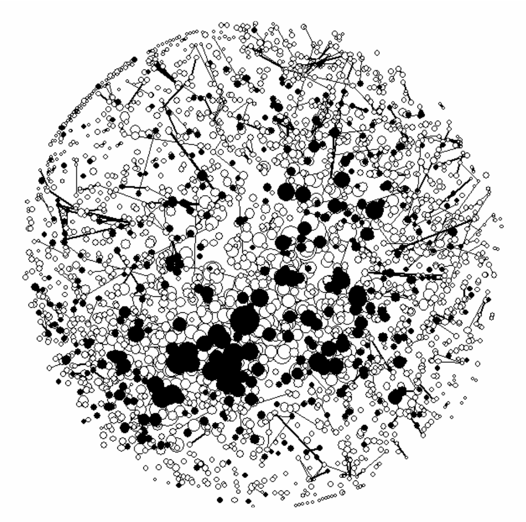
If in the same network as a parameter not the organisational type but the nationality of an institution is highlighted, the networks in figures 3.1 to 3.4 show some significant patterns, especially if compared with the patterns of organisational types in figures 2.1 to 2.3.



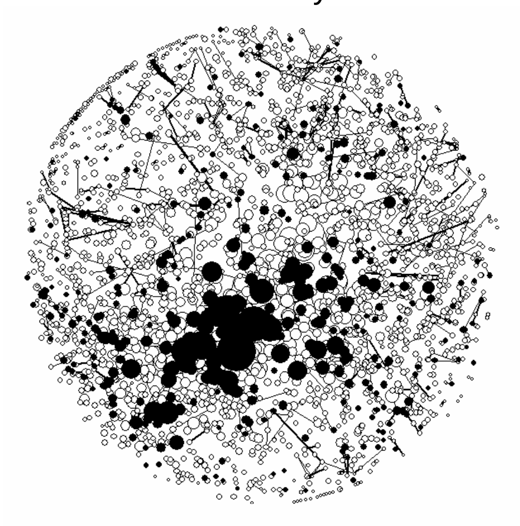
Austria



Germany



France



United Kingdom

Figure 3.1 to 3.4: Series of four identical networks (the same as in fig. 2), where the participation of selected Member States in the Fourth Framework Programme is highlighted in black for Germany, France, UK, and Austria respectively.

The small country of Austria shows the appearance of some academic organisations, who participated in more projects than industrial partners but both acted more in their own sector: universities in the university sector, industrial partners in the industry sector, there are quite a few participants in the intersectoral area. The picture on Germany is completely different. Members of all sectors participate strongly in the programme and there is a good mix of participants in all sectors, as well in the areas between the sectors. France shows a similar picture as Germany, but there is a bias to a stronger participation of universities in the university sector. The pattern of co-operation network of the United Kingdom tends more to the picture of Austria than to Germany or France. Naturally much more project participations are to be constated but there is a polarisation that university co-operations tend to the university sector, industrial partners to the industry sector.

This hypothesis should be verified of course, hence a detailed research is topic of ongoing research.

Zooming into the aeronautics cluster

An interesting example of a research cluster within the Fourth Framework Programme is aeronautics. Collaboration in this area is driven by the fact that this is a high-profile European industrial and political project. Aeronautics was not part of Transport Research, but integrated within the Industrial Materials and Technologies Programme. When looking at the individual organisations involved in this cluster (Figure 4), we can identify the main industrial players in Europe's aeronautics industry, e.g. *british aerospace, eurocopter, volvo aero, aerospatiale, saab*. These are industrial partners that collaborate very intensively (one of the most intense groupings) in the frame of the EU-funded research programmes. By zooming further into the network we see that some of them are also members of the *Airbus Industry* consortium.[11]

Starting from the above selected cluster we intend to identify those institutions outside this cluster that else collaborate with the aeronautic industrial partners. Based on the Jaccard matrix described above the relations of all institutions that are connected with the aeronautic cluster are calculated in terms of sum of Jaccard indices to each of the members of the specified cluster. Those institutions with the

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[11] The Airbus Industry is owned by four of Europe's leading aerospace companies: Aerospatiale Matra Airbus, Daimler Chrysler Aerospace Airbus, BAE SYSTEMS and CASA. (since 1967). Furthermore the Eurocopter

highest respective value are marked grey in fig. 4. All of them can be found in the close neighbourhood left of the aeronautic cluster and are clearly dominated by the university sector. That shows that the partners collaborating most intensively with the aeronautic firms were not other big companies or SMEs but mostly universities. Therefore this cluster can be cited as an example for industrial clusters that are primarily involved in intra-sectoral networks, yet gain additional know-how from the educational area.

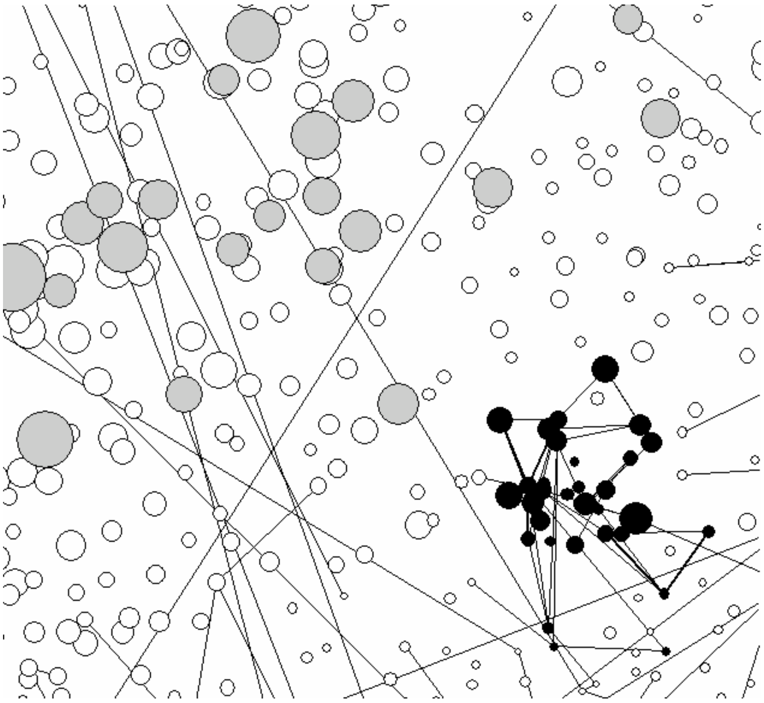


Fig. 4: The aeronautics cluster (black) and its most relevant partners (grey) in 4th FP

Group, founded in 1992, was created by merging the helicopters divisions of Aerospatiale Matra and Daimler Chrysler Aerospace. Links: http://www.airbus.com/; http://194.2.31.123/eurocopter/jf_z0005.html

5. Evaluating patterns of collaboration in the Transport Research Programme

More detailed observations can be made when moving deeper to the level of individual programmes. In this section, we will analyse some of the patterns that result from applying the bibliometric tool to the Transport Research Programme.[12]

The main thematic clusters

Figure 5 shows the result of the bibliometric analysis of the Transport Research Programme. The graphical representation shows eight well-delimited clusters of dense collaboration. Their titles have been chosen on the basis of a content analysis of the underlying project descriptions that make up the database. It is possible to identify the eight clusters with key thematic areas or priority themes of the Transport Research Programme:

1. Strategic research
2. Road and urban transport
3. Rail transport
4. Integrated transport
5. Inland waterborne transport
6. Air transport
7. Maritime waterborne transport
8. Mobility behaviour in Europe

The different modes of transport, road and rail on the one side, waterborne and air on the other, do gather around the common topics of mobility behaviour in Europe, Integrated transport and strategic research, the last one being in the very centre.

[12] Some transport-related research projects of the Fourth Framework Programme were not conducted within the Transport Programme, but within other programmes of FP4: ICT, Energy, Environment and Industrial Materials and Technologies.

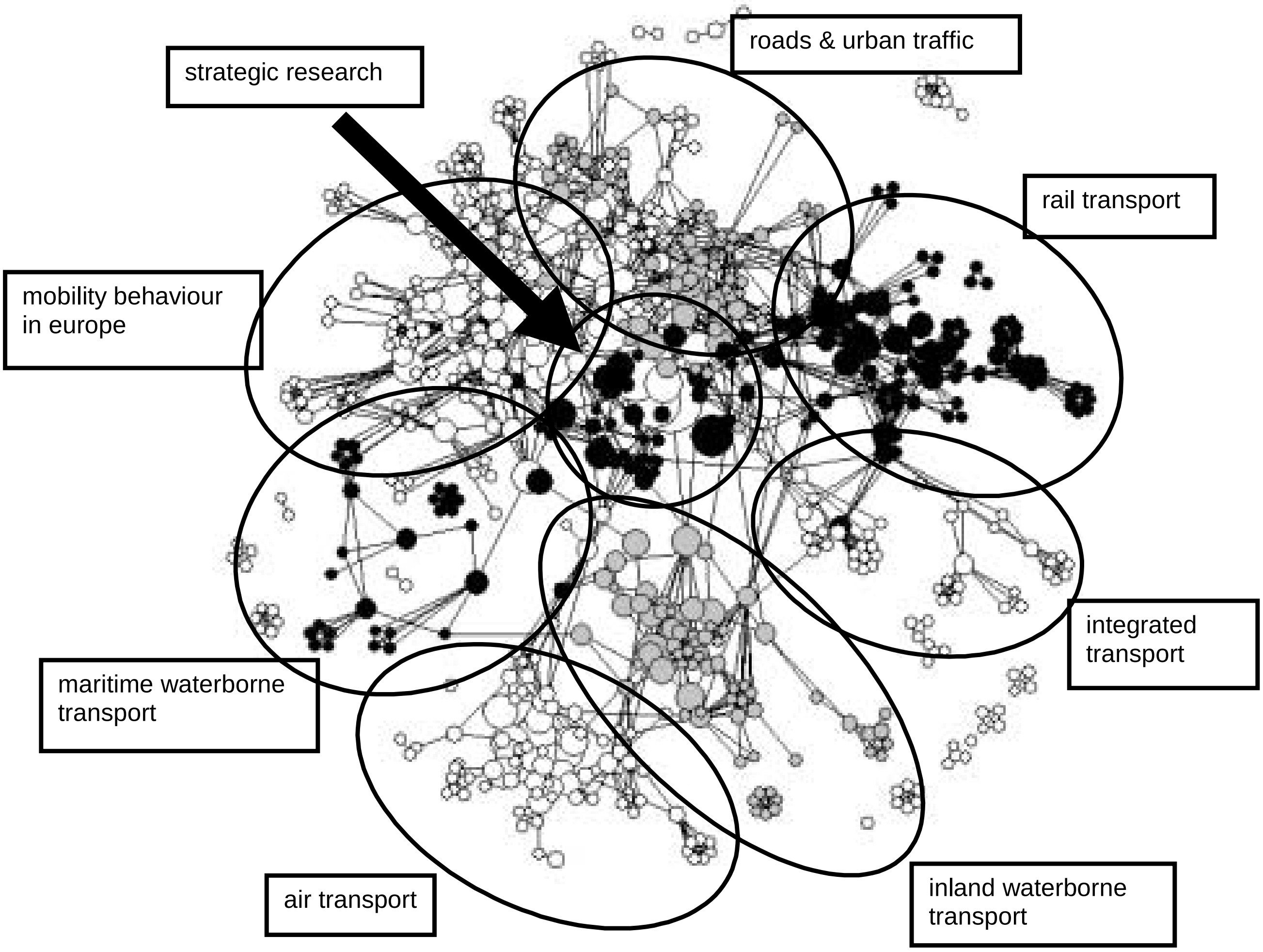


Figure 5: The main clusters of collaboration within the Transport Research Programme and their thematic orientation. Different colours (white, grey and black) help to distinguish the different thematic clusters.

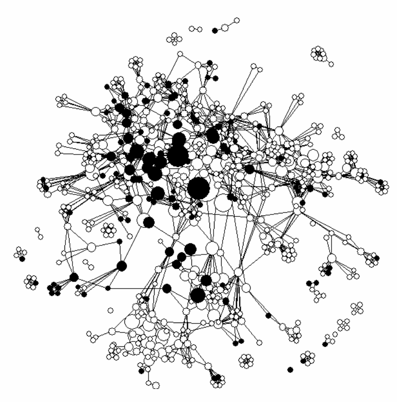
This is a quite interesting result because it allows to show that the Transport Research Programme has indeed led to a grouping of organisations around its priority themes. Whether these grouping also develops into more stable networks of collaboration is an issue that should be analysed by looking at the further evolution under FP5.

Another interesting feature is the respective densities of collaboration within the individual clusters. Especially in maritime waterborne transport and to some extent also in integrated transport the collaborating institutions are only loosely clustered, pointing to rather occasional collaborations in these areas. For integrated transport this can be explained by the fact that we are often dealing with partners coming from the individual modes, brought together by an intermodal “integrator” or service provider. In the maritime waterborne transport, the small number of incidences may be the reason for the scattered character of this cluster.

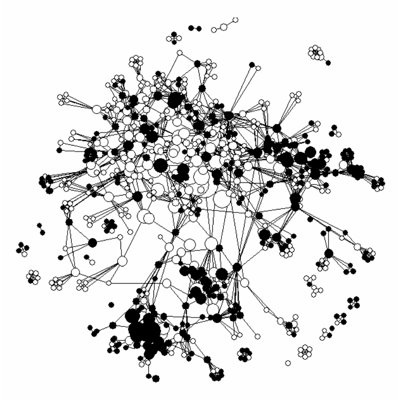
Industry, universities and non-university research organisations

In terms of the respective contributions of industrial and university research institutions, the Transport Research Programme shows quite different patterns than the 4th Framework Programme as a whole (Figures 6.1 to 6.3). Whereas at FP4 level, there is a pretty clear separation between these two types of institutions, in *transport research* the distribution is clearly more even. Moreover, it is possible to identify the fields of major or minor representation of university and industrial research. So, universities are particularly well represented in *strategic research* and in *mobility behaviour in Europe*. In rail- and especially in *air transport* industrial partners dominate European research.

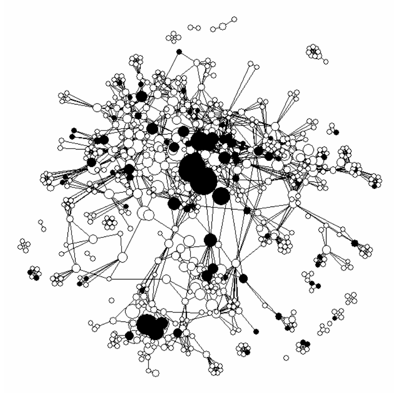
Non-university research organisations are in general they are well distributed over all research fields, even if their contribution is particulary remarkable in *strategic research*, in *air transport* and in *inland waterborne transport*. In other words, as for FP4 as a whole, their thematic and collaboration profiles tend to indicate a potential comparative strength as bridging institutions between industry and academic research, even if the need for such a bridging function may be less strong in transport than for FP4 in general terms.



educational institutes



industrial enterprises



non-university research organisations

Figures 6.1 to 6.3: Co-operation of the Transport Research Programme within FP4. Series of three identical networks (the same as in fig. 5), where educational, industrial and non-university research institutions are highlighted (in black) respectively.

The role of different Member States

Within the Transport Research Programme, some Member States show very pronounced patterns of specialisation on some research themes, and this can be easily visualised by means of the bibliometric tool used (Figure 7.1 to 7.4). German research organisations are quite evenly distributed over all fields. France and the UK, on the contrary, seem to specialise on some key areas. France, for example, is strongly represented in air transport related research, but also in rail, mobility behaviour and – through the participation of mainly one organisation – strategic research. The UK is best represented in the same three clusters. This means that the two countries together tend to dominate them. As an example of a small country, Austria contributes above average to railways research, and has contributed to a limited extent to a few other fields.

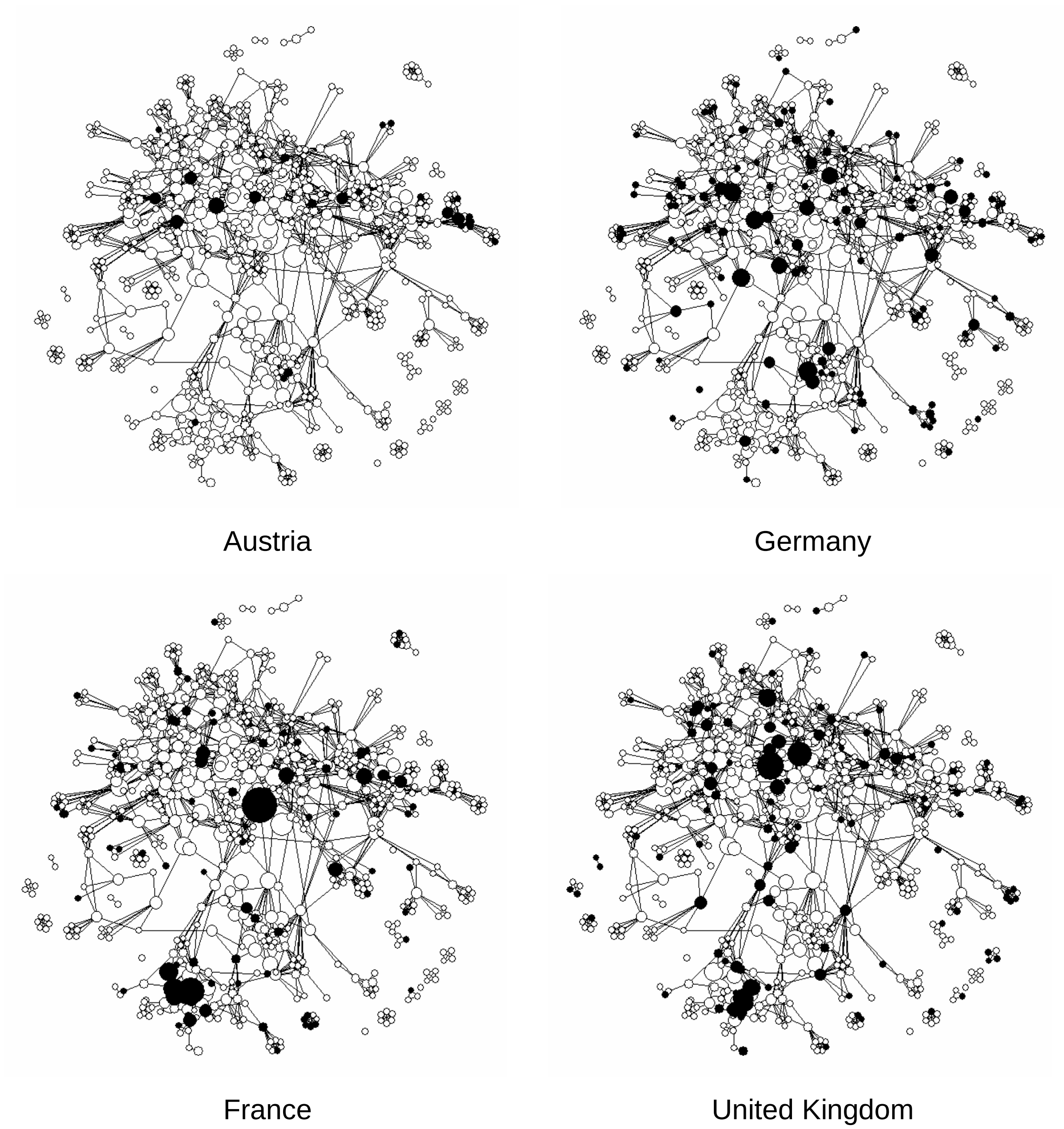


Figure 7.1 to 7.4: Co-operation of the Transport Research Programme within FP4. Series of four identical networks (the same as in fig. 5 and 6), where the participation of selected Member States, Germany, France, UK, and Austria, are highlighted (in black) respectively.

Zooming into the "centres of excellence" in European transport research

A final interesting feature of the transport research programme consists of the outstanding role of a rather limited number of research institutions that are located right in the centre of the overview picture of the Transport Research Programme (Figure 8). The extent of their involvement and the cross-cutting role they play in many fields of transport research indicates that they are very well positioned to develop into the future “centres of excellence” or at least into key network nodes in the envisaged European Research Area in the transport field. In other words, their central position does not mean that they are just core research actors in the horizontal area of strategic modelling, but that they are involved in many research fields in transport. This can be shown by searching deeper in the underlying database and to perform a content analysis of their research portfolios. In other words, their central position in the figure is thus the consequence of the clustering algorithm. The eight key organisations identified, each with 15 or more participations in the overall programme, are:

- Inrets, Institut National de Recherche sur les Transports et leur Securite
- VTT, Technical Research Centre of Finland
- National Technical University of Athens
- Netherlands organisation for applied scientific research (TNO)
- Sociiti Frangaise d'Etudes et Rialisations d'Equipements Aironautiques
- University of Leeds
- Stichting Nationaal Lucht- en Ruimtevaart Laboratorium
- Transport Research Laboratory (TRL)

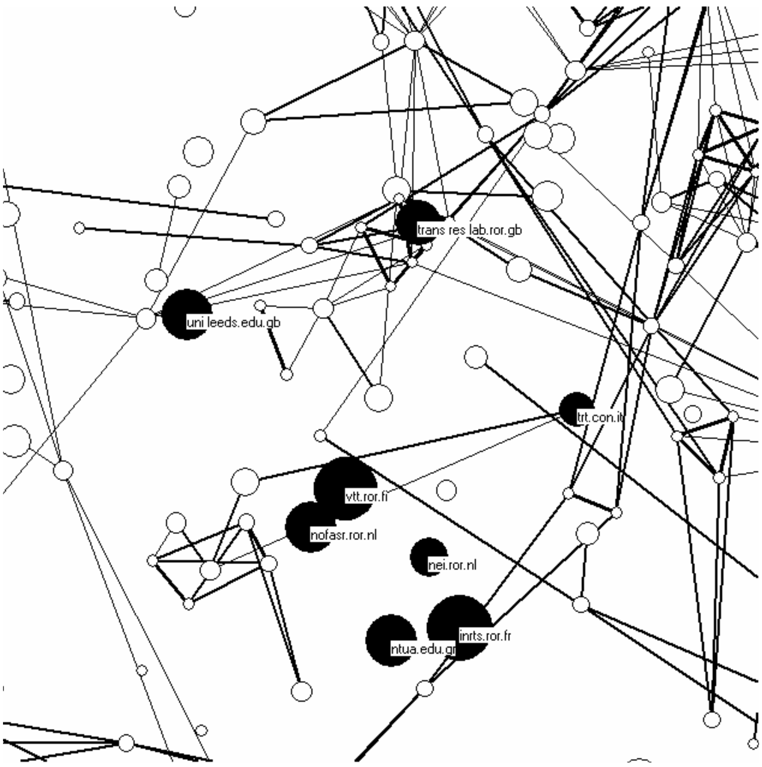


Figure 8: The key research organisations in the European Transport Research Programmes (in black).

6. Conclusions

The 4th FP involved more than 10.000 RTD-projects where several partners took part in each of them. To gain insight into the typical co-operational behaviour within 4th FP and therefore into a part of the European research area just hierarchical and one-dimensional structuring of the respective data is not sufficient. The complexity of this research network is multidimensional and therefore multidimensional indicators like co-occurrence and Jaccard index are to be used for an adequate characterisation. Unfortunately, the interpretation of multidimensional indicators is extremely difficult, and this is where the main advantage of the methodology and tool used in this article lies. As a reasonable compromise a graphical mapping methodology based on a spring model is presented where the multidimensional problem is reduced to a 2-dimensional knowledge-map with minimum aberrations to the original system.

The analysis as well as the graphical display of networks of partners provides an information base to analyse the structure and to characterise Europe-wide collaboration. Visualisation of networks indicates specific co-operation patterns beyond quantitative one-dimensional analysis and thus is a valuable method for characterisation of co-operational networks.

It could be shown that the tool is able to visualise features of European RTDI which are becoming increasingly important. Both the patterns of networking and collaboration, but also the role and impact of individual research institutions are important pieces of information to inform the ongoing debate on the European Research Area. The usefulness of this method could be illustrated by example patterns of co-operation behaviour with respect to the organisational types of partners involved, the countries of origin and the thematic cluster they form.

Future work on the methodology and the tool will concentrate on improving the possibilities to follow transformation patterns of the collaboration networks. In the current version of the tool, these are difficult to realise due to the clustering algorithm that is applied. This is going to be the next research challenge in methodological terms, which would make the tool even more versatile for evaluation purposes.

The evaluation results of the Fourth Framework and the Transport Research Programmes give evidence of the extent to which the objectives of EU FPs could be met. The stimulation of co-operation between partners from different countries and organisational types is one of the objectives pursued by the EU (co-operation principle), the bridging between technological fields and scientific disciplines is another one (principle of horizontality) (Grande 1996). The analysis has shown that educational and industrial partners tend to co-operate with partners of their own kind rather than taking part in cross-organisational networks, especially when looking at the overall Framework Programme. However, selected research segments such as aeronautics can be identified, where a core network of industrial partners is well connected to collaborators from the educational sector. Moreover, the existing high density of linkages within the aeronautics sector implies that research funding in this area can hardly be justified by a need to improve EU-wide co-operation, but only by the industrial policy concerns in this strategic and high-technology industry.[13] Overall, the intended networking effect of FP4 could not be fully met, but the even distribution of non-university research organisations across all fields of research indicates that they are well positioned to fulfil a bridging function in the future.

In the Transport Research Programme the different organisational types are better distributed, though with differences between individual segments of transport research, but it would be necessary to carry out a deeper analysis of individual networks to confirm this observation. However, more attention should possibly be dedicated in future programme and proposal evaluations to this specific function of non- university research organisations.

At Framework Programme level, a quite even distribution of countries could be observed, implying that at this level the principle of co-operation is met reasonably well. However, a more fine-grained analysis is needed to draw deeper conclusions. For the Transport Research Programme it could be shown that some countries show clear preferences for certain segments of transport research; up to the point that they dominate these segments. This means that the principle of co-operation between countries is not fully respected.

The analysis of collaboration patterns with our methodology at the level of the Transport Research Programme lead to some very interesting findings. It was possible to identify the main thematic clusters and show that the clusters of dense collaboration are identical to the main thematic areas of the programme. Apparently,

[13] With the beginning of the Fifth Framework Programme, the strategic interest of the European Commission in the aeronautics sector has further grown, as expressed in the increase of funding from 230MEuro to about 700MEuro.

the programme has indeed led to the creation of networks around these themes, even if there persistence should to be checked once data on the transport actions of the Fifth Framework Programme becomes available. This observation points to two further research questions to be addressed. First of all, it would be interesting to look for similar thematic clusters in other research programmes within FP4. Secondly, also at the aggregate level of FP4 the same question could be raised, especially with respect to research of a cross-cutting nature.

Finally, within the Transport Research Programme a few “centres of excellence” could be identified. These few institutions are active in many segments of transport research and are therefore very well positioned to become the future key nodes of a future European research area in the transport field.

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