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Some results on the graph-theoretical identification of micro-clusters in the Belgian National Innovation System

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Introduction

In this paper we will present some results of the graph-theoretical analysis of the Belgian network of research co-operation and research agreements as it transpires through the projects falling under the general heading of the R&D Framework programmes of the EU, the projects of the EUREKA initiative, the R&D projects financed by the national authorities at the regional and federal level, and finally the private agreements and other forms of co-operation contained in the MERIT/CATI database. Particular attention will be devoted to the clustering issue : how can we define micro-clusters ⁽²⁾ in a graph-theoretical context, which micro-clusters of actors emerge, and what are their main characteristics. We also briefly address the important question how these micro-clusters relate to clusters identified at higher levels of aggregation and in other types of approaches. A more thorough analysis of this last issue is left for later stages of our research.

The reasons for embarking on a study of joint R&D projects as an approach to the national innovation system are twofold. The first reason is of a purely practical nature. Data on joint R&D projects and agreements are relatively easily available, and they can be quantified in a straightforward way in a network context. The second reason is a fundamental one. Joint research projects often give access to funds, equipment and new potential markets. But most of all, they give nearly always access to information. They can be seen as one of the most powerful ways to disseminate knowledge and know-how within a NIS, and indeed might be considered as knowledge vehicle. Often, especially when the set of partners is mixed, and contains universities and research labs as well as private companies, projects will be carried out in a legal framework where project-results are differentiated according to whether they take a directly marketable form or the form of basic knowledge or new methodologies. The former become the intellectual property of the participating firm(s), the latter become part of the knowledge basis of the universities and/or research lab, but also very often become freely available, along with the rest of the knowledge background, for the private partner(s). In other words, joint R&D projects in such a case allow participating firms to tap in on a knowledge stock which was until then unavailable. An example of such a legal setting is IMEC's 'IPR R1-R2' contract model (IMEC, a Belgian IT research laboratory, is - as we shall show - very central in the network).

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² We define micro-clusters in this context as subgraphs of relatively high density in the graph of joint R&D projects and agreements between individual actors (firms, research laboratories, universities).

But network analysis applied to technological systems is still - despite a burgeoning literature - in a poor, underdeveloped state. A word of caution is therefore appropriate at this stage. It should be clear at the outset that the ambition of the present paper is limited. We give answers to 'who co-operates with whom?', and look at a number of characteristics of this co-operation, but we do not deal with the direct results of joint R&D projects. We do not try to discriminate between successful and unsuccessful projects, and assume for the time being that the Law of Large Numbers somehow applies : we neglect possible biases across industrial sectors, technological disciplines and programme-types as to the proportion of joint projects that have yielded the expected results with respect to innovation.

In section 1 we characterise in general terms the graph which is analysed and describe in some detail the data which are used. In section 2 we present a summary of a number of (descriptive) results obtained so far. Section 3 addresses the clustering issue. We conclude in section 4 by anticipating on further analytical steps, and on the research questions which we should be able to answer in the future stages of the study.

1. The model and the data

The observations are defined on the level of microeconomic agents : companies, research institutions, universities and government institutions, i.e. the nodal points of the graph. The network- (or 'co-occurrence-', or line-) criterion is primarily the fact that two actors are partners in the same joint research project or agreement. We consider also, secondarily, personal linkages : two actors who are partners in at least one joint research project may also be connected through one or more 'personal' lines if a same person sits on the board of directors or managing board of the two partners. It is obvious that both types of lines carry a different meaning, but one might probably say that R&D lines are stronger when they are backed by a personal line.

The set of personal linkages can help to reveal two major aspects in the description of the NIS. Personal linkages between companies lend an extra dimension to the S&T relationship, if they coincide with such a relation. Personal bonds between different companies ('interlocking directorates') not seldomly reflect a financial link or at least reveal a certain influence that, if it coincides with a technological link, may facilitate the transfer of knowledge or information. Through the analysis of 'co-occurrence' on the level of research projects *and* personal linkages we can therefore distinguish between relatively 'weak' and relatively 'strong' technological lines in the NIS network. Moreover the analysis of personal links gives a deeper understanding of the links between the government in a broad sense (semi-governmental institutions included) and the other participants of the NIS network.

It should be stressed that in order to avoid inconvenient informational redundancy and needless complexity of the analysis, 'interlocking directorates' that do not coincide with some kind of S&T relationship will not be considered for analysis.

The obtained graph can be specified as being :

- **Valued** : individual lines may be weighted.
- **A Multigraph** : two entities can be linked by several lines with different weights.

Apart from the aspect of being backed or not by a personal line, the connection between two actors can therefore also be evaluated according to the number of project lines which run between them. Each project line in its turn can be weighed by the size of the project :

proportional to the money value of the research contract, if available, and inversely proportional to the number of partners in the project.

The graph will contain **directed** as well as **undirected** lines. More specifically, a line will be directed if it relates to the link between the main contractor of a research project and one of the other partners. It will be undirected if it corresponds to a link between the other partners, and in those cases where no main contractor can be identified.

The graph consisting of nodes and lines, together with their corresponding information is defined as a *network*.

We go now into some more detail with respect to the different types of actors, the different types of projects and agreements (primary lines), and the variables which are attached to the different nodes and lines of the graph.

We distinguish between 4 different projects and agreements (*lines*) :

1. R&D projects in one of a selected list of EU R&D Framework programmes ;
2. EUREKA projects ;
3. Nationally subsidised R&D projects ;
4. Non-subsidised forms of R&D co-operation such as joint development agreements, joint ventures, licensing and cross-licensing, technology sharing, and explicit research contracts without external funding or other forms of support.

So as not to overburden the graph and avoid crossing computational thresholds, we discarded the project-lines between the foreign partners in the project or agreement. In other words, each foreign actor in a project or agreement with at least one Belgian private partner is part of the pointset considered (with a small exception relating to universities and institutes of higher education - see below), but the lineset only contains the links of these foreign actors with their Belgian partners.

The source for the first and the second type of project-lines is the CORDIS database distributed by EUROSTAT, and the EUREKA-database respectively. The source for the third type of project-lines are the annual reports of the subsidising agencies of the Belgian regional authorities responsible for the implementation of S&T policy (IWT for the Flemish Region and the respective regional Ministries responsible for R&D for the Walloon and Brussels Regions). The source for the fourth type of lines is the 'Belgian' part of the MERIT/CATI databank compiled at the University of Maastricht.

All projects and agreements which have at least one private Belgian company as one of its partners and started or completed its activities after 1-1-1990 are considered.

MERIT/CATI and CORDIS, two important sources, start in 1986. It seemed advisable however to start the analysis later than that : the year 1990 coincides with the year in which, as one of the results of the radical constitutional reform of 1989, the regionalisation of the Belgian S&T policy took place.

The source for data for the personal lines in the graph is the databank of the 'Balanscentrale' of the National Bank of Belgium.

The fact that we focus our analysis on those contracts that contain at least one national *company* means that we discard the (numerous) projects where the national partners are exclusively universities or institutions of higher education. This limitation is especially relevant for co-operation in the framework of the (pre-competitive) EU-programmes falling under DG-XIII.

We distinguish between 4 different types of actors (points) :

1. Companies : the 200 largest companies in Belgium, ranked according to value added, supplemented with all (*national* and *non-national*) companies participating in a technological research co-operation project or agreement considered in our analysis, whether it is funded by the national government or the EU or not-funded.
The first part of the selection ensures that we get a representative picture of the segment of the national economy which is involved in joint R&D projects or technological co-operation agreements. The latter addition to the core set guarantees that high-tech companies with a size below the implied threshold value are considered in our analysis as well and that the international context of the national innovation system is covered.
2. Research institutes and laboratories : the national and non-national research institutes and universities that participate in at least one technological research project or agreement in which at least one national company is involved.
3. Universities and other institutes of higher education. Individual non-Belgian universities and institutes of higher education are - for simplicity purposes - aggregated into one actor for each foreign country.
4. Advisory committees with direct or indirect relevance to the national science and technology policy and national and international subsidising organisations in the field of science and technology.

The actors in the point-set of the graph are identified by a 8-character acronym. The first character of the acronym is a country code (see appendix A1). The lines of the graph (in the line-set) are identified by the 'head-tail' sequence of the corresponding acronyms.

In addition to the basic point- and line data the values of a number of variables are attached to the points and lines.

With respect to the points : qualitative and quantitative data in relation to the different points (the type of point, a label (the full name); company data of the 'Dun and Bradstreet' type ; company data from the national R&D surveys carried out for the OECD, company data from the CIS survey, etc. (the last two databases are at present not yet integrated in the data-set)).

With respect to the lines :

if it is a project-line or another agreement of co-operation :

- * different variables relating to the type of programme or agreement
- * start and duration of the contract,
- * amount of the grant, if available,
- * start and duration of the contract ;

if it is a personal line :

- * name of the person,
- * his or her function, etc.

Complete details on the variables contained in the point- and line-files are in appendix A2.

A special problem arose because of the timespan considered. Some companies which were partner in a project which started in a particular year disappeared afterwards, or merged with or were taken over by other companies. In the former case the node was simply deleted from the graph. In the latter case the lines of the company were redirected to the newly formed company or to the absorbing company, respectively.

2. Description of the complete graph

2.1. General features

The complete graph at present contains 3885 nodes and 16288 lines, including the IWT nodes and lines, and 3753 nodes and 14918 lines excluding ⁽³⁾. We discarded the IWT project-lines (i.e. the 'Flemish' lines relating to the R&D projects subsidised by the Flemish regional government) in the present stage of the analysis for reasons of symmetry since at this moment the necessary information from the Walloon and Brussels Ministries responsible for R&D could not yet be incorporated in the graph. For the same reason we did not yet incorporate already available information on nodes and lines relating to governmental and semi-governmental agencies.

Of these lines 3078 were directed (i.e., lines which connect a main contractor with a partner). 11840 were undirected.

These figures actually give an inflated picture of the density ⁽⁴⁾ of the graph, since a relatively large number of nodes are connected through multiple lines. After having combined all multiple lines between two points into one (aggregated) line, 10634 single lines remained, which means that the density of the (combined) graph is equal to .0015.

Of the 3885 actors, 776 were Belgian, 626 of which were private companies (private research institutes and consulting firms not included). Tables A3 and A4 in appendix give the details of the composition of the point-set per nationality, organisation type and project/agreement type. In tables A5 and A6 the nodes of the private Belgian companies are classified by size, region and NACE ⁽⁵⁾ sector.

The representativeness of the firms included in the pointset of the graph can be judged from the share of the Top200 companies present in the graph related to the total of the Top200. Table A7 in the appendix contains these proportions, per sector, in terms of value added.

Although only 84 Top 200 companies belong to the graph they account for 65.78 % of the generated added value in that set. Furthermore all high-tech Top 200 companies, recognised as such in the Top-30000 Trends directory used for this purpose, are represented.

The table confirms broadly preconceived ideas on the innovativeness of different sectors and technology disciplines. IT and Telecommunication, Metallurgy, Chemical Industry and Pharmaceuticals, and Transport Equipment all score highly. The traditional metal-using firms in the Top200 on the contrary are apparently not active in joint R&D projects. The zero share for the sector of informatics services (NACE 72) comes as a surprise, but can be explained by the fact that the firms concerned in the Top200 are in the consultancy business, and that the very many software producing firms that are present in the graph all have small size, and therefore are not present in the Top200.

³ The software used is GRADAP v. 2.10, a social network analysis programme developed at the University of Groningen (C.J.A. Sprenger and F.N. Stokman (1989)).

⁴ The density of a graph is defined as the actual number of lines in proportion to the number which is maximally possible ($n(n-1)/2$).

⁵ The sector classification used is the so-called NACE-BEL one, which is the Belgian version of NACE Rev.1.

Of the 16288 lines in the uncombined graph
 13151 were 'CORDIS' lines, covering 972 projects,
 1156 were EUREKA lines, covering 117 projects,
 104 were MERIT/CATI lines, covering 75 agreements,
 1370 were IWT lines, covering 287 projects, and
 507 were personal lines.

More details on the different sorts of lines are in appendix (tables A8 to A11).

The distribution of the lines over the points is very skew : a small group of actors takes care of a large number of lines and there is therefore a large group of actors with low involvement (cfr. Steurs & Kesteloot, 1991). The 20 Belgian actors (9 of which are private companies) with the highest degree centrality are involved in 44.9 % of all lines ; the 30 actors (15 of which are companies) with the highest degree centrality are involved in 50.7 % of all the lines. There is obviously - as a result of the very nature of the R&D Framework programmes of the EC - a large and important participation of research institutes and universities : the 20 Belgian firms with the highest degree centrality account for only 20.8 % of all lines.

2.2. Component analysis

We define a component C of a graph as a maximally connected subgraph, i.e. every node of C is connected with at least one other node of C , and there exist no node outside C which is connected to at least one node of C .

In tables 1 and 2 we report the results for different subgraphs of the complete graph.

Table 1 : Largest components of the graph (IWT-lines not included), globally and per information source

	# of com- ponents	# of nodes	# of lines	density
Complete graph	45	3753	14918	
largest component		3626	10528	
2nd component		8	18	
3rd, 4 th component		7	11, resp. 6	
Complete graph, multiplicity 2	25	822	1870	
largest component		766	1835	
2nd component		6	8	
Complete graph, multiplicity 3	18	371	799	
largest component		337	782	
Complete graph, multiplicity 4	10	222	484	
largest component		200	470	
Complete graph (combined)	45	3753	10623	.0015
CORDIS graph	16	3247	13151	
largest component		3199	9197	
2nd and 3rd component		8, resp. 7	18, resp. 11	
CORDIS graph (combined)		3247	9248	.0018
EUREKA graph	42	600	1156	
largest component		446	1003	
2nd component		22	21	
EUREKA graph (combined)		600	1131	.0006
MERIT/CATI graph	29	104	104	.0194
largest component		20	23	
2nd component		9	9	

2.3. Centrality indicators

Freeman (1975) distinguishes between three types of point-centrality indicators based on degree, closeness and ‘betweenness’, respectively.

Degree-centrality is the most straightforward of the three. A node is considered to be more central than others if more nodes are adjacent to it. This leads to the following expression for the degree-centrality of a node :

$$C_i^D = \sum_{\substack{j=1 \\ j \neq i}}^n a(i, j)$$

where $a(i, j)$ is 0 or 1 ; 0 if i and j are not connected, 1 if they are.

Closeness is a related concept, but looks at distances $d(i, j)$, i.e. the length of the shortest path from i to j (‘geodesics’).

‘Betweenness’ or ‘rush’ is an indicator for the strategic position of a node in a graph and is based on the number of ‘geodesics’ between two nodes j and k that pass through i .

Memory constraints with the software used most of the time does not permit us - given the size of the graph - at the present stage of the analysis to compute ‘closeness’ and ‘betweenness’ centrality indicators.

In the following table we present the 30 actors with the highest degree-centrality for the complete graph, the complete graph at multiplicity level 6, and the subgraphs of CORDIS, EUREKA and MERIT-CATI (the full names of the actors, and the corresponding acronyms and the industrial sectors to which they belong are in appendix A1 ; appendix A1bis contains the country codes).

Table 2 : Degree-centrality for the complete graph and some subgraphs

	Compl. Graph		Compl. Graph Mult6		CORDIS		EUREKA		Cati
BUG	437	BIMEC	37	BUG	391	BPHILIPS	78	BSOLVAY	19
BIMEC	335	BALCATEL	28	BIMEC	317	BBARCO	77	BPGS	8
BALCATEL	306	UEDU	16	BALCATEL	275	BVISION	76	BSOCGEN	6
BUCL	299	GEDU	15	BUCL	268	BKUL	59	NDSM	5
BKUL	282	BUG	12	BWTCM	236	BUM	56	BUCB	5
BWTCM	259	BKUL	11	BKUL	229	BRADENG	52	BPETROFI	5
BBARCO	199	BUCL	11	BVUB	191	BUG	50	FELF	4
BVITO	197	BBELGACO	11	BUNIVL	187	BUCL	43	UBP	4
BVUB	195	BMIETEC	11	BVITO	161	BALCATEL	41	IENIMONT	4
BUNIVL	193	SEDU	9	BBELGACO	158	BBELGACO	34	GBENZ	3
BBELGACO	182	BVITO	7	BBARCO	140	BVITO	32	UROLLS	3
BSOLVAY	159	NEDU	7	UEDU	133	BSOLVAY	26	FSNECMA	3
UEDU	135	BVUB	7	BMIETEC	129	BELT	22	ULAPORTE	3
GEDU	132	FCNRS	7	GEDU	128	FMATRA	19	BPR	3
BMIETEC	130	FEDU	6	BSCK	119	BCHAMP	16	X7INBANK	3
BSCK	120	HEDU	6	BSOLVAY	109	BBOSAL	16	X7NIPKAY	3
BCRM	114	IEDU	6	BCRM	91	BINFTEC	15	BIMEC	2
BUM	105	FTHOMSON	4	SEDU	91	BLMSINT	14	BINNOGEN	2
BPHILIPS	103	BUNIVL	4	BE2S	85	GEDU	13	GSIEMENS	2
SEDU	94	BSCK	4	FEDU	82	BMETALOG	13	BELECTRA	2
FEDU	87	BUNIGEM	4	BKARMAN	79	BMEDOC	13	BAMYLUM	2
BE2S	85	PEDU	4	BWTCB	78	BOPL	13	BBEKAERT	2
BLMSINT	82	BTIENSE	4	BLMSINT	73	BIMEC	12	BELENCO	2
BWTCB	82	GSIEMENS	3	BUNIGEM	72	BSIDMAR	12	UBRITST	2
BKARMAN	79	NPHILIPS	3	IEDU	71	VEDU	11	NBROCADE	2
BVISION	76	ITHOMSON	3	HEDU	66	CEDU	10	GVARIA	2
BUNIGEM	72	UBT	3	BLABOREL	64	BINNOGEN	10	UBEAMECH	2
IEDU	71	STEFON	3	BHYGEPI	63	SEDU	9	UDELT	2
HEDU	69	DEDU	3	BULB	62	BACSET	9	UOXFINSI	2
BULB	69	FALCATEL	3	BRIC	61	BRHONE	9	KFOAMEX	2
NEDU	65	YEDU	3	NEDU	61	BULB	8	KTANDEM	2

Note : the first character of the acronym indicates the country-origin. Actors like UEDU, GEDU etc. relate to ‘aggregated’ foreign universities and institutions of higher education.

2.4. Coincidence of different types of lines

In the complete graph 13151 of the 15781 project-lines relate to RTD Framework programmes financed by the EU. These projects are labelled pre-competitive as they are often more close to basic research than to development, production or marketing of new products or to the introduction of new processes. This is, as we saw, reflected in the large participation of research institutes and higher education institutions in the EU Framework programmes (58.7% in the 2nd Framework, 61.8% in the 3rd Framework (see The European Report on Science and Technology Indicators, 1994, p.225)). The high number of CORDIS lines is not only explained by the considerable number of RTD projects in our graph (972) but also by the relatively high number of participants in some of these projects. With respect to innovation the 'near-market' EUREKA projects and the private agreements on innovation and R&D contained in the MERIT-CATI database provide in this respect more relevant information, albeit that they only account for 1156, respectively 104, of the 15781 project-lines. Notwithstanding this, we should probably not be over-worried by the present asymmetry in the data with respect to the types of R&D co-operation. Especially with respect to IT projects and agreements, which, as we shall see, are very prominent in the graph, it was shown by Hagedoorn and Schakenraad (1993) that 'private' and publicly subsidised networks show high congruence.

With regard to the pre-competitive RTD-lines it is - particularly because of the relatively recent character of the phenomenon of joint European R&D projects (⁶) - interesting to analyse the extent to which they coincide in the global graph with EUREKA- and CATI-lines and how often they precede these lines in time. The 'linear' causal model of innovation would lead us to expect that near-market co-operation between firms would follow an earlier phase where this co-operation follows the more loose and informal channels of pre-competitive research, and not the other way round. From the evaluation of EUREKA, quoted in the *European Report on Science and Technology Indicators 1994*, we learn however that "The original policy conception of a 'pipeline model', whereby pre-competitive EC projects are followed by nearer-market EUREKA projects has not materialised to date. Rather there has emerged a complex picture in which involvement in EC programmes could either precede or follow a EUREKA project". In our graph only 36 Belgian firms (on a total of 637) appear both in at least one RTD project and at least one EUREKA project and there is a coincidence of 256 EUREKA and CORDIS lines (see Table A10). The RTD projects in the area of Information Technology and Telecommunications (ESPRIT, ACTS, RACE, TELEMATICS) by far coincide the most with EUREKA (IT or COMM) with 234 lines, where other technological disciplines account for only 22 coinciding lines.

This is not all too surprising, given the importance of Information Technology and Telecommunications both in the EU Framework programmes and EUREKA. Nevertheless there seems to be a disproportional coincidence between RTD and EUREKA lines in these disciplines. Of the 256 CORDIS lines 149 (58.2%) precede EUREKA lines (⁷). Moreover involvement in some specific RTD programmes seems even more often to precede involvement in EUREKA projects (e.g. 74 of 88 ESPRIT lines precede EUREKA lines). So in our graph

⁶ A sequence analysis loses meaning as the period in which joint projects have been set up grows longer. The reason is a 'demographic' one: R&D initiatives set up between two partners which are in a mature stage will be more often coexistent with new initiatives between the same partners as time proceeds.

⁷ The observed difference between 149 lines where RTD Framework projects precede EUREKA projects and 107 where the opposite is true or RTD and EUREKA projects started in the same year, is statistically significant (compared to a 50-50 proportion) at a level of 99 %.

the ‘pipeline model’ to a certain extent seems to be materialised, especially for those projects in the area of IT and Telecommunications.

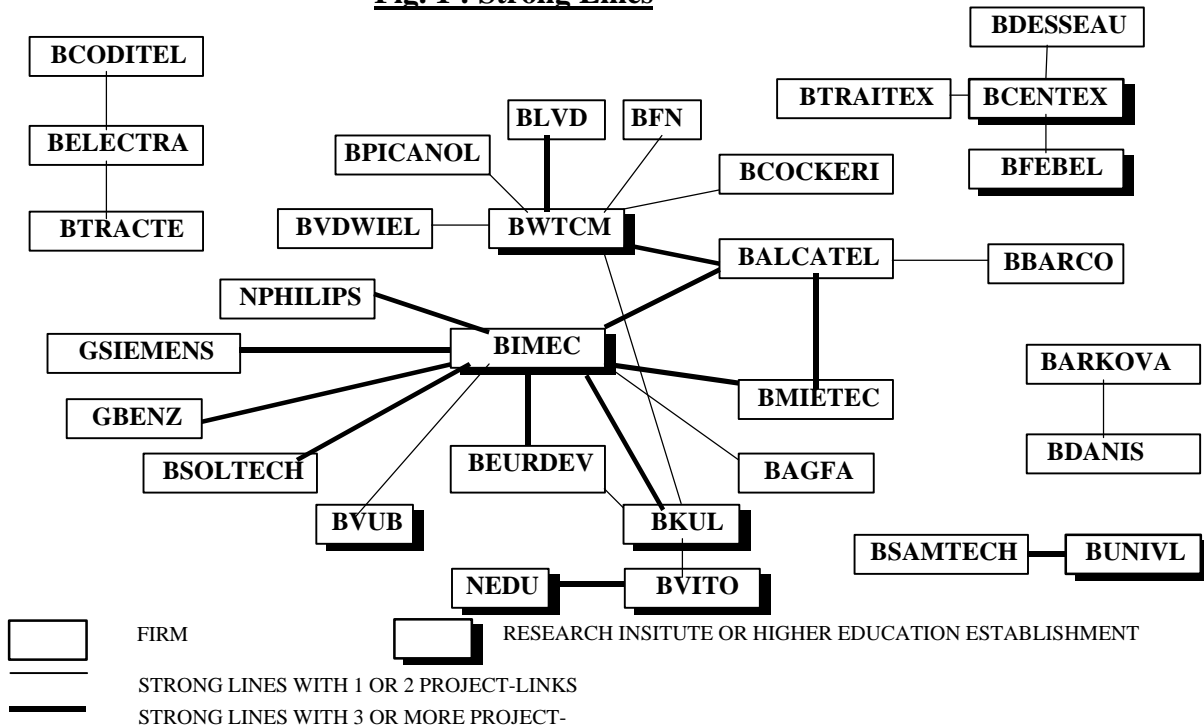
There is very little coincidence of CORDIS with CATI. The Belgian biotechnology company Plant Genetic Systems (a spin-off of the University of Ghent) was involved in 2 RTD projects (started in 1991 and 1992) with the Dutch company Mogen. In 1994 both companies signed an agreement concerning a patent exchange in pesticide technology. In the period 1987-1988 the Belgian research institute IMEC concluded an agreement with Dutch Philips as a follow-up of an ESPRIT1 project(1983-1988). IMEC and Philips, along with Mentor Graphics own the European Development Centre (EDC) which was to commercialise the results of the ESPRIT project.

No EUREKA lines coincide with CATI lines.

Finally we analysed the coincidence of project-lines with personal lines (‘interlocking directorates’) (see figure 1). There is only a moderate number of ‘strong lines’: a set of 31 actors, 22 of which are private firms, are interlinked through 173 project-lines which are backed by at least one personal line. In total the line-set comprises 225 lines (173 project-lines and 52 personal lines). Most of the actors in the ‘strong line’ set are actors who are together involved in relatively many joint projects.

Most of the project-lines backed by a personal link are CORDIS-lines (170 out of 173) and relate to IT or Telecommunications. The Belgian Interuniversity Microelectronics Centre IMEC has a central position in the graph (2nd highest degree centrality in the complete graph, highest degree centrality in the graph at multiplicity level 6) and in the IT and Telecommunications subgraphs. IMEC has personal links with several of its most active projectpartners among which are 2 foreign MNEs (Philips, involved in 46 projects with IMEC and Siemens involved in 42 projects with IMEC). The thick lines in figure 1 represent the strong lines with 3 or more project-links.

Fig. 1 : Strong Lines



The results of the strong line analysis does not support the idea that personal influence becomes more important as R&D co-operation moves closer to direct market applicability. On the other hand we find it difficult to believe that personal influence would be more often instrumental in obtaining 'easy' government subsidies for more or less noncommittal research, than in making strategic choices with respect to the development of new products and the entry on new markets. The issue merits further attention.

2.5. Intra- and intersectoral R&D co-operation

Innovation practice increasingly transcends not only borders of firms but also borders of industrial sectors, technological disciplines and nations. This evolution raises some questions on the relevance of analysis on the level of traditionally defined sectors and nations. The study of cross-sectoral R&D co-operation between firms may help to clarify this issue.

In Table 3 we present a matrix with the intra- and intersectoral project-lines of Belgian companies. Project-lines between Belgian firms account for only 2.3 % of all project-lines in the graph and 216 Belgian companies (out of 505) do not co-operate with another Belgian company. These low numbers can be explained by the very nature of the databases used, i.e. by the fact that the data mainly relate to international pre-competitive projects financed by the EU or to international agreements (CATI). For the 2nd and the 3rd Framework programmes links between organisations within Belgium account for 5 % respectively 7.1 % of all collaborative links, which is on average for the EU for the 2nd Framework and even above EU average for the 3rd Framework programme (The European Report on Science and Technology Indicators 1994, Table IV.9 & IV.10 in the Statistical Annex).

Although table 3 does not allow us to draw any far-reaching conclusions on the international dimension of the Belgian Innovation System it is interesting to see some differences between the overall distribution of lines and the distribution of lines between Belgian companies. CRAFT, which is a BRITE/EURAM initiative aimed at co-operation between SMEs, yields 125 of all 332 project-lines between Belgian companies, and 23 % of all the CRAFT lines in the graph link Belgian Companies, whereas ESPRIT, with 3000 lines in the graph, has only 43 lines (1.4 %) linking Belgian companies.

Table 3 clearly shows that, except for the textile industry (NACE 17), most lines are between 2 companies belonging to a different sector.

This might reflect the user-supplier characteristic often attributed to technology transfer and R&D co-operation. The relatively large number of intersectoral links, especially those in sectors related to IT and Telecommunications, certainly indicates that innovative activity transcends sectoral borders.

The table can in our view be used to test the significance of innovation megaclusters detected on the basis of input-output tables of intersectoral flows of capital goods and technology. The reason is that IO cluster-lines which coincide with R&D co-operation ('project') lines carry a different meaning than the ones that do not. In other words, if it is the intention to analyse innovation clusters by means of client-supplier relations, R&D project-lines can be used as a filter to eliminate redundant lines, or at least to discriminate between 'R&D supported' and simple client-supplier lines.

Table 3 : Intra- and intersectoral project-lines (Belgian companies)

NACE	1	15	17	24	25	26	27	28	29	31	32	33	35	45	515	516	64	70	72	73	74	B	F	B/F	B/ NC	F/NC	INTRA
1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	17	0,06	0,2	3,4	0,00
15		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	5	37	0,14	0,4	2,6	0,00
17			19	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	23	127	0,18	1,0	5,5	0,83
24				1	0	0	0	0	0	0	1	5	0	0	0	1	0	0	2	1	0	12	220	0,05	0,4	7,9	0,08
25					0	0	0	2	0	1	0	0	0	0	0	0	0	0	1	0	1	5	23	0,22	0,6	2,9	0,00
26						2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	30	0,07	0,3	5,0	1,00
27							3	4	1	0	4	0	0	0	0	0	0	0	1	0	4	17	110	0,15	1,3	8,5	0,18
28								7	5	1	1	0	0	0	0	0	0	0	0	0	10	30	62	0,48	1,9	3,9	0,23
29									2	1	2	0	0	0	0	0	0	1	2	0	5	20	68	0,29	1,2	4,0	0,10
31										0	2	0	0	0	0	0	1	0	0	0	0	6	52	0,12	0,4	3,5	0,00
32											11	2	0	0	0	9	9	0	4	0	6	52	909	0,06	4,0	69,9	0,21
33												1	0	0	0	0	0	0	1	0	1	10	88	0,11	1,7	14,7	0,10
35													0	0	0	0	0	0	0	0	0	0	74	0,00	0,0	14,8	0,00
45														0	0	0	0	0	0	0	1	1	3	0,33	0,2	0,6	0,00
515															0	0	0	0	0	0	0	0	15	0,00	0,0	3,0	0,00
516																3	1	0	3	0	2	19	104	0,18	1,3	6,9	0,16
64																	1	0	0	0	2	14	211	0,07	3,5	52,8	0,07
70																		0	1	0	0	2	2	1,00	0,5	0,5	0,00
72																			5	2	3	25	370	0,07	0,6	8,8	0,20
73																				0	0	6	36	0,17	1,2	7,2	0,00
74																					2	39	279	0,14	0,8	6,2	0,05
Total																						169 *	2843	0,06	0,6	9,4	0,34
Average																						8	135	0,19	1,1	11,6	0,15

B : Total number of project-lines between Belgian companies (with known NACE classification)
 F : Total number of project-lines between Belgian companies (with known NACE classification) and foreign actors
 NC : Number of companies classified in this NACE sector
 INTRA : Percentage of intrasectoral lines

* This total is not equal to the sum of the column but is the total number of project-lines between Belgian companies with known NACE classification, i.e. the sum of the cells in the upper triangle displayed.

3. Graph-theoretical clustering

3.1. Concepts and methodologies of cluster approaches

In studies dealing with innovation clusters and cluster-based policies a wide variety of cluster definitions and concepts is used. A clear distinction must be made between cluster approaches using traditional cluster analysis techniques to detect objects that are similar or proximate as to some relevant characteristic(s) (i.e. cluster-analysis in the traditional, statistical, sense), and those approaches that focus on relationships between actors or groups of actors (firms, sectors, branches) in networks. Another distinction concerns the level of aggregation used in the analysis⁽⁸⁾.

Since 'The Competitive Advantage of Nations' (Porter, 1990) most research has been carried out on the macro- or meso-level of aggregation (e.g. by means of I-O techniques) with the intent to detect and analyse the technological disciplines in which nations are specialised due to favourable factor conditions. However the globalisation of the economy, European economic integration and the fusion of technological disciplines raise questions on the relevance of the analysis based on national borders and traditional sectoral classifications (see Petrella (1989), Imai and Baba (1991), Grupp (1992), Bidault and Fischer (1994), Papanastassiou and Pearce (1994), Elam (1997), Meyer-Krahmer (1997), Caracostas and Soete (1997) ; see also the 'World Investment Report 1995'). As mentioned in section 2.5 the network-analysis of R&D relations between NIS-actors may help to clarify the innovative nature of clusters found at higher levels of aggregation.

The graph-theoretical method for the detection and analysis of micro-clusters, presented in this paper, as already stressed in the introduction, starts from the assumed importance of R&D co-operation between firms and other actors of the Innovation System as one of the main mechanisms weaving the network-tissue of the NIS. This is in accordance with recent literature on innovation and international competitiveness (Ouchi and Kremen Bolton (1988), Imai and Baba (1991), Teece (1992), Schott (1994), Hagedoorn (1995), Duysters (1996), Dunning (1997)).

Dunning uses the term 'alliance capitalism' to describe what he sees as an important new phase of developed economic systems (Dunning, 1997). A main feature of this 'alliance capitalism' is the coexistence of competition, sharpened by globalisation and liberalisation, with an increasing number of network relations of R&D co-operation and strategic alliances between competitors. Carlsson and Jacobsson (1997, p. 271), following Håkansson (1989), give a rationale for this. Technological networks, through the reciprocal flow of information, result in a 'blending of visions' on the future technological evolution of markets. This leads to a reduction in perceived risk and to a better co-ordination of investments between competitors. Innovation and diffusion turn into a collective action.

Explaining the benefits of technological networking is one thing, the 'prisoner's dilemma' aspects of the situation another : competitors may end better off by co-

⁸ 'Clusters' is also a term which sometimes is used in a a-prioristic, non-analytical, context. An example is the cluster-concept used by the Flemish regional government, which considers (and in a number of cases, finances) clusters as formal organisations of firms in a particular industrial sector or active in the same field, formed on a voluntary basis, and taking care of co-ordination and advisory tasks with respect to product and process innovation on behalf of its members (see Debackere and Vermeulen (1997) who place this cluster-concept in a more general perspective).

ordination, but why should they make the first move ? This is where government, resp. European, subsidies for joint R&D come in, enabling the creation of an atmosphere of trust in joint R&D projects of the pre-competitive type, and pushing the competitors over the threshold in near-market R&D projects.

Porter (1990, p. 635) qualifies this point of view : firms will usually try to bring their own proprietary technologies on the market and will only divert a modest part of their R&D facilities to joint projects. Also Geroski (1994) remains reluctant to the idea of horizontal relationships.

3.2. Cliques and micro-clusters of R&D co-operation

In what follows we specialise the rather loosely defined concept of 'cluster' to the graph-theoretical concept of 'clique'. N-Cliques can be defined as subgraphs of which all points are linked with one another through a path with maximal length equal to n in a way that no point outside the subgraph has the same quality.

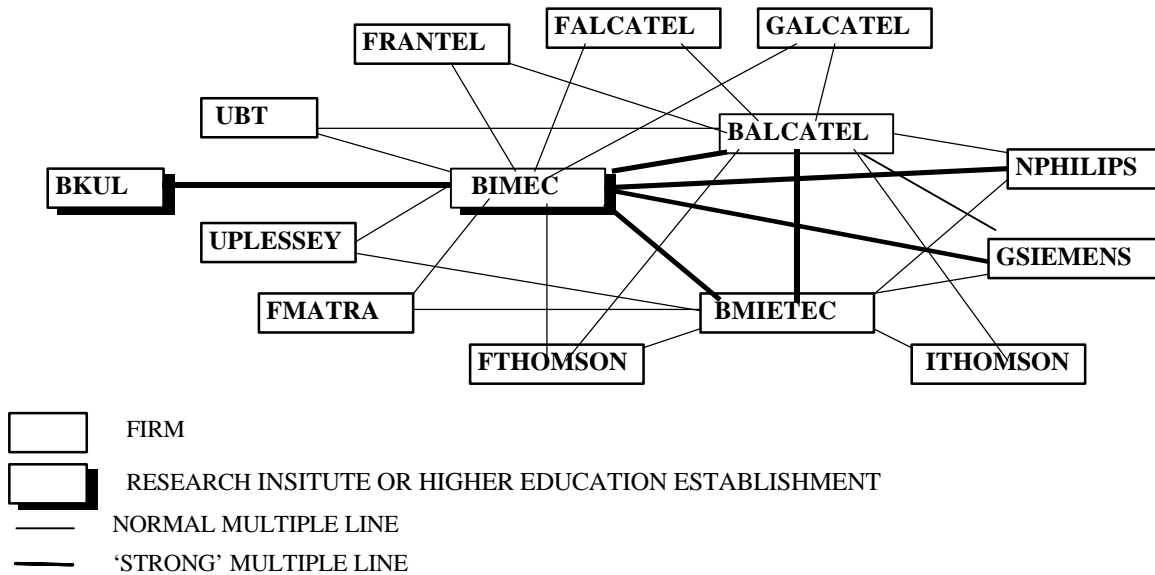
As links between foreign actors, due to constraints in the use of the computer programme, are not considered, 2 foreign actors cannot be in the same clique in the present analysis. This introduces, as will become apparent below, a downward bias in the size of the cliques which are identified.

3.2.1. Cliques in the complete graph

The detection of n-cliques poses some problems for the complete graph due to the size of the graph and programme limitations with respect to central memory. In order to reduce computational complexity the multiplicity of lines was taken into account. For the complete graph 1-cliques could be detected from a multiplicity level of 8 onwards. The subgraph at multiplicity level 8 (containing all actors inter-linked by at least 8 lines) has 4 components. The largest contains 56 actors and 108 multiple lines and the 3 other components each contain 2 actors and 1 multiple line. At the multiplicity level of 12 2 components remain. The largest contains 35 actors and 53 multiple lines. At the multiplicity level 8 there are 20 1-cliques, 3 of which contain 4 actors and 17 contain 3 actors. The 20 cliques without exception are generated by RTD projects related to IT or telecommunications (ESPRIT, ACTS, RACE, ...) and are themselves highly linked to one another.

In figure 2 the interlinkage of the cliques is shown. All actors (except foreign education establishments) appearing in at least one clique are shown with their links in the cliques. The thick lines are 'strong' lines (project-lines backed up by a personal link between the actors). The central triangle IMEC, Alcatel Telecom and Alcatel Mietec consists of these strong lines. The multiple line (46 projects) between IMEC and Dutch Philips and the multiple line (42 projects) between IMEC and German Siemens are also backed up by a personal link.

Fig. 2 : Interlinkage of the cliques in the complete graph (multiplicity ≥ 8)



The dominance of links related to Information Technology and Telecommunications clearly reflects the dominance of these disciplines in the EU Framework programmes. In the 2nd Framework Programme (1987-1991) 42.2 % of the total RTD budget was attributed to IT & Telecommunications (2275 Mecu). In the 3rd Framework Programme (1990-1994) the share decreased to 37.7 % (2491 Mecu). In the 4th Framework Programme (1994-1998) the share further decreased to 27.7 % (3405 Mecu) but remained the largest area of RTD funding (The European Report on Science and Technology Indicators 1994, p.214-216).

Furthermore a large number of projects in the area of Industrial and Materials Technology (BRITE/EURAM) are also related to these disciplines.

For EUREKA the share of IT and Communications in the total value was 69 % for the ongoing projects and 40 % for the finished projects. This high share is primarily explained by the high value per project as the areas 'medical & biotechnology and environment' generate more projects than IT or Communications but have a lower share in total value.

The table in appendix A13 shows that the overall participation of Belgian organisations in RTD programmes is above EU average in the areas of IT, Telecommunications and Materials (cfr. Lichtenberg, 1996) and below EU average in the areas of Energy Technology, Biotechnology and Environmental Technology. Table A14 shows the same pattern of participation for EUREKA where only Communications differs with a participation degree below the European average. On the contrary, the lines that belong to the Belgian part of MERIT-CATI show that most agreements relate to Biotechnology, followed by Chemicals. IT-related agreements only account for 16 % of all agreements and none of these agreements seem to coincide with IT related projects in the pre-competitive phase, except for the joint development agreement (1987-1988) between IMEC and Philips, as a follow-up of an ESPRIT 1 project (⁹).

⁹ This result may possibly be caused by the fact that at this stage we only had access to a small part of the MERIT-CATI database.

In order to detect cliques at lower multiplicity levels and clusters in different technological disciplines we created some specific subgraphs.

3.2.2. Information Technology and Telecommunications

Information Technology is a term given to the discipline that covers different but increasingly related technological areas like electronics, data processing, software and related services, and in some publications it also includes Telecommunications. Imai and Baba add two new categories to the Pavitt taxonomy, namely the new information-intensive services industry and the emergent generic-complex industry (IT).

The last category is characterised by multi-layer cross-border networks with joint R&D as an important feature (Imai and Baba, 1991).

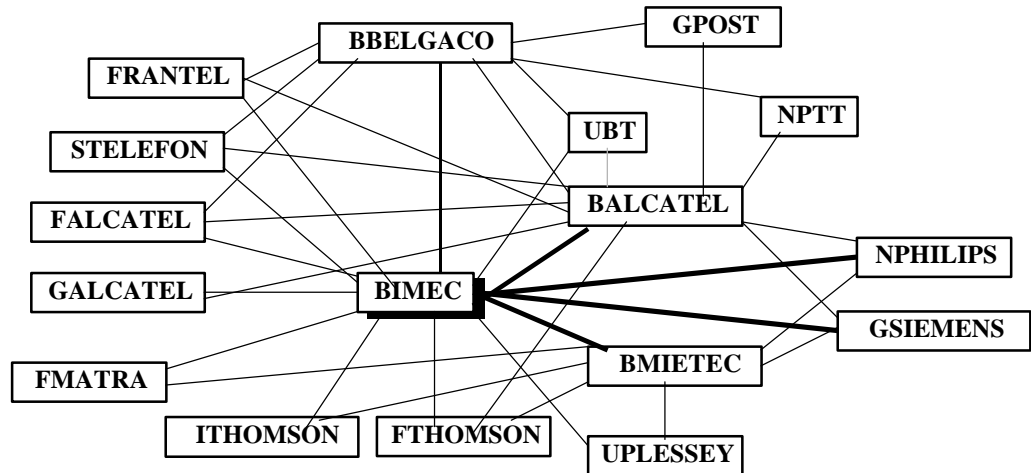
Faced with the importance of IT and Telecommunications for economic growth and the relative weakness of Europe vis-à-vis Japan and the US, the European Union launched cost-sharing programmes of considerable magnitude aimed at fostering R&D co-operation between firms, research institutes and higher education establishments of different EU countries in these fields (ESPRIT, RACE, ACTS). As shown in the previous chapter IT is by far the most important area of EU Framework programmes and also very important in EUREKA. The IT & Comm. subgraph contains therefore a large number of points and lines : 5767 lines (40 % of all project-lines) and 1485 actors (38 % of all nodes). The largest component contains 1453 actors and 4072 single or multiple lines. Table 5 shows the 20 actors with the highest degree centrality in the IT subgraph.

Table 5 : 20 actors with highest degree centrality in the IT subgraph

BIMEC	263
BALCATEL	208
BBELGACO	141
BKUL	123
BMIETEC	120
BBARCO	119
BUCL	111
BWTCM	86
BUG	85
BUNIVL	75
BRIC	61
UEDU	60
BVUB	60
BE2S	58
BSOLVAY	58
BEBU	57
BTELIND	56
BATEA	56
GEDU	55
BCAPGEM	54

At multiplicity level 5 there is a component of 63 actors containing 44 cliques (all with size 3) involving 35 actors of which 4 are Belgian (IMEC, Alcatel Telecom, Alcatel Mietec and Belgacom). At multiplicity level 6 there is a component of 50 actors containing 34 cliques, involving 27 actors. In figure 3 the interlinkage of these cliques is shown (for the sake of clearness the lines of foreign educational actors and research institutes are not reproduced). The thick lines again represent strong lines.

Fig. 3 : Lines between actors in the IT cliques (multiplicity ≥ 6)



The Telecommunications subgraph contains 2340 lines (some lines coincide with project-lines in the IT subgraph) and only 1 component of 598 actors and 1723 single or multiple lines. Table 6 shows the 20 actors with the highest degree centrality for this subgraph.

Table 6: 20 actors with highest degree centrality in the Telecommunications subgraph

BALCATEL	139
BBARCO	135
BBELGACO	99
BVISION	76
BPHILLIPS	76
BIMEC	72
BEBU	57
BATEA	56
BUG	55
BREFER	54
BRIC	54
BTELIND	44
BBBN	35
BELECTRA	33
BCODITEL	33
BINTEGAN	33
GPOST	30
BVUB	28
BUA	28
BIBIEF	24

At multiplicity level 3 there is a component of 61 actors containing 24 cliques (12 with set size 4) and at multiplicity level 5 there are 17 cliques (all with set size 3). In figure 4 the lines between the actors in the different cliques are shown (again for the sake of clearness only the lines between Belgian actors and foreign non-educational actors are reproduced). Both subgraphs to a great extent coincide, with many common links and common strong lines (thick lines).

The main difference is the absence of Alcatel Mietec in the Telecom subgraph (it is not involved in any Telecommunications related project).

Fig. 4 : Interlinkage of the Telecommunications cliques (multiplicity ≥ 5)

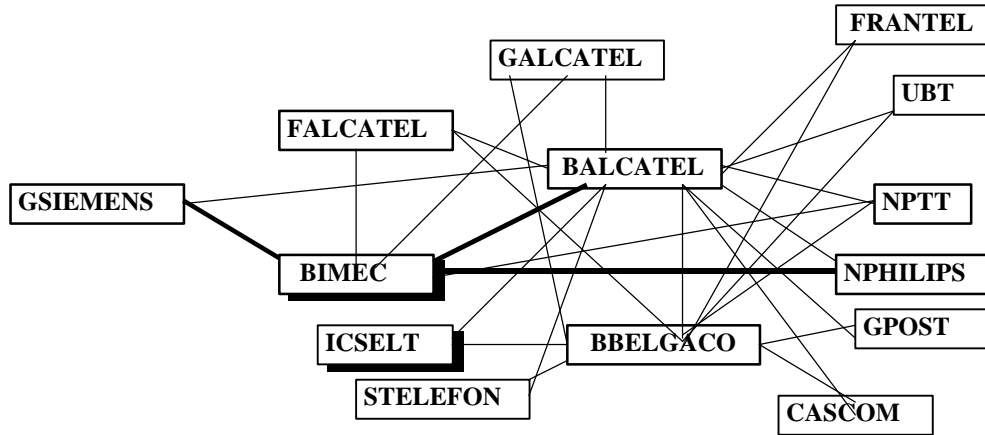


Table 7 shows the time-evolution of some network indicators for a subset of 20 important actors in the field of IT (accounting for 44.8 % of all ESPRIT lines) from ESPRIT 1 (1984-1988) to ESPRIT 3 (1990-1994). In Table 8 the evolution is given for a subset of 20 important actors in the field of Telecommunications for RACE 1 and RACE 2. All measures indicate an increase in density of the network over time (cfr. Duysters, 1996).

In addition to the usual degree centrality measure we also report the so-called Beauchamp centrality which is a centrality measure based on the average distance of a node to the other nodes (¹⁰). This is possible because the subgraph is relatively small and fully connected.

Table 7 : Evolution of the network of 20 important IT actors

7a.

	ESPRIT 1 (1984-1988)	ESPRIT 2 (1987-1992)	ESPRIT 3 (1990-1994)
DENSITY	0.17	0.26	0.28
NUMBER OF CLIQUES of size 3	3	20	6
NUMBER OF CLIQUES of size 4	1	0	12
AVERAGE DEGREE CENTR.	2.3	3.6	5.1
BEAUCHAMP	0.179	0.192	0.579
ADJACENCY (INTEGRATION)	46	72	106

¹⁰ The Beauchamp centrality index is defined as $(n-1)/D_i$ where D_i is defined as the sum of the distances of point i to each other point of the subgraph.

7b.

DEGREE CENTRALITY WITHIN IT 20			
	ESPRIT 1 (1984-1988)	ESPRIT 2 (1987-1992)	ESPRIT 3 (1990-1994)
BIMEC	11	16	17
BALCATEL	8	9	15
UGECCMAR	4	1	3
NPHILIPS	3	3	5
BMIETEC	3	13	16
BEURDEV	3	0	5
FTHOMSON	2	3	5
BBARCO	2	0	4
FRANTEL	2	3	4
FES2	1	3	3
FALCATEL	1	2	3
GTELEFUN	1	2	3
GSIEMENS	1	3	4
UBT	1	2	1
UPLESSEY	1	3	3
ITHOMSON	1	3	3
FMATRA	1	2	4
STEFELFON	0	2	3
SALCATEL	0	0	2
GALCATEL	0	2	3

Table 8: Evolution of the network of 20 important Telecommunications actors

8a.

	RACE 1	RACE 2
DENSITY	0.23	0.27
NUMBER OF CLIQUES of size 3	17	2
NUMBER OF CLIQUES of size 4	0	15
AVERAGE DEGREE CENTR.	4.3	5.2
BEAUCHAMP	0.568	0.605
ADJACENCY (INTEGRATION)	86	104

8b.

DEGREE CENTRALITY WITHIN TELCOM 20		
	RACE 1	RACE 2
BALCATEL	18	19
BBELGACO	18	19
BIMEC	8	17
NPHILIPS	3	3
GSIEMENS	3	3
NPTT	3	3
NATT	3	3
FALCATEL	3	3
CASCOM	3	3
GALCATEL	3	3
UBT	3	3
DJYDSK	2	3
VNOKIA	2	3
MNORTEL	2	3
FRANTEL	2	3
DKTAS	2	3
GPHILIPS	2	3
GPOST	2	3
STEFELFON	2	2
SALCATEL	2	2

The high density and the thick lines in the IT subgraph can be given an interpretation in terms of the shift away from strategic alliances motivated by the desire of better market

access, to technological partnerships in order to cope with rapidly rising investment costs, steeper learning curves and shortening product life cycles. These phenomena are more important in IT and telecommunications, and subgraphs for this technological discipline may therefore be expected to be more dense and to have grown more rapidly than for other technological disciplines (see also Duysters (1996, ch. 7)).

The absence in the subgraph of corporations like IBM, very prominent in a global (world-wide) MERIT-CATI analysis (Duysters), is of course explained by the European bias in the data, but perhaps also by what Porter (1990) sees as one of the main aspects of technological partnering, i.e. ‘second-tier’ competitors trying in a defensive way to catch up with the leaders on the market (see Chesnais (1988) for a dissenting view).

3.2.3. Materials Technology

Another important area of the Framework programmes and EUREKA is that of materials technology accounting for 15.7 % (845 Mecu) of all funding in the 2nd and 16.2 % (1995 Mecu) in the 4th Framework programme (The European Report on Science and Technology Indicators 1994, p.214-216)). As mentioned above many BRITE/EURAM projects are related to IT disciplines (e.g. electronics).

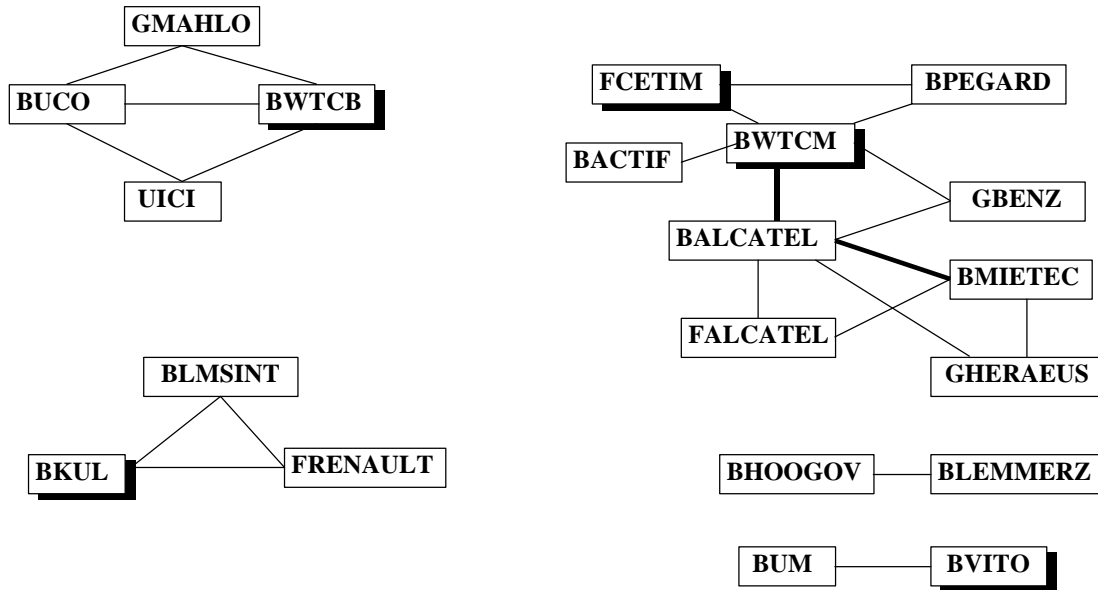
The subgraph with the lines related to Materials Technology contains 2353 lines and 1000 actors. The largest component contains 956 actors and 2119 lines. Table 9 shows the 20 actors with the highest degree centrality in this subgraph.

Table 9 : 20 actors with highest degree centrality in the Materials Technology subgraph

BWTCM	160
BKUL	87
BUG	86
BALCATEL	75
BUM	67
BRADENG	58
BVITO	44
BCENTEX	41
BLMSINT	41
BWTCB	36
BCADCO	35
BIMEC	34
UEDU	33
GEDU	32
BKARMAN	31
BPEGARD	31
BSOLVAY	30
BUNIVL	29
BDESSEAU	28
BSTEWAL	28

Despite the large number of projects and lines there are few multiple lines in this subgraph. At multiplicity level 3 there is a component of 26 actors and 29 lines and a component with 4 actors and 3 lines. At multiplicity level 4 there are only 15 actors left. For the complete Materials Technology subgraph cliques can not be detected at multiplicity levels 1 and 2 and at multiplicity level 3 there is only 1 clique left. As a second best solution for the detection of cliques we considered the subgraph of the BRITE/EURAM programme. This subgraph contains 14 cliques at multiplicity level 2. The interlinkage of these cliques is shown in figure 5 (foreign higher education establishments are again not shown).

Fig. 5 : Interlinkage of cliques in the BRITE/EURAM subgraph (multiplicity ≥ 2)



3.2.4. Energy Technology

In terms of funding, Energy Technology is the 2nd largest area of RTD projects accounting for 21.7 % (1173 Mecu) of all funding in the 2nd and 18.3 % (2256 Mecu) in the 4th Framework programme (European Report on Science and Technology Indicators 1994, p.214-216). The main RTD programme in this field is JOULE/THERMIE. The EUREKA action also has an important Energy Technology chapter.

The subgraph with the Energy Technology related lines contains 247 actors and 668 lines (4.6% of all project-lines). Table 10 (gives the 20 actors with the highest degree centrality of this subgraph).

Table 10 : 20 actors with highest degree centrality in the Energy Technology subgraph

BVUB	50
BEEIG	38
BIMEC	33
BUCL	31
BWTCB	25
BCOHER	25
UEDU	25
BVITO	24
BCITELEC	21
BUG	19
BSOLTECH	18
BECOENV	18
BHMZ	17
GEDU	17
BULB	17
BENE	15
BFACMON	15
HEDU	13
BSIDMAR	12
BINVER	12

Energy Technology is a discipline that is relatively more than others oriented towards research institutes and higher education establishments. In the 2nd Framework Programme 68.5 % of all participants were research centres or education establishments, whereas in the area of IT and Telecommunications they only accounted for 37 % of all participants (European Report on Science and Technology Indicators 1994, Table IV.5 in the Statistical Annex). This is also reflected in the low number of projects in the field of Energy Technology with Belgian participation that were considered for analysis under the constraint that at least 1 Belgian private firm should participate in the project (Table A13).

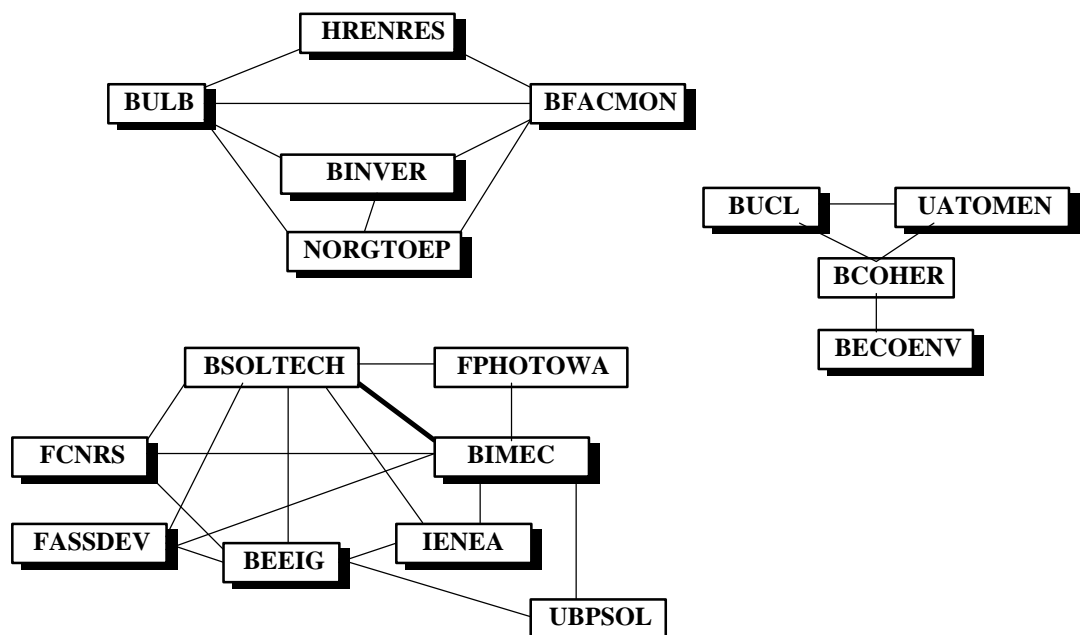
Furthermore, as mentioned before, the Belgian participation degree in this discipline is below average both for RTD projects and EUREKA.

At multiplicity level 2 there is a component of 51 actors and 87 lines containing 18 cliques (8 with set size 4).

At multiplicity level 4 there are no more cliques and only 2 components left, one with 9 actors and one with 2 actors.

In Figure 5 the lines between the actors (except for foreign education establishments) of the cliques at multiplicity level 2 are shown. Even at this low multiplicity level the network is not very dense and only few actors are firms. The line between Soltech and IMEC represents is a ‘strong’ one.

Fig. 6 : Lines between actors of the Energy cliques (multiplicity ≥ 2)



3.2.5. Biotechnology

The share of Biotechnology (Life Sciences and Technologies) in RTD funding more than doubled from 5.2 % (280 Mecu) in the 2nd to 12.8 % (1572 Mecu) in the 4th Framework Programme (European Report on science and Technology Indicators 1994, p.214-216). Like for Energy Technology this discipline is still largely dominated by research institutes and higher education establishments. They accounted for over 90 % of all participants in the area of Biotechnology in the 3rd Framework Programme (Ibid., Table IV.6 in the Statistical Annex). Table A13 shows that only 24.15 % of Biotechnology projects in which Belgian organisations were involved were considered ; the others did not contain a Belgian private partner. The Belgian participation degree is slightly below average for Biotechnology RTD projects and for EUREKA (Table A14). The contrary is true however if we look at CATI lines. In Table 11 the 20 actors with the highest degree centrality in the Biotechnology subgraph are shown.

Table 11: 20 actors with highest degree centrality in the Biotechnology subgraph

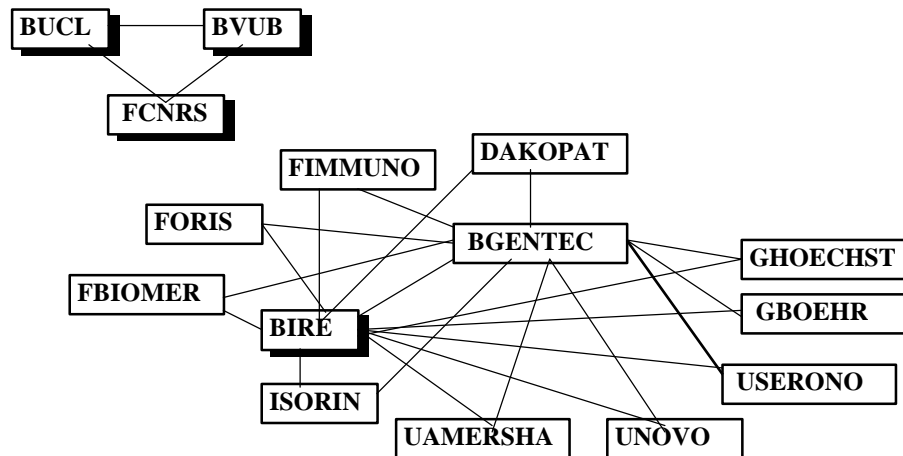
BUG	221
BUCL	119
BVITO	110
BVUB	87
BUNIGEM	72
BUNIVL	64
BAGRILAB	60
BHYGEPI	58
BGENTEC	54
BAFECON	54
BAKZO	48
BPGS	48
BIRE	47
BEMPLOI	43
BINNOGEN	41
BHYBRITE	41
BUA	41
BKUL	38
BJRC	38
GEDU	37

The Biotechnology subgraph contains 3471 lines (24% of all Project-lines) and 802 actors. The largest component contains 779 actors and 2192 single or multiple lines. At multiplicity level 4 there is 1 component of size 72 with 188 lines containing 49 cliques (29 with set size 5 and 12 with set size 4). At multiplicity level 5 there is 1 component of size 39 with 79 lines containing 20 cliques. The interlinkage of these cliques is shown in figure 7.

At multiplicity level 4 there is a very dense network where the Belgian Universities UCL and VUB are also linked to IRE and Eurogentec. Also Belgian Hybritech is present in a large number of cliques, more particularly with Eurogentec, IRE and VUB. At multiplicity level 5 Hybritech no longer appears.

Although relatively few participants in this science based area are firms, there is active co-operation between a reasonable number of them.

Fig. 7 : Interlinkage of Biotechnology cliques (multiplicity ≥ 5)



4. Further analytical steps and research questions

In this early phase of the research at least one thing became abundantly clear, and comes for that matter – in the light of previously published research - as no surprise for those studying national innovation systems. The (international) network aspects of R&D activities are very pronounced and ‘markets and hierarchies’ are obviously transcended . There is however some irony in the high connectedness of the graph of R&D co-operation. The linear causal model of innovation in which fundamental scientific research leads to the actual implementation of new technologies in production and the introduction of new products on the markets for final goods, over applied technology research, first industrial prototypes and upscaling, was taken as inspiration for governments, and indeed for the European Commission, to promote liaison functionality through cross-national funding of pre-competitive research jointly undertaken by firms, universities and research laboratories (the Framework programmes) and the stimulation of ‘near-market’ research (the EUREKA initiative). In doing so they acted as a powerful catalyst in turning this same linear structure into a systemic (network) structure.

One might say that ‘new’ industrial policy is essentially reduced to government funding and stimulation of R&D and innovation.

In other words, if we now take the systemic approach for granted, then this is – among other things surely - much so *because of* the same type of government action that many economists working in the field now put forward as adequate in the light of the network, that is ‘systemic’, aspects of present R&D.

Arguing in the same vein, we cannot but realise that the shape of the network that we find gives a somewhat biased view of national innovation systems. Because in the last decade the EC selected a number of S&T fields which they considered of being of growing importance in terms of international competitiveness and future growth potentiality, heavy emphasis was placed in the EU Framework programmes on fields such as information technology, telecommunication, new materials, bio-engineering, new forms of energy etc. The result is of course a R&D co-operation network in which the highest connectivity can be found in precisely these fields.

Should we therefore not consider to put more weight on the information contained in databases of the MERIT/CATI type, since they do not reflect this bias resulting from governmental policy ?

A number of relevant research questions were already (tentatively) addressed in this paper, such as the question whether there is a difference across CORDIS-type pre-competitive programmes in the way the research is carried through to 'near-market' and competitive research, and the question whether backing by personal links becomes more frequent as one approaches marketability.

We also suggested a method to check the empirical relevance of innovative clusters defined by means of the inter-sectoral flows of 'technological' goods.

A number of others issues (e.g. many of those formulated by Duysters (1996, Chapter 7)) can only be answered by means of a comparative analysis of the structure of the innovation systems in different countries.

Some other topics, however, remain still unexplored, or could be tackled with the obtained description of the national network, once the pointset information of the database is completed with variables from the OECD R&D statistics at firm level, and with CIS data.

For example:

- Is there a connection between pointcentrality on the one hand and performance, innovativity and R&D-intensity on the other ? Is this relation significantly different in the case of pre-competitive, 'near-market' and competitive research ?
- Is 'co-operative' R&D a substitute or a supplement to 'non-co-operative' R&D ?
- What is the time-evolution of the graph ?
- Do large firms more frequently engage in R&D co-operation than small firms ?
- Does a high centrality aim at a large control span of the company concerned, or at a better exploitation of existing market opportunities (Walker, 1988) ; i.e. do central companies have a great control span ?
- Is there a relation between the sort of co-operation (with or without state support) and the performance of the companies involved ?

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Appendix A1 : List of actors

LABEL	NAME	TYPE	NAT
BACSET	ACSET	IND	BE
BACTIF	Actif Industries	IND	BE
BAFECON	Ministere des affaires economiques	NCL	BE
BAGFA	Agfa-Gevaert	IND	BE
BAGRILAB	Agrilab	IND	BE
BAKZO	Akzo	IND	BE
BALCATEL	Alcatel Telecom	IND	BE
BAMYLUM	Amylum	IND	BE
BBARCO	Barco	IND	BE
BARKOVA	Arkova	IND	BE
BATEA	Siemens-Atea	IND	BE
BBBN	Burger Breedband Net (BBN)	NCL	BE
BCADCO	Cadco Nv	IND	BE
BCAPGEM	Cap Gemini	IND	BE
BCENTEX	Centexbel	ROR	BE
BCHAMP	Champion Spark Plug	IND	BE
BCITELEC	Citelec	IND	BE
BCOCKERI	Cockerill-Sambre	IND	BE
BCODITEL	Coditel Brabant	IND	BE
BCOHER	Coherence CV	IND	BE
BCRM	Centre for Research in Metallurgy	ROR	BE
BDANIS	Danis	IND	BE
BDESSEAU	Desseaux	IND	BE
BE2S	Expert Software Systems (E2S)	IND	BE
BEBU	European Broadcast Union	NCL	BE
BECOENV	Economics for Environmental Protection	NCL	BE
BEEIG	European Renewable Energy Centers Agency	NCL	BE
BBEKAERT	Bekaert	IND	BE
BELECTRA	Electrabel	IND	BE
BELENCO	Elenco	IND	BE
BBELGACO	Belgacom	IND	BE
BELT	E.L.T.	IND	BE
BEMPLOI	Ministere de l'Emploi et du Travail	NCL	BE
BENE	E.N.E. SA	IND	BE
BEURDEV	European Development Centre	IND	BE
BFACMON	Faculte Polytechnique de Mons	EDU	BE
BFEBEL	Febeltex	NCL	BE
BFN	FN-Herstal	IND	BE
BGENTEC	Eurogentec	IND	BE
BHOGOV	Hoogovens Aluminium	IND	BE
BHYGEPI	Institute for Hygiene and Epidemiology	ROR	BE
BIBIEF	Internazionale Banca Informazione	NCL	BE
BIMEC	Interuniversity Micro-electronics Centre (IMEC)	ROR	BE
BINFTEC	Information Technologies & Services	IND	BE
BINNOGEN	Innogenetics	IND	BE
BINTEGAN	Integan	IND	BE
BINVER	National Institute of Glass	ROR	BE
BIRE	IRE-Medgenix	ROR	BE
BJRC	Joint Research Centre (EU)	ROR	BE
BKARMAN	Von Karman Inst. For Fluid Dynamics	ROR	BE
BKUL	Catholic University of Leuven	EDU	BE

Appendix A1 (continued)

BLABOREL	Laborelec	IND	BE
BLEMMERZ	Lemmerz Belgie	IND	BE
BLMSINT	LMS International	IND	BE
BLVD	LVD company	IND	BE
BMEDOC	Medoc-Media	IND	BE
BMETALOG	Metalogic	IND	BE
BMIETEC	Alcatel Mietec	IND	BE
BOPL	Opl Benelux	IND	BE
BBOSAL	Bosal	IND	BE
BPEGARD	Pegard Productions	IND	BE
BPETROFI	Petrofina	IND	BE
BPGS	Plant Genetic Systems	IND	BE
BPHILIPS	Philips Belgium	IND	BE
BPICANOL	Picanol	IND	BE
BPRB	PRB SA	IND	BE
BRADENG	Radius Engineering	IND	BE
BREFER	REFER BVBA	IND	BE
BRHONE	Rhone-Poulenc	IND	BE
BRIC	RIC AI	IND	BE
BSAMTECH	Samtech	IND	BE
BSCK	Study Centre for Nuclear Energy	ROR	BE
BSIDMAR	Sidmar	IND	BE
BSOCGEN	Société Générale de Belgique	IND	BE
BSOLTECH	Soltech	IND	BE
BSOLVAY	Solvay	IND	BE
BSTEWAL	Stewal NV	IND	BE
BTELIND	Telindus	IND	BE
BTIENSE	Tiense Suikerraffinaderijen	IND	BE
BTRACTE	Tractebel	IND	BE
BTRAITEX	Traitex	IND	BE
BUA	University of Antwerp (RUCA, UFSIA, UIA)	EDU	BE
BUCEB	UCB	IND	BE
BUCL	Catholic University of Louvain	EDU	BE
BUCO	Uco SA Bellevue	IND	BE
BUG	University of Ghent	EDU	BE
BUKELEC	UCB-JSR Electronics	IND	BE
BULB	Université Libre de Bruxelles	EDU	BE
BUM	Union Miniere	IND	BE
BUNIGEM	University of Gembloux	EDU	BE
BUNIVL	University of Liège	EDU	BE
BVDWIEL	Michel van de Wiele	IND	BE
BVISION	Vision 1250	IND	BE
BVITO	Flemish Institute for Technological Research (VITO)	ROR	BE
BVUB	Free University Brussels	EDU	BE
BWTCB	Scientific Technological Centre of the Forest Industry (WTCB)	ROR	BE
BWTCM	Scientific Technological Centre of the Metal Industry (WTCM)	ROR	BE
CASCOM	Ascom	IND	CH
DAKOPAT	Dakopatts A/S	IND	DK
DJYDSK	Jydsk Telefon	IND	DK

Appendix A1 (continued)

DKTAS	Copenhagen Telephone Company	IND	DK
FALCATEL	Alcatel-Alsthom	IND	FR
FASSDEV	Association pour le developpement de la	NCL	FR
FBIOMER	Biomerieux	IND	FR
FBULL	Bull SA	IND	FR
FCCETT	CCETT	ROR	FR
FCENPAP	Centre Technique de l'industrie des papiers	ROR	FR
FCETIM	Centre Technique des Industries Mecaniques	ROR	FR
FCNRS	Centre National pour la recherche scientifique	ROR	FR
FELF	ELF-Atochem	IND	FR
FES2	European Silicon Structures (ES2)	IND	FR
FIMMUNO	Immunotech	IND	FR
FMATRA	Matra Cap systemes	IND	FR
FORIS	Oris-Industrie	IND	FR
FPHOTOWA	Photowatt International	IND	FR
FRANTEL	France Telecom	IND	FR
FRENAULT	Renault	IND	FR
FSNECMA	Snecma	IND	FR
FTELEDIF	Telediffusion de France	IND	FR
FTHOMSON	SGS-Thomson	IND	FR
GALCATEL	Alcatel Sel AG	IND	DE
GBENZ	Daimler-Benz	IND	DE
GBMW	Bayerische Motorenwerke	IND	DE
GBOEHR	Boehringer Mannheim	IND	DE
GBOSCH	Robert Bosch	IND	DE
GFRAUN	Fraunhofer Gesellschaft	IND	DE
GHERAEUS	Heraeus Quarzschmelze	IND	DE
GHHI	Heinrich Hertz Institute (HHI)	ROR	DE
GHOECHST	Hoechst	IND	DE
GIRT	Institut fuer Rundfunktechnik GMBH	IND	DE
GMAHLO	Mahlo Gmbh & Co KH	IND	DE
GPHILIPS	Philips	IND	DE
GPORSCH	Porsche	IND	DE
GPOST	Deutsche Bundespost Telekom	IND	DE
GRUNDIG	Grundig E.M.V.	IND	DE
GSIEMENS	Siemens	IND	DE
GTELEFUN	Telefunken Electronic	IND	DE
GVARIA	Varia	IND	DE
HINTRACO	Intracom	IND	GR
HRENRES	Centre for Renewable Energy Sources	IND	GR
ICSELT	Centro studi e Laboratori Telecomunicazione	IND	IT
IENEA	Ente per la Nuove Tecnologie (ENEA)	NCL	IT
IENIMONT	Enimont Spa.	IND	IT
IFIAT	Fiat Spa	IND	IT
IITALTEL	Italtel SIT	IND	IT
IRAI	Radiotelevisione Italiana	NCL	IT
ISELECO	Seleco Spa	IND	IT
ISORIN	Sorin Biomedica Cardio	IND	IT
ITHOMSON	SGS Thomson	IND	IT
KFOAMEX	Foamex LP.	IND	US

Appendix A1 (continued)

KTANDEM	Tandem	IND	US
MNORTEL	Norwegian Telecom	IND	NO
NASM	ASM International	IND	NL
NATT	ATT Networks Systems Nederland	IND	NL
NBROCADE	Gist-Brocades	IND	NL
NDSM	DSM	IND	NL
NESA	European Space Agency (ESA)	NCL	NL
NORGT0EFP	Nederlandse Organisatie voor Toegepast Onderzoek	ROR	NL
NPHILIPS	Philips	IND	NL
NPTT	PTT Telecom	IND	NL
SALCATEL	Alcatel standard Electrica	IND	ES
SCENCOR	Centunion Espanol de coordination	OTH	ES
SHISPAS	Hispaset	OTH	ES
SRETEVI	Ente Publico Retevision	OTH	ES
STELEFON	Telefonica de Espana	IND	ES
UAFRC	AFRC	ROR	GB
UAMERSHA	Amersham International	IND	GB
UATOMEN	UK Atomic Energy Authority	NCL	GB
UBBC	British Broadcasting Corporation	NCL	GB
UBEAMECH	Beamech Ltd.	IND	GB
UBP	BP	IND	GB
UBPSOL	BP Solar	IND	GB
UBRITST	British Steel	IND	GB
UBT	British Telecommunications	IND	GB
UDELTA	Delta Group Plc.	IND	GB
UGECMAR	Gec Marconi	IND	GB
UHP	Hewlett-Packard LTD	IND	GB
UICI	Imperial Chemical Industries	IND	GB
UINDETEL	Independent television Association	OTH	GB
ULAPORTE	Laporte	IND	GB
UNATRANS	National Transcommunications LTD	IND	GB
UNOVO	Novo Biolabs	IND	GB
UOXFINSI	Oxford Instruments Group	IND	GB
UPHILIPS	Philips Electronics UK LTD	IND	GB
UPLESSEY	Gec Plessey	IND	GB
UROLLS	Rolls-Royce Ltd	IND	GB
USERONO	Serono Diagnostics	IND	GB
VNOKIA	Nokia	IND	FI
X7INBANK	Industrial Bank of Japan	IND	JP
X7NIPKAY	Nipkaya	IND	JP
ZTELEVER	Swedisch Telecom	IND	SE

Appendix A1bis : country codes

AUSTRIA	A
BELGIUM	B
SWITZERLAND	C
DANMARK	D
ROUMANIA	E
FRANCE	F
GERMANY	G
GREECE	H
ITALY	I
POLAND	J
USA	K
LUXEMBOURG	L
NORWAY	M
the NETHERLANDS	N
HUNGARY	O
PORTUGAL	P
SLOVAKIA	Q
KOREA	R
SPAIN	S
CZECH REP.	T
GB	U
FINLAND	V
S-AFRICA	W
IRELAND	Y
SWEDEN	Z
ICELAND	X0
AUSTRALIA	X1
BULGARIA	X2
CANADA	X3
EUROPE	X4
CROATIA	X5
INDIA	X6
JAPAN	X7
LITHUANIA	X8
MALTA	X9
RUSSIA, USSR	X10
SLOVENIA	X11
THAILAND	X12
TURKEY	X13
UKRAINIAN SSR	X14
YUGOSLAVIA	X15
ARGENTINA	X16

Appendix A2 : file-formats of the pointset-file and the lineset-file

Pointset information

Info	Format	Record	Columns	Description
POINTNUM	I4	1	1 - 4	Number of actor in pointset
POINTLAB	A40	1	5 - 44	Name of Actor
POINTNAM	A8	1	51 - 58	Acronym of Actor
NACE	A4	1	60 - 63	Sectoral classification (NACE)
TW	F7.0	1	64 - 70	Value added, 1995
OMZET	F6.0	1	71 - 76	Turnover, 1995
AP95	F5.0	1	77 - 81	Number of employees, 1995
INV95	F7.0	1	82 - 88	Material investments, 1995
NW95	F7.0	1	89 - 95	Net profit, 1995
CF95	F7.0	1	96 - 102	Cash flow, 1995
ROE	F5.0	2	1 - 5	Return on equity, 1995
ROA	F5.0	2	6 - 10	Return on assets, 1995
CR	F5.0	2	11 - 15	Current ratio, 1995
REGIO	A5	2	16 - 20	Region (NUTS)
TYPE	A3	2	22 - 24	Type of organisation (IND,ROR,NCL,EDU,CON,OTH)
PCODE	A4	2	26 - 29	Postal code
RANGO	I5	2	31 - 35	Ranking TOP 30000 (Turnover)
RANGTW	I5	2	37 - 41	Ranking TOP 30000 (Value Added)
E	I1	2	43 - 43	Occurrence in EUREKA = 1
I	I1	2	45 - 45	Occurrence in IWT = 1
C	I1	2	47 - 47	Occurrence in CORDIS = 1
M	I1	2	49 - 49	Occurrence in MERIT/CATI = 1
NAT	A2	2	50 - 51	Nationality
BTW	A9	2	55 - 63	V.A.T.-number

Lineset information

Info	Format	Record	Columns	Description
TAIL	A8	1	7 - 14	Acronym of TAIL-actor
HEAD	A8	1	17 - 24	Acronym of HEAD-actor
DU	I1	1	27 - 27	Directed (1)/Undirected (0)
LIT	A1	1	30 - 30	Line Type [Project(P)/Agreement(A)/Directorate(D)]
BRON1	A1	1	32 - 32	Source for TAIL
BRON2	A1	1	36 - 36	Source for HEAD
PROGRAM	A16	1	40 - 55	Name or acronym of the program
RECNR	A5	1	56 - 60	Record number
BEGIN	A8	1	62 - 69	Date of commencement
END	A8	1	72 - 79	Date of completion
DUR	F4.0	1	80 - 83	Duration
STATUS	A1	1	84 - 84	Completed (C)/Execution (E)
TEC	A4	1	87 - 90	Technological discipline
SEC	A6	1	91 - 96	Sectoral division (CATI)
SUB	A7	1	97 - 103	Subsectors (CATI)
AMOUNT	F4.0	1	104 - 107	Amount of the project or agreement
NP	I3	1	108 - 110	Number of partners
FCOOP	A7	1	111 - 117	Form of co-operation (CATI)
NAME	A40	2	1 - 40	Name of agreement or name of director
FU1	A1	2	46 - 46	Function of director in TAIL
FU2	A1	2	50 - 50	Function of director in HEAD
INU	I1	2	57 - 57	Involvement of universities (0 or 1)
OC	I1	2	60 - 60	Operational context (CATI)
SE	I1	2	64 - 64	Subject environment (CATI)
DM	I1	2	68 - 68	Distance to market (CATI)
SIRD	A3	2	70 - 72	Sector division code (CATI)
M1	A5	2	75 - 79	Motives for certain agreements (CATI)
M2	A3	2	81 - 83	Motives for joint Ventures (CATI)
M3	A5	2	85 - 89	Motives for direct investment (CATI)
PE1	F5.0	2	93 - 97	Percentage of ownership by TAIL (CATI)
PE2	F5.0	2	101 - 105	Percentage of ownership by HEAD (CATI)
LITINT	I3	2	115 - 117	Integer for LIT for the analysis of 'strong links'

Appendix A3 : Classification of Belgian and foreign actors by organisation type

COUNTRY	IND	ROR	NCL	CON	EDU	OTH	TOTAL
BELGIUM	631	38	47	11	18	36	781
FRANCE	245	61	45	6	1	195	553
GERMANY	294	53	47	1	1	157	553
GREAT BRITAIN	261	26	47	6	1	110	451
ITALY	122	30	32	0	1	105	290
SPAIN	103	27	26	0	1	72	229
NETHERLANDS	117	26	26	6	1	51	227
DENMARK	56	20	22	2	1	20	121
GREECE	56	9	10	1	1	28	105
SWEDEN	42	17	13	1	1	15	89
SWITZERLAND	46	15	7	0	1	7	76
PORTUGAL	23	9	12	1	1	22	68
IRELAND	31	4	7	0	1	24	67
FINLAND	29	5	6	0	1	7	48
NORWAY	15	8	4	0	1	15	43
AUSTRIA	20	6	5	0	1	9	41
LUXEMBOURG	15	0	4	0	1	4	24
US	16	0	1	0	1	5	23
24 OTHER COUNTRIES	31	15	16	0	12	27	101
TOTAL	2153	369	377	35	47	909	3890

IND : private company (private research institutions and consultancy firms not included) ;
ROR : research institutions and laboratories ;
NCL : non-commercial organisations ;
CON : consultancy firms ;
EDU : universities and institutions of higher education ;
OTH : others.

Appendix A4 : Classification of nodes by country and project/agreement type

COUNTRY	CORDIS	EUREKA	CATI	IWT	TOTAL
BELGIUM	506	131	39	251	781
FRANCE	479	97	8	0	553
GERMANY	506	69	4	1	553
GREAT BRITAIN	413	46	10	0	451
ITALY	268	38	2	0	290
SPAIN	195	46	0	0	229
NETHERLANDS	178	58	8	0	227
DENMARK	115	13	0	0	121
GREECE	104	3	0	0	105
SWEDEN	80	12	0	0	89
SWITZERLAND	62	17	2	0	76
PORTUGAL	66	4	0	0	68
IRELAND	65	2	0	0	67
FINLAND	41	12	2	0	48
NORWAY	34	10	0	0	43
AUSTRIA	33	11	0	0	41
LUXEMBOURG	23	1	0	0	24
US	7	0	16	0	23
24 OTHER COUNTRIES	64	27	13	0	101
TOTAL	3239	597	104	252	3890

Note : the row-totals do not correspond because an actor can be active in more than one type of programme.

Appendix A5 : Classification of Belgian companies according to size (# of employees and ranking by value added), and to region (NUTS code)

	#	%
NUMBER OF EMPLOYEES (n)		
n > 1000	56	9
1000 > n > 500	31	5
500 > n > 250	45	7
250 > n > 100	66	10
100 > n > 50	65	10
50 > n , OR UNKNOWN	368	58
NATIONAL RANKING BY VALUE ADDED		
TOP 100	41	6
TOP 500	108	17
TOP 1000	143	23
TOP 5000	258	41
TOP 10000	303	48
TOP 30000	373	59
NOT RANKED in TOP 30000	258	41
REGION (NUTS)		
BRUSSELS (R5300)	80	13
ANTWERP (R5111)	22	3
LIEGE (R5242)	17	3
LEUVEN (R5123)	16	3
GENT (R5184)	14	2
HALLE-VILVOORDE (R5122)	13	2
NIVELLES (R5224)	13	2
TURNHOUT (R5113)	12	2
VERVIERS (R5243)	11	2
KORTRIJK (R5194)	9	1
HASSELT (R5151)	7	1
UDENNAARDE (R5185)	6	1
AALST (R5181)	5	1
BRUGGE (R5191)	5	1
NAMUR (R5272)	5	1
SINT-NIKLAAS (R5186)	4	1
TIELT (R5197)	4	1
CHARLEROI (R5232)	4	1
MONS (R5233)	4	1
MECHELEN (R5112)	3	0
TONGEREN (R5153)	3	0
EKLO (R5183)	3	0
MOUSCRON (R5234)	3	0
SOIGNIES (R5235)	3	0
IEPER (R5193)	2	0
OOSTENDE (R5195)	2	0
ATH (R5231)	2	0
OTHER OR UNKNOWN	359	57

Appendix A6 : Belgian private companies classified by NACE code

SECTOR(nace)	#	%
Other business services (74)	66	15,64
Informatics (72)	50	11,85
Chemical industry (24)	37	8,77
Textile industry (17)	27	6,40
Manufacture of metal products (28)	28	6,64
Machinery & Tools (29)	37	8,77
Electrical machines (31)	16	3,79
Wholesale trade machinery (516)	21	4,98
Audio-, video- & Telecommunications (32)	14	3,32
Food & Beverages (15)	20	4,74
Metallurgy (27)	17	4,03
Rubber&Synthetic materials (25)	14	3,32
Manufacture of Non-metallic mineral products (26)	11	2,61
Medical& Optical instruments,Finemechanics (33)	10	2,37
Manufacture of Other means of Transport (35)	7	1,66
Building industry (45)	10	2,37
Wholesale trade intermediate goods (515)	7	1,66
Post&Telecommunications (64)	4	0,95
Rent&Sale of real estate (70)	4	0,95
Research&Development (73)	6	1,42
Agriculture (1)	7	1,66
Manufacture of Motor vehicles (34)	4	0,95
Furniture industry (36)	5	1,18
Total	422	100
Other or at present unknwn	215	

Appendix A7 : Added value generated by the graph's Top200 companies as a share of added value of all Top200 companies

NACE	AV Graph200	AV Top200	%	#GR200	#TOP200
15	40	67	59,70	6	15
17	5	7	71,43	2	3
24 (excl. 244)	153	182	84,07	12	23
244	40	40	100,00	3	3
25	5	5	100,00	2	2
26	30	67	44,78	5	7
27	84	105	80,00	5	10
28	0	8	0,00	0	3
29	27	31	87,10	5	7
31	3	10	30,00	1	3
32 (excl.321)	44	44	100,00	5	5
321	3	3	100,00	1	1
33	3	3	100,00	1	1
34	6	12	50,00	4	9
353	8	8	100,00	3	3
40	168	179	93,85	1	19
45	3	10	30,00	1	3
515	15	62	24,19	4	7
516	14	16	87,50	3	4
60	84	92	91,30	3	5
62	19	19	100,00	1	1
64	124	124	100,00	4	4
72	0	5	0,00	0	2
74	2	42	4,76	2	12
Other	35	250	14,00	10	48
Total	915	1391	65,78	84	200

AVGRAPH200 : Added Value of the Top 200 Companies represented in the graph, belonging to the given NACE sector

AVTOP200 : Added Value of all Top 200 Companies belonging to the given NACE sector

% : AVGRAPH200/AVTOP200*100

#GR200 : Number of Top 200 companies in this NACE sector represented in the graph

#TOP200 : Number of Top200 companies in this NACE sector

Source: BNB, 1996

Appendix A8 : Number of lines in the graph according to type of project/agreement

	# Projects	# Lines	# Belg. Companies	# Other Belg. Actors
CORDIS	972	13151	386	120
EUREKA	117	1156	114	17
MERIT/CATI	75	104	38	1
IWT	287	1370	222	29
INTERLOCKING DIRECTORATES		507		
TOTAL	1451	16288	631	105

Appendix A9 : Number of lines and projects in the EU R&D Framework programmes

	# of Projects	# of Lines
ESPRIT	274	3000
BRITE/EURAM	170	1426
CRAFT	61	534
JOULE/THERMIE	55	535
BCR 4	54	2151
RACE	48	1126
ACTS	35	617
TELEMATICS 2C	32	278
AIR	28	444
DRIVE 1	15	99
NFS 2	14	108
RAWMAT 2C	12	30
ÉCLAIR	10	133
PECO/COPERNICUS	9	59
RADWASTOM 4C	9	48
RENA	9	64
TRANSPORT	9	57
DRIVE 2	8	264
ENS	8	155
AERO 0C	7	140
COST	7	372
MAP	7	29
AERO 1C	6	135
BRIDGE	6	103
DECOM 3C	6	12
ENV 1C	6	19
MAT	6	47
AIM 1	5	95
AIM 2	5	94
BIOTECH 1	5	486
REWARD	5	24
ENNONUC 3C	4	20
ESSI 1	3	9
FAIR	3	24
MAST 2	3	42
NFS 1	3	16
RAWMAT 3C	3	9
ENV 2C	2	22
FOREST	2	15
LIBRARIES	2	16
LRE	2	29
MELREG C	2	13
RADWASTOM 3C	2	3
BIOMED 1	1	5
CAMAR	1	7
COSU C	1	25
DELTA 1	1	34
ENALT 2c	1	1
ENDEMO C	1	1
EURET	1	11
MAST 1	1	9
MAST 3	1	7
MATREC C	1	3
TOTAL CORDIS	972	13151

Appendix A10 : Number of lines and projects in the EUREKA initiative

AREA	# of Projects	# of Lines
Information technology	27	256
Biotechnology	20	93
Environment	20	169
Robotics	16	74
New materials	15	57
Transport	8	71
Laser	5	160
Communications	3	255
Energy	3	21
Total	117	1156

Appendix A11 : Forms of agreements in the MERIT/CATI part of the graph

FORM OF AGREEMENT	#
Minority Holding	21
Joint Development Agreement	22
Joint Ventures	21
Cross-Licensing	4
R&D Contract	5
Technology Sharing	4
Licensing	4
Total number of agreements	75
Total number of lines	104

Appendix A12 : Coinciding RTD and EUREKA lines

CORDIS		EUREKA			
ACTS	(1995-1997)	COMM	(1986-1995)	BBARCO	GHHI
ACTS	(1995-1997)	COMM	(1986-1995)	BBARCO	GIRT
ACTS	(1995-1997)	COMM	(1986-1995)	BBARCO	SHISPAS
ACTS	(1995-1997)	COMM	(1986-1995)	BBARCO	FC CETT
ACTS	(1995-1997)	COMM	(1986-1995)	BBARCO	FTHOMSON
ACTS	(1995-1998)	COMM	(1986-1995)	BBARCO	GBOSCH
ACTS	(1995-1998)	COMM	(1986-1995)	BBARCO	SALCATEL
ACTS	(1995-1998)	COMM	(1986-1995)	BBARCO	SRETEVI
ACTS	(1995-1998)	COMM	(1986-1995)	BBARCO	FC CETT
ACTS	(1995-1998)	COMM	(1986-1995)	BBARCO	FTHOMSON
ACTS	(1995-1998)	COMM	(1986-1995)	BBARCO	UINDETTEL
ACTS	(1995-1998)	COMM	(1986-1995)	BBARCO	IRAI
ACTS	(1995-1998)	ENVIRON	(1995-1999)	BALCATEL	NPHILIPS
ACTS	(1995-1998)	IT	(1992-1995)	BBELGACO	ICSELT
ACTS	(1995-1998)	IT	(1992-1995)	BBELGACO	ICSELT
ACTS	(1995-1998)	IT	(1992-1995)	BBELGACO	IITALTEL
ACTS	(1995-1998)	IT	(1992-1995)	BBELGACO	NPPT
ACTS	(1995-1998)	IT	(1996-2001)	BALCATEL	FALCATEL
ACTS	(1995-1998)	IT	(1996-2001)	BALCATEL	FALCATEL
ACTS	(1995-1998)	IT	(1996-2001)	BALCATEL	FALCATEL
ACTS	(1995-1998)	IT	(1996-2001)	BALCATEL	NPHILIPS
ACTS	(1996-1997)	IT	(1992-1995)	BBELGACO	GPOST
ACTS	(1996-1997)	IT	(1992-1995)	BBELGACO	STEFELFON
ACTS	(1996-1997)	IT	(1992-1995)	BBELGACO	HINTRACO
ACTS	(1996-1997)	IT	(1992-1995)	BBELGACO	ICSELT
ACTS	(1996-1997)	IT	(1992-1995)	BBELGACO	ICSELT
ACTS	(1996-1997)	IT	(1992-1995)	BBELGACO	NPPT
ACTS	(1996-1997)	IT	(1992-1995)	BBELGACO	NPPT
ACTS	(1995-1998)	ROBOT	(1987-1992)	BALCATEL	SALCATEL
AERO 0C	(1990-1992)	ROBOT	(1990-1993)	BLMSINT	FMATRA
AERO 1C	(1994-1997)	ROBOT	(1990-1993)	BLMSINT	FMATRA
AIR	(1993-1996)	MEDBIO	(1994-1998)	BINNOGEN	UAFRC
AIR	(1994-1997)	ENVIRON	(1993-1997)	BSOLVAY	FCENPAP
BIOTECH	(1993-1996)	MEDBIO	(1993-1997)	BSMITHKB	FCNRS
BRITE/EURAM		ENVIRON	(1995-1999)	BALCATEL	NPHILIPS
BRITE/EURAM	(1994-1997)	ENVIRON	(1993-1997)	BSOLVAY	FELF
BRITE/EURAM	(1996-1998)	ENVIRON	(1986-1990)	BLMSINT	GPORSCH
BRITE/EURAM	(1996-1999)	ENVIRON	(1995-1999)	BALCATEL	NPHILIPS
BRITE/EURAM		IT	(1996-2001)	BALCATEL	NPHILIPS
BRITE/EURAM	(1993-1996)	IT	(1994-1997)	BAGFA	NPHILIPS
BRITE/EURAM	(1996-1999)	IT	(1996-2001)	BALCATEL	GBOSCH
BRITE/EURAM	(1996-1999)	IT	(1996-2001)	BALCATEL	FALCATEL
BRITE/EURAM	(1996-1999)	IT	(1996-2001)	BALCATEL	NPHILIPS
BRITE/EURAM	(1992-1995)	ROBOT	(1990-1993)	BLMSINT	FMATRA
BRITE/EURAM	(1993-1995)	LASER	(1996-1999)	BHOOGOV	BVITO
BRITE/EURAM	(1996-1998)	TRANSPORT	(1996-1998)	BLMSINT	GBMW
COST	(1990-1994)	IT	(1992-1995)	BBELGACO	STEFELFON
COST	(1990-1994)	IT	(1992-1995)	BBELGACO	NESA
COST	(1990-1994)	IT	(1992-1995)	BBELGACO	ZTELEVER
COST	(1991-1994)	IT	(1992-1995)	BBELGACO	GPOST
DRIVE 2	(1992-1994)	IT	(1992-1995)	BBELGACO	ZTELEVER
ENS	(1992-1993)	IT	(1992-1995)	BBELGACO	STEFELFON
ENS	(1992-1993)	IT	(1992-1995)	BBELGACO	ICSELT
ENS	(1992-1993)	IT	(1992-1995)	BBELGACO	NPPT
ESPRIT 1	(1984-1989)	COMM	(1986-1995)	BBARCO	FTHOMSON
ESPRIT 2	(1989-1993)	COMM	(1986-1995)	BPHILIPS	GSIMEMENS
ESPRIT 2	(1989-1993)	COMM	(1986-1995)	BPHILIPS	SALCATEL
ESPRIT 2	(1989-1993)	COMM	(1986-1995)	BPHILIPS	NPHILIPS
ESPRIT 3	(1992-1995)	COMM	(1986-1995)	BPHILIPS	FTHOMSON
ESPRIT 3	(1993-1994)	COMM	(1986-1995)	BBARCO	FTHOMSON
ESPRIT 3	(1993-1994)	COMM	(1986-1995)	BBARCO	FTHOMSON
ESPRIT 3	(1993-1994)	COMM	(1986-1995)	BBARCO	UPHILIPS
ESPRIT 3	(1993-1994)	COMM	(1986-1995)	BBARCO	NPHILIPS
ESPRIT 3	(1994-1995)	COMM	(1986-1995)	BBARCO	FTHOMSON
ESPRIT 3	(1994-1995)	COMM	(1986-1995)	BBARCO	UPHILIPS
ESPRIT 4	(1996-1997)	COMM	(1986-1995)	BBARCO	FTHOMSON
ESPRIT 2	(1986-1990)	ENVIRON	(1986-1990)	BLMSINT	GPORSCH
ESPRIT 1	(1983-1988)	ENVIRON	(1995-1999)	BALCATEL	FTHOMSON
ESPRIT 1	(1983-1988)	ENVIRON	(1995-1999)	BALCATEL	NPHILIPS

Appendix A12 (continued)

ESPRIT 2	(1988-1989)	ENVIRON	(1995-1999)	BALCATEL	GSIEMENS
ESPRIT 2	(1988-1989)	ENVIRON	(1995-1999)	BALCATEL	FTHOMSON
ESPRIT 2	(1988-1989)	ENVIRON	(1995-1999)	BALCATEL	FTHOMSON
ESPRIT 2	(1989-1990)	ENVIRON	(1995-1999)	BALCATEL	GSIEMENS
ESPRIT 2	(1989-1990)	ENVIRON	(1995-1999)	BALCATEL	NPHILIPS
ESPRIT 2	(1989-1992)	ENVIRON	(1995-1999)	BALCATEL	NPHILIPS
ESPRIT 2	(1990-1991)	ENVIRON	(1995-1999)	BALCATEL	GSIEMENS
ESPRIT 2	(1990-1991)	ENVIRON	(1995-1999)	BALCATEL	NPHILIPS
ESPRIT 2	(1990-1992)	ENVIRON	(1995-1999)	BALCATEL	GSIEMENS
ESPRIT 2	(1990-1992)	ENVIRON	(1995-1999)	BALCATEL	FTHOMSON
ESPRIT 2	(1990-1992)	ENVIRON	(1995-1999)	BALCATEL	FTHOMSON
ESPRIT 2	(1990-1992)	ENVIRON	(1995-1999)	BALCATEL	NPHILIPS
ESPRIT 3	(1992-1995)	ENVIRON	(1995-1999)	BALCATEL	GFRAUN
ESPRIT 3	(1992-1995)	ENVIRON	(1995-1999)	BALCATEL	GSIEMENS
ESPRIT 3	(1992-1995)	ENVIRON	(1995-1999)	BALCATEL	GSIEMENS
ESPRIT 3	(1992-1995)	ENVIRON	(1995-1999)	BALCATEL	FTHOMSON
ESPRIT 3	(1992-1995)	ENVIRON	(1995-1999)	BALCATEL	NPHILIPS
ESPRIT 3	(1993-1995)	ENVIRON	(1995-1999)	BALCATEL	GSIEMENS
ESPRIT 3	(1993-1995)	ENVIRON	(1995-1999)	BALCATEL	GSIEMENS
ESPRIT 3	(1993-1995)	ENVIRON	(1995-1999)	BALCATEL	FTHOMSON
ESPRIT 3	(1993-1995)	ENVIRON	(1995-1999)	BALCATEL	NPHILIPS
ESPRIT 3	(1993-1995)	ENVIRON	(1995-1999)	BALCATEL	NPHILIPS
ESPRIT 3	(1993-1995)	ENVIRON	(1995-1999)	BALCATEL	NPHILIPS
ESPRIT 3	(1993-1996)	ENVIRON	(1995-1999)	BALCATEL	FTHOMSON
ESPRIT 3	(1993-1996)	ENVIRON	(1995-1999)	BALCATEL	NPHILIPS
ESPRIT 2	(1988-1991)	IT	(1986-1989)	BUKELEC	BIMEC
ESPRIT 3	(1994-1996)	IT	(1996-1997)	BSAMTECH	FIAT
ESPRIT 1	(1983-1988)	IT	(1996-2001)	BALCATEL	FTHOMSON
ESPRIT 1	(1983-1988)	IT	(1996-2001)	BALCATEL	NPHILIPS
ESPRIT 1	(1984-1989)	IT	(1996-2001)	BALCATEL	FALCATEL
ESPRIT 2	(1988-1989)	IT	(1996-2001)	BALCATEL	GSIEMENS
ESPRIT 2	(1988-1989)	IT	(1996-2001)	BALCATEL	FTHOMSON
ESPRIT 2	(1988-1989)	IT	(1996-2001)	BALCATEL	FTHOMSON
ESPRIT 2	(1989-1990)	IT	(1996-2001)	BALCATEL	GSIEMENS
ESPRIT 2	(1989-1990)	IT	(1996-2001)	BALCATEL	FBULL
ESPRIT 2	(1989-1990)	IT	(1996-2001)	BALCATEL	NPHILIPS
ESPRIT 2	(1989-1992)	IT	(1996-2001)	BALCATEL	NPHILIPS
ESPRIT 2	(1989-1993)	IT	(1996-2001)	BALCATEL	FALCATEL
ESPRIT 2	(1990-1991)	IT	(1996-2001)	BALCATEL	GBOSCH
ESPRIT 2	(1990-1991)	IT	(1996-2001)	BALCATEL	GSIEMENS
ESPRIT 2	(1990-1991)	IT	(1996-2001)	BALCATEL	ITHOMSON
ESPRIT 2	(1990-1991)	IT	(1996-2001)	BALCATEL	NPHILIPS
ESPRIT 2	(1990-1992)	IT	(1996-2001)	BALCATEL	GBOSCH
ESPRIT 2	(1990-1992)	IT	(1996-2001)	BALCATEL	GSIEMENS
ESPRIT 2	(1990-1992)	IT	(1996-2001)	BALCATEL	FBULL
ESPRIT 2	(1990-1992)	IT	(1996-2001)	BALCATEL	FBULL
ESPRIT 2	(1990-1992)	IT	(1996-2001)	BALCATEL	FTHOMSON
ESPRIT 2	(1990-1992)	IT	(1996-2001)	BALCATEL	FTHOMSON
ESPRIT 2	(1990-1992)	IT	(1996-2001)	BALCATEL	FTHOMSON
ESPRIT 2	(1990-1992)	IT	(1996-2001)	BALCATEL	ITHOMSON
ESPRIT 2	(1990-1992)	IT	(1996-2001)	BALCATEL	NPHILIPS
ESPRIT 3	(1992-1994)	IT	(1996-2001)	BALCATEL	FALCATEL
ESPRIT 3	(1992-1995)	IT	(1996-2001)	BALCATEL	GSIEMENS
ESPRIT 3	(1992-1995)	IT	(1996-2001)	BALCATEL	GSIEMENS
ESPRIT 3	(1992-1995)	IT	(1996-2001)	BALCATEL	FALCATEL
ESPRIT 3	(1992-1995)	IT	(1996-2001)	BALCATEL	FBULL
ESPRIT 3	(1992-1995)	IT	(1996-2001)	BALCATEL	FTHOMSON
ESPRIT 3	(1992-1995)	IT	(1996-2001)	BALCATEL	FTHOMSON
ESPRIT 3	(1992-1995)	IT	(1996-2001)	BALCATEL	ITHOMSON
ESPRIT 3	(1992-1995)	IT	(1996-2001)	BALCATEL	NASM
ESPRIT 3	(1992-1995)	IT	(1996-2001)	BALCATEL	NPHILIPS
ESPRIT 3	(1993-1995)	IT	(1996-2001)	BALCATEL	GSIEMENS
ESPRIT 3	(1993-1995)	IT	(1996-2001)	BALCATEL	GSIEMENS
ESPRIT 3	(1993-1995)	IT	(1996-2001)	BALCATEL	FTHOMSON
ESPRIT 3	(1993-1995)	IT	(1996-2001)	BALCATEL	ITHOMSON
ESPRIT 3	(1993-1995)	IT	(1996-2001)	BALCATEL	NPHILIPS
ESPRIT 3	(1993-1996)	IT	(1996-2001)	BALCATEL	FALCATEL
ESPRIT 3	(1993-1996)	IT	(1996-2001)	BALCATEL	FTHOMSON
ESPRIT 3	(1993-1996)	IT	(1996-2001)	BALCATEL	NPHILIPS
ESPRIT 2	(1989-1993)	IT	(1997-2001)	BPHILIPS	NPHILIPS
ESPRIT 3	(1992-1995)	IT	(1997-2001)	BPHILIPS	FTHOMSON
ESPRIT 2	(1989-1993)	ROBOT	(1987-1992)	BALCATEL	SCENCOR
ESPRIT 3	(1992-1995)	ROBOT	(1987-1992)	BALCATEL	SALCATEL
ESPRIT 1	(1984-1989)	TRANSPORT	(1996-1998)	BLMSINT	GBMW

Appendix A12 (continued)

FAIR	(1995-1998)	ENVIRON	(1993-1997)	BSOLVAY	FCENPAP
MELREG C	(1983-1985)	ENVIRON	(1995-1999)	BALCATEL	GSIEMENS
MELREG C	(1983-1986)	ENVIRON	(1995-1999)	BALCATEL	GSIEMENS
MELREG C	(1983-1986)	ENVIRON	(1995-1999)	BALCATEL	GFRAUN
MELREG C	(1983-1986)	ENVIRON	(1995-1999)	BALCATEL	NPHILIPS
MELREG C	(1983-1985)	IT	(1996-2001)	BALCATEL	GSIEMENS
MELREG C	(1983-1986)	IT	(1996-2001)	BALCATEL	GSIEMENS
MELREG C	(1983-1986)	IT	(1996-2001)	BALCATEL	NPHILIPS
RACE 1	(1988-1992)	COMM	(1986-1995)	BBARCO	GPOST
RACE 1	(1988-1992)	COMM	(1986-1995)	BBARCO	GBOSCH
RACE 1	(1988-1992)	COMM	(1986-1995)	BBARCO	GSIEMENS
RACE 1	(1988-1992)	COMM	(1986-1995)	BBARCO	SALCATEL
RACE 1	(1988-1992)	COMM	(1986-1995)	BBARCO	STELETRA
RACE 1	(1988-1992)	COMM	(1986-1995)	BBARCO	VNOKIA
RACE 1	(1988-1992)	COMM	(1986-1995)	BBARCO	FMATRA
RACE 1	(1988-1992)	COMM	(1986-1995)	BBARCO	FTHOMSON
RACE 1	(1988-1992)	COMM	(1986-1995)	BBARCO	UBT
RACE 1	(1988-1992)	COMM	(1986-1995)	BBARCO	ITHOMSON
RACE 2	(1992-1994)	COMM	(1986-1995)	BBARCO	UBT
RACE 2	(1992-1994)	COMM	(1986-1995)	BBARCO	ITHOMSON
RACE 2	(1992-1995)	COMM	(1986-1995)	BBARCO	GPOST
RACE 2	(1992-1995)	COMM	(1986-1995)	BBARCO	GRUNDIG
RACE 2	(1992-1995)	COMM	(1986-1995)	BBARCO	GIRT
RACE 2	(1992-1995)	COMM	(1986-1995)	BBARCO	SRETEVI
RACE 2	(1992-1995)	COMM	(1986-1995)	BBARCO	FCETT
RACE 2	(1992-1995)	COMM	(1986-1995)	BBARCO	FPHILIPS
RACE 2	(1992-1995)	COMM	(1986-1995)	BBARCO	FTHOMSON
RACE 2	(1992-1995)	COMM	(1986-1995)	BBARCO	FTELEDIF
RACE 2	(1992-1995)	COMM	(1986-1995)	BBARCO	UBBC
RACE 2	(1992-1995)	COMM	(1986-1995)	BBARCO	UNATRANS
RACE 2	(1992-1995)	COMM	(1986-1995)	BBARCO	IRAI
RACE 2	(1992-1995)	COMM	(1986-1995)	BBARCO	ISELECO
RACE 2	(1992-1995)	COMM	(1986-1995)	BBARCO	ITHOMSON
RACE 1	(1989-1990)	COMM	(1991-1994)	BALCATEL	UHP
RACE 1	(1988-1990)	ENVIRON	(1995-1999)	BALCATEL	NPHILIPS
RACE 1	(1988-1991)	ENVIRON	(1995-1999)	BALCATEL	GSIEMENS
RACE 1	(1988-1991)	ENVIRON	(1995-1999)	BALCATEL	FTHOMSON
RACE 1	(1988-1991)	ENVIRON	(1995-1999)	BALCATEL	NPHILIPS
RACE 1	(1988-1992)	ENVIRON	(1995-1999)	BALCATEL	GSIEMENS
RACE 1	(1988-1992)	ENVIRON	(1995-1999)	BALCATEL	FTHOMSON
RACE 1	(1989-1990)	ENVIRON	(1995-1999)	BALCATEL	GSIEMENS
RACE 2	(1992-1993)	ENVIRON	(1995-1999)	BALCATEL	NPHILIPS
RACE 2	(1992-1994)	ENVIRON	(1995-1999)	BALCATEL	GSIEMENS
RACE 2	(1992-1994)	ENVIRON	(1995-1999)	BALCATEL	GSIEMENS
RACE 2	(1992-1994)	ENVIRON	(1995-1999)	BALCATEL	FTHOMSON
RACE 2	(1992-1994)	ENVIRON	(1995-1999)	BALCATEL	FTHOMSON
RACE 2	(1992-1994)	ENVIRON	(1995-1999)	BALCATEL	NPHILIPS
RACE 2	(1994-1995)	ENVIRON	(1995-1999)	BALCATEL	N'TNO
RACE 1	(1988-1990)	IT	(1992-1995)	BBELGACO	GPOST
RACE 1	(1988-1990)	IT	(1992-1995)	BBELGACO	GTELENOR
RACE 1	(1988-1990)	IT	(1992-1995)	BBELGACO	VNOKIA
RACE 1	(1988-1990)	IT	(1992-1995)	BBELGACO	NPPT
RACE 1	(1988-1990)	IT	(1992-1995)	BBELGACO	PSISTEM
RACE 1	(1988-1992)	IT	(1992-1995)	BBELGACO	GPOST
RACE 1	(1988-1992)	IT	(1992-1995)	BBELGACO	STELEFON
RACE 1	(1988-1992)	IT	(1992-1995)	BBELGACO	VNOKIA
RACE 1	(1988-1992)	IT	(1992-1995)	BBELGACO	FMATRA
RACE 1	(1988-1992)	IT	(1992-1995)	BBELGACO	FTHOMSON
RACE 1	(1988-1992)	IT	(1992-1995)	BBELGACO	HINTRACO
RACE 1	(1988-1992)	IT	(1992-1995)	BBELGACO	ICSELT
RACE 1	(1988-1992)	IT	(1992-1995)	BBELGACO	IITALTEL
RACE 1	(1988-1992)	IT	(1992-1995)	BBELGACO	NPPT
RACE 1	(1988-1992)	IT	(1992-1995)	BBELGACO	ZTELEVER
RACE 2	(1992-1993)	IT	(1992-1995)	BBELGACO	GPOST
RACE 2	(1992-1993)	IT	(1992-1995)	BBELGACO	STELEFON
RACE 2	(1992-1993)	IT	(1992-1995)	BBELGACO	VNOKIA
RACE 2	(1992-1993)	IT	(1992-1995)	BBELGACO	PSISTEM
RACE 2	(1992-1995)	IT	(1992-1995)	BBELGACO	GPOST
RACE 2	(1992-1995)	IT	(1992-1995)	BBELGACO	STELEFON
RACE 2	(1992-1995)	IT	(1992-1995)	BBELGACO	VNOKIA
RACE 2	(1992-1995)	IT	(1992-1995)	BBELGACO	FPHILIPS
RACE 2	(1992-1995)	IT	(1992-1995)	BBELGACO	NPPT
RACE 2	(1992-1995)	IT	(1992-1995)	BBELGACO	PSISTEM

Appendix A12 (continued)

RACE 1	(1988-1990)	IT	(1996-2001)	BALCATEL	FALCATEL
RACE 1	(1988-1990)	IT	(1996-2001)	BALCATEL	FALCATEL
RACE 1	(1988-1990)	IT	(1996-2001)	BALCATEL	NPHILIPS
RACE 1	(1988-1991)	IT	(1996-2001)	BALCATEL	GSIEMENS
RACE 1	(1988-1991)	IT	(1996-2001)	BALCATEL	FALCATEL
RACE 1	(1988-1991)	IT	(1996-2001)	BALCATEL	FALCATEL
RACE 1	(1988-1991)	IT	(1996-2001)	BALCATEL	FTHOMSON
RACE 1	(1988-1991)	IT	(1996-2001)	BALCATEL	NPHILIPS
RACE 1	(1988-1992)	IT	(1996-2001)	BALCATEL	GBOSCH
RACE 1	(1988-1992)	IT	(1996-2001)	BALCATEL	GSIEMENS
RACE 1	(1988-1992)	IT	(1996-2001)	BALCATEL	FALCATEL
RACE 1	(1988-1992)	IT	(1996-2001)	BALCATEL	FTHOMSON
RACE 1	(1988-1992)	IT	(1996-2001)	BALCATEL	ITHOMSON
RACE 1	(1989-1990)	IT	(1996-2001)	BALCATEL	GSIEMENS
RACE 2	(1992-1993)	IT	(1996-2001)	BALCATEL	NPHILIPS
RACE 2	(1992-1994)	IT	(1996-2001)	BALCATEL	GSIEMENS
RACE 2	(1992-1994)	IT	(1996-2001)	BALCATEL	GSIEMENS
RACE 2	(1992-1994)	IT	(1996-2001)	BALCATEL	FALCATEL
RACE 2	(1992-1994)	IT	(1996-2001)	BALCATEL	FALCATEL
RACE 2	(1992-1994)	IT	(1996-2001)	BALCATEL	FTHOMSON
RACE 2	(1992-1994)	IT	(1996-2001)	BALCATEL	FTHOMSON
RACE 2	(1992-1994)	IT	(1996-2001)	BALCATEL	NPHILIPS
RACE 2	(1992-1995)	IT	(1996-2001)	BALCATEL	FALCATEL
RACE 2	(1994-1995)	IT	(1996-2001)	BALCATEL	FALCATEL
RACE 2	(1994-1995)	IT	(1996-2001)	BALCATEL	FALCATEL
RACE 2	(1994-1995)	IT	(1996-2001)	BALCATEL	ITHOMSON
RACE 1	(1988-1990)	ROBOT	(1987-1992)	BALCATEL	SALCATEL
RACE 1	(1988-1990)	ROBOT	(1987-1992)	BALCATEL	SALCATEL
RACE 1	(1988-1991)	ROBOT	(1987-1992)	BALCATEL	SALCATEL
RACE 1	(1988-1992)	ROBOT	(1987-1992)	BALCATEL	SALCATEL
RACE 2	(1992-1993)	ROBOT	(1987-1992)	BALCATEL	SALCATEL
RACE 2	(1992-1994)	ROBOT	(1987-1992)	BALCATEL	SALCATEL
RACE 2	(1992-1995)	ROBOT	(1987-1992)	BALCATEL	SALCATEL
RACE 2	(1994-1995)	ROBOT	(1987-1992)	BALCATEL	SALCATEL
RACE 2	(1994-1995)	ROBOT	(1987-1992)	BALCATEL	SALCATEL
TELEMATICS		IT	(1992-1995)	BBELGACO	GPOST
TELEMATICS		IT	(1992-1995)	BBELGACO	STEFELFON
TELEMATICS		IT	(1992-1995)	BBELGACO	NPTT
TELEMATICS	(1996-1997)	IT	(1996-2001)	BALCATEL	FALCATEL

Appendix A13 : Distribution of some major RTD projects (Belgium compared to EU average)

	BELG	%	SELPROJ	%	SELPROJ/BELG(%)	ALL	%
IT	329	25,64	274	36,63	83,28	1643	23,87
ESPRIT	329	25,64	274	36,63	83,28	1643	23,87
MATERIALS	241	18,78	170	22,73	70,54	1237	17,97
BRITE/EURAM	241	18,78	170	22,73	70,54	1237	17,97
COMM.	161	12,55	123	16,46	76,40	586	8,51
RACE	51	3,98	48	6,43	94,12	215	3,12
ACTS	39	3,04	35	4,68	89,74	114	1,66
TELEMATICS	63	4,91	32	4,28	50,79	243	3,53
ENS	8	0,62	8	1,07	100,00	14	0,20
ENERGY	169	13,17	81	10,82	47,93	1103	16,03
JOULE/THERMIE	115	8,96	55	7,35	47,83	855	12,42
RENA	10	0,78	9	1,20	90,00	70	1,02
NFS	44	3,43	17	2,27	38,64	178	2,59
BIOTECH.	207	16,14	50	6,68	24,15	1192	17,31
AIR	103	8,03	28	3,74	27,18	436	6,33
ECLAIR	12	0,94	10	1,34	83,33	42	0,61
BRIDGE	24	1,87	6	0,80	25,00	97	1,41
BIOTECH	45	3,51	5	0,67	11,11	203	2,95
BIOMED	23	1,79	1	0,13	4,35	414	6,01
ENVIRONM.	135	10,52	18	2,41	13,33	908	13,19
ENV	115	8,96	8	1,07	6,96	821	11,93
AIM	20	1,56	10	1,34	50,00	87	1,26
TRANSPORT	41	3,20	32	4,27	78,05	214	3,11
TRANSPORT	17	1,33	9	1,20	52,94	79	1,15
DRIVE	24	1,87	23	3,07	95,83	135	1,96
TOTAL	1283	100,00	748	100,00	58,30	6883	100,00

BELG: Total number of projects with at least one Belgian participant

SELPROJ: Total number of projects restrained for analysis (at least one Belgian company)

ALL: Total number of projects in this RTD area

Appendix A14 : Distribution of EUREKA projects (Belgium compared to EUREKA average)

AREA	BELG	%	ALL	%
Information technology	27	23,08	202	16,93
Biotechnology	20	17,09	217	18,19
Environment	20	17,09	233	19,53
Robotics	16	13,68	199	16,68
New materials	15	12,82	128	10,73
Transport	8	6,84	81	6,79
Laser	5	4,27	28	2,35
Communications	3	2,56	48	4,02
Energy	3	2,56	57	4,78
Total	117	100,00	1193	100,00

BELG: Total number of projects with one Belgian participant

ALL: Total number of EUREKA projects in this area