European Research Funding and Regional Technological Capabilities: Network Composition Analysis

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Abstract

We use network and correspondence analysis to describe the composition of the research networks in the European BRITE-EURAM program. Our main finding is that 27% of the participants in this program fall into one of two sets of highly ”interconnected” institutions – one centered around large firms (with smaller firms and research centers providing specialized services), and the other around universities. Moreover, these ”hubs” are composed largely of institutions coming from the technologically most advanced regions of Europe. This is suggestive of the difficulties of attaining European ”cohesion”, as technically advanced institutions naturally link with partners of similar technological capabilities.

JEL Classifications: O32 (Management of Technological Innovation and R & D), O38 (Government Policy).

1 Introduction

The European Union (EU) has strongly encouraged the formation of R&D networks among institutions belonging to its member countries, recognizing that these networks have become very important for innovation and economic growth. Through these linkages the EU also hopes to achieve greater European integration in research and technology.

But the networks that are formed within the EU research programs have not been investigated in detail. Systematic studies of these research contracts could usefully assess the extent to which the formation and the composition of the networks fulfill the goals of European research policy. Moreover, the EU research contracts would represent a unique data set to discuss more ”theoretical” questions about the sociological and economic behavior of research institutions (whether firms, universities, or other public or private organizations).

This paper looks at the research networks formed under one EU Program, Brite-Euram (BE), in 1990. Our sample is composed of all BE contracts signed in that year. BE is an interesting program for our purposes. First, it covers many technologies (new materials, chemicals and chemical processing, aeronautics, industrial automation, simulation, etc.), and it comprises a heterogeneous set of participants (large firms, small-medium firms, universities, other research centers). Moreover, it is concerned with both the generation of new technologies and their development and commercialization. At the same time, because of our focus on this program, any generalization of our conclusions to other EU programs will only be speculative. In this respect, one of our goals is to describe a methodology that can be usefully employed to analyze the research networks and the relationships among the institutions that participate in EU R&D tenders.

In a previous paper, Gambardella and Garcia-Fontes (1996), we analyzed this issue at the network level. We performed multivariate analysis to identify ”clusters” of networks with homogeneous characteristics along certain dimensions. The main result was that the networks tended to be composed of institutions with similar characteristics. Thus, for instance, our networks clustered separately according to the basic or applied character of the work performed. Most interestingly, we found that the vast majority of our networks had main contractors coming from high patent-intensive regions (at the level of Baden- Wuerttenberg, Lombardy, East Anglia) with partners coming from other high patent-intensive regions. The fewer contracts whose main contractors came from low-tech regions attracted primarily partners coming from other low-tech regions. This was suggestive of the importance of complementarity in technological capabilities.

In this paper we focus on the individual institutions. We study the extent to which the participating institutions in this program are connected with each other through one or many networks. For example, institution A could link with B in one network and with C in another, and B and C could link together in a third network. A, B, and C would then define a completely ”closed” set of interconnected relationships. Two isolated institution would instead be D and E which link together in one network, but do not belong to any of the networks wherein A, B, or C are present. Moreover, there could be different sets of interconnected institutions – e.g. F, G and H partner with each other in three networks two at the time, but do not belong to any of the networks wherein A, B, or C are present. Finally, other institutions, e.g. J, could belong to, say, both the F-G network and the A-B network. These institutions would serve as a ”bridge” between the two sets of interconnected partners. The strategy of our investigation is as follows. We first identify ”blocks” of institutions which can be distinguished according to their degree of interconnection (e.g. isolated, highly connected). We then use correspondence analysis to study the characteristics of the institutions that belong to the different blocks. This will be performed along a set dimensions, like the technological quality of the regions wherein the partners come from, the type of institutions (big firms, small firms, universities, etc.), the size of the networks (number of partners), etc.. Ultimately, this would enable us to assess, for instance, whether the isolated institutions come from low- or high-tech regions, or whether a certain set of highly interconnected institutions is formed only by universities or firms, or whether these sets mix and match large and small firms or firms and universities.

The next section describes the BE program, the variables in our data set, and our blocks of institutions. We discuss our results in Section 3, and conclude in Section 4.

2 The 1990 Brite–Euram Contracts

2.1 The Brite-Euram Program

The 1990 BE contracts cover one of the four years of this program (1989-1992). The main objective of BE 1989-1992 was to enhance the competitive position of the Community’s manufacturing industries. Related goals included trans-frontier collaboration in strategic industrial research and the transfer of technology across Community frontiers and between sectors, particularly those with many small- medium enterprises (SME) (CEC, 1993). Although not an explicit objective of the program, European “cohesion”, i.e. stronger inter-relationships among most and least favored regions of the Community, was mentioned to be a desirable outcome of BE (CEC, 1993, p.12).

We obtained our data from DGXII (1991), which lists all contracts signed by DGXII in 1990. Our sample is composed of 143 contracts (networks) and 488 institutions. For each network, DGXII (1991) provides the following information: contract number, title of project, name and location (ISO regions) of partners, type of institution (large firm, small-medium firm, university, research center, other), its position in the network (main contractor, secondary contractor, third contractor, sub-contractor of main contractor, of secondary contractor, etc.), duration of project, total cost of the project, total EU contribution, break-down of costs and EU contribution for each participant in the networks.

2.2 Patent count by regions

We collected data on the 1978-1990 European patents (European Patent Office – EPO) of individual European regions in three technological classes: new materials, aircraft and mechanical engineering. These were created after aggregating homogeneous EPO sub-classes. Our three classes roughly correspond to the technologies targeted by BE. For the large countries (France, Germany, Italy, Spain, UK) our regions correspond to the political regions of the country (e.g. Lombardy, Baden-Wuerttemberg). For the other countries, we counted the patents of the country as a whole. This is because in practice the vast majority of patents come from the same region – typically that of the capital. Moreover, this creates regions of comparable size. To match the patent with the regions we used the address of the main inventor indicated in the patent.

Our patent count by regions represents an approximate measure of the regional technological capabilities in the main technological classes of BE [1]. The use of patent data has some drawbacks. For instance, it is well known that an important part of the output of research cannot be patented, especially for basic research. At any rate, here we are only trying to measure differences in technological capabilities among European regions, and these are likely to be correlated with the number of patents of these regions.

2.3 Regional contribution to the Brite-Euram networks

Table 1 presents the main characteristics of the regions of the participants in the BE program considered in this study. The first column reports the number of patents in the regions in our three technological classes – new materials, aircraft, mechanical engineering. The second column shows the number of main contractors from each

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[1] Data on individual patents or scientific publication production was not available for participants in the BE program.

region. On comparing these two columns, regions with high number of patents usually contribute with a higher number of main contractors to the networks – e.g. the Paris region with 2,104 patents and 16 main contractors, Holland with 525 and 13, or South East in the United Kingdom with 703 and 13. The pattern is not as clear in the third column, which reports the total number of participants from the regions. In this case the heterogeneity is much higher. Although the Paris region is again the region with the highest number of participants, 90, we find cases like the Madrid region with only 11 patents and 23 participants, or the Bayern region with 1,046 patents and 29 participants. The table is completed with information about the population of the regions and GDP per capita.

2.4 Descriptive analysis of the participating institutions

We described the participating institutions in this program by identifying first different clusters or ”blocks” of institutions according to their degree of connectivity. We then described the characteristics of these blocks by correspondence analysis.

There are 488 institutions in our sample. [2]. We defined the connections within the network as the relation between the participants in each network and the main contractor. That is, if two institutions participate in a network and they are not the main contractor, they are not directly connected, but they are are connected through the main contractor. The main contractor is instead directly connected to the participants in each network. Different networks are connected if they share one or more participants [3].

We first obtained a set of ”components” within the whole sample of participating institutions [4]. These are all the subsets of connected institutions, either directly or indirectly. The institutions in our program are highly interrelated. This is because, as shown by Table 2. one component, namely component 2, is composed of 439 of the original 488 institutions. This means that all these 439 institutions, which constitute a large fraction of our population, are interconnected either directly or indirectly. The remaining institutions are grouped in 15 other compo-

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[2] We assigned an identification number to each institution. The correspondence between the identification numbers and the names of the institutions is available upon request from the authors.

[3] By direct connection we mean the relation between main contractors and the participants in a network. Indirect connection means that a path of connections of any size can be found through a main contractor within a network, or through different networks. For instance if A and B participate in the same network, where A is the main contractor, and B,C, and D participate in another network, where C is the main contractor. A would be directly connected to B and B and D would be directly connected with C, while A would be indirectly connected with C and D, and so on.

[4] The identification of components and all the subsequent network analysis has been carried out with UCINET IV (1992).

Table 1: Characteristics of the Regions in Europe with participants in the BRITE/EURAM program 1990

Code	**Region**	Number of Patents	Number of Main Contractors	Number of Participants in Networks	Population (thousands)	GDP per person ECUs – 1985 (EUR12=100)
	Belgium	155	5	41	9,967.4	103
	Denmark	133	6	26	5,139.9	145
	France					
fra	Alsace	18	0	7	1,627.6	122
frb	Aquitaine	10	0	2	2,803.0	116
frc	Auvergne	0	1	2	1,321.4	94
frj	Languedoc Roussillon	1	0	2	2,124.8	93
frk	Limousin	2	1	1	722.6	93
frl	Lorraine	43	3	6	2,305.4	102
frn	Nord Pas De Calais	22	0	3	3,966.8	99
frp	Haute-Normandie	15	0	1	1,740.8	129
frq	Paris (Region)	2104	16	90	10,692.0	180
frr	Pays de Loire	27	1	6	3,064.6	102
frs	Picardie	22	0	3	1,814.2	105
fru	Provence, Cote d’Azur, Alpes	15	0	1	4,273.6	110
frv	Rhone Alpes	160	5	30	5,368.0	120
	Germany					
de01	Baden-Wuerttemberg	1,018	5	33	9,726.2	136
de02	Bayern	1,046	7	29	11,334.8	129
de03	Bremen	33	2	6	679.2	166
de04	Hamburg	70	1	4	1,640.9	212
de05	Hessen	503	6	16	5,717.0	146
de06	Nidersachsen	222	6	15	7,340.4	111
de07	Nordrhein-Westfalen	1,472	6	32	17,243.6	126
de08	Rheiland-Pfalz	209	0	2	3,733.8	114
de09	Saarland	31	0	1	1,070.2	121
de10	Schleswig-Holstein	65	0	1	2,614.2	108
de11	Berlin	32	1	5	3,420.2	146

Table 1: Characteristics of the Regions in Europe with participants in the BRITE/EURAM program 1990 (continued)

Code	**Region**	Number of Patents	Number of Main Contractors	Number of Participants in Networks	Population (thousands)	GDP per person ECUS – 1985 (EUR12=100)
	Greece					
gr35	Athens	5	1	14	3,506.4	36
	Rest of the country	3	0	8	6,582.3	42[a]
	Holland	525	13	43	14,951.5	111
	Italy					
it04	Campania	5	1	4	5,831.4	66
it05	Emilia-Romagna	52	1	4	3,952.2	120
it06	Friuli-Venezia Giulia	16	0	2	1,202.0	107
it07	Lazio	13	0	3	5,181.0	101
it08	Liguria	7	1	3	1,723.2	122
it09	Lombardia	203	2	12	8,925.8	122
it12	Piemonte	133	1	9	4,356.8	115
it13	Puglia	6	0	3	4,075.4	68
it16	Toscana	8	0	3	3,561.6	106
it20	Veneto	27	0	2	4,391.6	97
	Ireland	32	3	15	3,502.8	67
	Luxemburg	32	2	2	391.8	121
	Portugal	0	1	27	9,868.4	27
	Spain					
	Andalucía	0	0	1	6,919.8	42
	Cantabria	0	0	1	527.2	59
	Cataluña	24	3	8	6,007.6	61
	C. Valenciana	0	0	3	3,786.6	54
	Madrid	11	2	23	4,877.8	62
	Navarra	2	0	1	521.2	71
	País Vasco	11	3	15	2,129.2	66
	Castilla-León	0	0	1	2,625.8	54
	United Kingdom					
SW	South West	130	0	8	4,666.6	96
SE	South East	703	13	46	17,548	121
EA	East Anglia	277	6	18	2,059.0	100
EM	East Midlands	58	4	12	4,018.8	96
WM	West Midlands	600	7	21	5,219.2	93
NW	North West	113	1	7	6,388.6	95
YO	Yorkshire	104	5	13	4,951.8	93
NO	North	55	1	7	3,075.4	90
GBI	Northern Ireland	42	0	1	1,589.4	78
GBS	Scotland	45	2	8	5,102.4	96
GBW	Wales	45	0	3	2,881.4	87

Source: European Patent Office, CEE-DGXII (1991) and Eurostat.

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[a] Average for all the country

Table 2: Components within the whole set of participating institutions

Components	Participating institutions
1	1, 196, 346, 361, 381
2	All 439 other institutions not mentioned in the rest of rows.
3	14, 73, 105, 276, 373, 396
4	15, 142, 238, 357
5	16, 98, 223, 407
6	101, 462
7	120, 356, 365
8	184, 278, 297, 340, 479
9	194, 268
10	230, 231, 239, 299
11	232, 261, 432
12	287, 292
13	309, 345
14	343, 344
15	374
16	419, 438, 439, 458

Note: Institutions IDs are available upon request.

nents. The institutions in components 1 and 3–16 partner (directly or indirectly) only with the institutions in the same component. For instance, institution 374 in component 15 belongs to a network composed only by itself, and it belongs to no other network in our sample. We grouped components 1 and 3–16 into a single block, which, for obvious reasons, we called the "Isolated" block.

We then studied whether component 2 could be partitioned into finer blocks. We first analyzed the relationships among the institutions in this component with 3 or more participations. These are shown in Figure 1. The figure helps to visualize how we obtained finer blocks within component 2. First, there are two main sub-components of highly interconnected institutions. The institutions in the left section of the figure are highly interconnected. The institutions in the right section are also well interconnected. But the two sets are not well interconnected between them. They are connected only by two institutions, 25 and 377. We called these two sets of institutions ”Hub1” and ”Hub2” because they are central to a large number of connections formed by the networks in this program. Institutions 25 and 377 form instead a group that we called "Bridge". These are participants that are not central in the network grid, but that connect the two hubs. In figure 1 there are also institutions represented on the right hand side of the picture as isolated nodes. We called the block formed by these institutions the "Semi–isolated" block. These

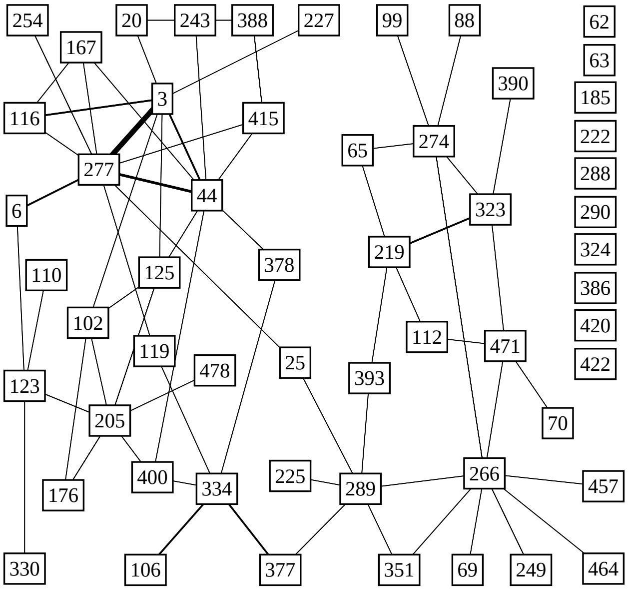

Figure 1: Network connections of institutions with more than 2 participations (Component 2)

are institutions with 3 or more participations that are only indirectly connected to the hubs. Finally, we labeled the institutions with only one or two participations “Periphery”, because of their marginal position in the BE networks.

2.5 Analyzing the blocks

To summarize, we grouped all the institutions participating in BE during 1990 in 6 blocks. These are:

Block 1: Isolated (49 participants)

Block 2: Semi-Isolated (124 participants)

Block 3: Hub1 (78 participants)

Block 4: Hub2 (56 participants)

Block 5: Periphery (132 participants)

Block 6: Bridge (49 participants)

We shall now describe the institutions belonging to these blocks according to the following dimensions: a) technological quality of the regions of the participants, and average technological quality of the main contractors of the networks in which they participate; b) type of participants (i.e. whether private firms, or public institutions or research laboratories); c) average size of the networks where the partners participate and average individual cost of projects.

We operationalized these dimensions using the following variables:

a) technological quality of the regions of the partners (QUAL);

b) average technological quality of main contractor, computed over the networks wherein the institution participates (QMAIN);

c) type of participants (TYPE), using the following classification: big (Big firms); sme (Small–medium firms); edu (academic institutions); rpr (private research laboratories); rpu, rmx (public research laboratories); oth (other institutions);

d) index of "privateness" of the networks where the partners participate, defined as an average of the proportion of firms over the total number of participants in each network where the institution participates (PRIVAT);

e) the average size of the networks where each institution participates (SIZE);

f) the average cost per participant of all the networks in which a given institution participates (COST).

TYPE and PRIVAT account for the type of participants. Particularly we look at whether each block is characterized by networks that are co-ordinated by firms or not, and the extent to which they are predominately "private" or "public" (or mixed). SIZE and COST measure of the dimension of the networks. Although they are clearly correlated, they span different characteristics. There could be networks with many partners, each of them contributing to a relatively small share of the project. Other networks may have fewer participants, but each of them may perform a considerable amount of activities.

To define QUAL and QMAIN we ranked our regions according to their total number of patents in our three classes, and divided them in 10 groups. These correspond to the deciles of the patent distribution by region. Thus the 10 groups are of approximately the same size – i.e. similar number of regions. Group 1 corresponds to the regions with the lowest number of patents, whereas group 10 corresponds to the highest number of patents. This gives us a direct measure of the technological quality of the region of each participant. We then computed an average of the quality of the main contractors of the networks where each partner participated.

Table 3: Descriptive Statistics for the Quality, Size, and Cost of the Networks

Variable	Mean	Standard Deviation	Min.	Median	Max.	Range 75-25 %
Average size of networks (SIZE)	6.12	2.43	1	5.67	14	2.19
Quality of participants (QUAL)	7.79	2.79	1	9	10	4
Average quality of main contractors (QMAIN)	8.48	2.25	1	9.31	10	2
Average proportion of firms within the networks (PRIVAT)	0.54	0.29	0	0.56	1	0.38
Average individual cost of projects (1,000 Ecus) (COST)	345	241	0	294	1,445	305

We used these groups as a measure of the technological capability of the region, and we call it *quality*, as it represents a discrete scalar indicator of the technological capabilities of the region of origin of each participant.

Table 3 provides descriptive statistics for all our numerical variables.

The different characteristics of our blocks in terms of the variables defined above can be visualized using correspondence analysis on the frequency tables computed for each variable. Correspondence analysis is a multivariate statistical technique used to study the association of variables within a contingency table. Tables 4-9 below present the frequency table for each variable. Figures 2-7 in the Appendix present the symmetric correspondence map for these tables.

We begin by discussing the technological quality of the regions of the partners and main contractors. Table 4 reports the number of institutions in each block that belong to the different regional patent classes.

The table also reports the relative frequency of the number in each cell over the total number of institutions in our sample, as well as the percentages over the totals by row and by column.

The way to read this and the following tables is to look at the distribution of participants in the categories showed in the corresponding columns. Moreover, one can compare the row or column percentages in each cell. This would suggest

Table 4: Regional quality of the participants (QUAL)

Block	Quality group of the participants										
Frequency Percent Row Pct. Col. Pct	1	2	3	4	5	6	7	8	9	10	Total
Isolated	0	3	3	2	0	5	3	2	13	18	49
	0.0	0.6	0.6	0.4	0.0	1.0	0.6	0.4	2.7	3.7	10.0
	0.0	6.1	6.1	4.1	0.0	10.2	6.1	4.1	26.5	36.7	
	0.0	13.6	15.0	10.5	0.0	23.8	12.5	4.6	12.9	9.3	
Semi-isolated	8	8	4	6	7	3	2	11	29	46	123
	1.6	1.6	0.8	1.2	1.4	0.6	0.4	2.3	5.9	9.4	25.5
	6.5	6.5	3.2	4.8	5.7	2.4	1.6	8.9	23.4	37.1	
	38.1	36.4	20.0	31.6	30.4	14.3	8.3	25.6	28.7	23.7	
Hub1	0	2	1	1	0	3	4	10	21	36	78
	0.0	0.4	0.2	0.2	0.0	0.6	0.8	2.1	4.3	7.4	16.0
	0.0	2.6	1.3	1.3	0.0	3.9	5.1	12.8	26.9	46.2	
	0.0	9.1	5.0	5.3	0.0	14.3	16.7	23.3	20.8	18.6	
Hub2	2	3	2	0	4	1	3	8	8	25	56
	0.4	0.6	0.4	0.0	0.8	0.2	0.6	1.6	1.6	5.1	11.5
	3.6	5.4	3.6	0.0	7.1	1.8	5.4	14.3	14.3	44.6	
	9.5	13.6	10.0	0.0	17.4	4.8	12.5	18.6	7.9	12.9	
Periphery	9	5	6	8	11	4	10	9	24	46	132
	1.8	1.0	1.2	1.6	2.3	0.8	2.1	1.8	4.9	9.4	27.1
	6.8	3.8	4.6	6.1	8.3	3.0	7.6	6.8	18.2	34.9	
	42.9	22.7	30.0	42.1	47.8	19.1	41.7	20.9	23.8	23.7	
Bridge	2	1	4	2	1	5	2	3	6	23	49
	0.4	0.2	0.8	0.4	0.2	1.0	0.4	0.6	1.2	4.7	10.0
	4.1	2.0	8.2	4.1	2.0	10.2	4.1	6.1	12.2	46.9	
	9.5	4.6	20.0	10.5	4.4	23.8	8.3	7.0	5.9	11.9	
Total	21	22	20	19	23	21	24	43	101	194	488
	4.3	4.5	4.1	3.9	4.7	4.3	4.9	8.8	20.7	39.8	100

whether, in the given block, the corresponding category in the column has a higher relative frequency than the relative frequency of the block (utmost right column in each table) or than the relative frequency of that category (last row of the table). In brief, we shall be looking at the relative frequencies conditional upon block and category, and compare them with the relative frequencies conditional only upon category (total of column) or block (total of row). This interpretation is reinforced by the visualization of the correspondence maps.

As one can see from Table 4, the distribution of participants in all blocks, in terms of regional patent classes, is skewed towards the right. This is because most participants in our program come from advanced regions. (See the descriptive statistics in Table 3.) But the share of the low quality regions varies across blocks.

Table 4 shows that Hub1 is associated with institutions coming from high-quality regions. This can be seen in various ways. First, note that Hub1, Hub2, and Bridge show a higher share of institutions coming from the most patent-intensive region, region 10, than the average share of institutions coming from region 10 in the entire sample – i.e., respectively, 46%, 45%, and 47% vs 40%, which is the frequency computed for the total of column 10. By conditioning upon any of these three blocks, the relative frequency of the top high-tech region is higher than the unconditional relative frequency for that region. At the same time, the relative frequency of regions 9 or 10 for Hub1 is about 73%, well above the relative frequency of regions 9 or 10 for the entire sample, which is about 50%. No other group (including Hub2 or Bridge) has a relative frequency of the top two patent-intensive regions as high as Hub1. Note also that, by conditioning on region 10, Hub1 shows a higher relative frequency (19%) than the unconditional one (16%). Finally, the Isolated, Semi-Isolated, and Periphery blocks show a high relative frequency for some of the low-tech regional classes. These groups then include a good fraction of institutions coming from technologically less advanced areas.

In Table 5, and Figure 3 in the Appendix, we present the composition of our blocks according to the average quality of the main contractors of the networks to which the institutions belong (QMAIN).

Hub1 and Hub2 are associated with main contractors coming from technologically advanced regions. For instance, the relative frequency of region 10 for Hub1 and Hub2 is 65% and 64% respectively, and they are the only two blocks whose relative frequency for region 10 is higher than the unconditional one for that region (50%). By contrast, the Periphery block shows a high relative frequency of institutions from technologically less advanced regions (e.g. groups 0-1, 2-3, and 4-5). Similarly, the Isolated block has a high relative frequency for the class 1-2, as well as moderately high frequencies for some of the intermediate classes. The Semi-Isolated block also exhibits relatively high frequencies for the lower techno-

Table 5: Regional quality of main contractors (QMAIN)

Block	Average quality of main contractors										
Frequency Percent. Row Pct. Col. Pct.	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Sum
Isolated	0	4	0	0	0	2	2	1	17	23	49
	0.0	0.8	0.0	0.0	0.0	0.4	0.4	0.2	3.5	4.7	10.0
	0.0	8.2	0.0	0.0	0.0	4.1	4.1	2.0	34.7	46.9	
	0.0	25.0	0.0	0.0	0.0	9.5	10.0	2.5	16.8	9.3	
Semi-isolated	0	11	2	3	2	4	4	12	31	55	124
	0.0	2.3	0.4	0.6	0.4	0.8	0.8	2.5	6.4	11.3	25.4
	0.0	8.9	1.6	2.4	1.6	3.2	3.2	9.7	25.0	44.3	
	0.0	68.8	12.5	50.0	13.3	19.1	20.0	29.3	30.7	22.2	
Hub1	0	0	0	1	0	3	3	4	16	51	78
	0.0	0.0	0.0	0.2	0.0	0.6	0.6	0.8	3.3	10.5	16.0
	0.0	0.0	0.0	1.3	0.0	3.9	3.9	5.1	20.5	65.4	
	0.0	0.0	0.0	16.7	0.0	14.3	15.0	9.8	15.8	20.6	
Hub2	1	0	1	0	1	1	1	6	9	36	56
	0.2	0.0	0.2	0.0	0.2	0.2	0.2	1.2	1.8	7.4	11.5
	1.8	0.0	1.8	0.0	1.8	1.8	1.8	10.7	16.1	64.3	
	25.0	0.0	6.3	0.0	6.7	4.8	5.0	14.6	8.9	14.5	
Periphery	3	0	11	1	11	6	8	11	22	59	132
	0.6	0.0	2.3	0.2	2.3	1.2	1.6	2.3	4.5	12.1	27.1
	2.3	0.0	8.3	0.8	8.3	4.6	6.1	8.3	16.7	44.7	
	75.0	0.0	68.8	16.7	73.3	28.6	40.0	26.8	21.8	23.8	
Bridge	0	1	2	1	1	5	2	7	6	24	49
	0.0	0.2	0.4	0.2	0.2	1.0	0.4	1.4	1.2	4.9	10.0
	0.0	2.0	4.1	2.0	2.0	10.2	4.1	14.3	12.2	49.0	
	0.0	6.3	12.5	16.7	6.7	23.8	10.0	17.1	5.9	9.7	
Sum	4	16	16	6	15	21	20	41	101	248	
	0.8	3.3	3.3	1.2	3.1	4.3	4.1	8.4	20.7	50.8	100

logical classes, although both Isolated and Semi-Isolated show a good number of institutions in group 8-9 as well. Finally, the Bridge block is associated with main contractors of intermediate technology classes (5-6, 6-7, and 7-8).

By combining these results with those in the previous table, the two Hubs associate high-quality institutions with high-quality main contractors. Moreover, while both blocks have relatively higher frequencies of main contractors coming from high-tech regions, Hub1 also shows a slightly higher frequency of partners coming from the most patent-intensive areas. One can fairly say that both the Hub1 and Hub2 institutions come to a good extent from high-tech regions, and they match with partners coming from regions with similar technological capabilities. By contrast, the relationships between quality of partners and main contractors in the other blocks is more mixed, with larger relative frequencies of partners and main contractors coming from technologically less advanced regions.

These findings confirm those of our previous paper (Gambardella and Garcia-Fontes, 1996) in which main contractors coming from advanced regions attracted partners coming from advanced regions and vice versa. Here, however, it is also interesting to note that the networks composed of partners coming from less advanced regions are ”semi-isolated” or ”peripheral”. Not only does this suggest that the mixing of institutions with different technological capabilities was not pronounced in this program, but also that there are strong ties among partners coming from advanced regions, while institutions coming from less R&D-intensive parts of the Community remained at the margin of the set of interconnected relationships in our sample.

In Table 6 and Figure 4 we analyze the association between our blocks and the types of participants (big or small-medium firm, universities, etc.). The notable feature in this case is the distinction between Hub1 and Hub2. The former shows a higher relative frequency of larger firms. Big firms represent about 40% of the institutions in Hub1, whereas the (unconditional) fraction of big firms in the program is about 27%. Similarly, the share of big firms in Hub1 is 23%, whereas the unconditional share of Hub1 institutions in the program is 16%. Hub1 also presents a share of small-medium firms and private research institutions around the average for the entire sample. There are also some universities and public research centers in these networks, but their relative frequency is slightly below the sample average. Hub1 is then a set of interconnected networks and institutions centered around private agents, particularly big firms. This also suggest that these networks focus on large projects of technological development, which are typically carried out by large companies, with smaller firms, research institutions and universities providing specialized research and technological services.

Table 6: Type of the Participants (TYPE)

Block Frequency Percent. Row Pct. Col. Pct.	Type of participating institutions							
	big	edu	oth	rmx	rpr	rpu	sme	Sum
Isolated	9	8	2	1	0	5	24	49
	1.8	1.6	0.4	0.2	0.0	1.0	4.9	10.0
	18.4	16.3	4.1	2.0	0.0	10.2	49.0	
	6.8	7.6	18.2	9.1	0.0	8.3	15.5	
Semi-isolated	26	28	3	5	5	14	43	124
	5.3	5.7	0.6	1.0	1.0	2.9	8.8	23.4
	21.0	22.6	2.4	4.0	4.0	11.3	34.7	
	19.6	26.7	27.3	45.5	38.5	23.3	27.7	
Hub1	31	13	1	0	2	8	23	78
	6.4	2.7	0.2	0.2	0.4	1.6	4.7	16.0
	39.7	16.7	1.8	1.8	2.6	10.3	29.5	
	23.3	12.4	9.1	9.1	15.4	13.3	14.8	
Hub2	17	20	1	1	2	8	7	56
	3.5	4.1	0.2	0.2	0.4	1.6	1.4	11.5
	30.4	35.7	1.8	1.8	3.6	14.3	12.5	
	12.8	19.1	9.1	9.1	15.4	13.3	4.5	
Periphery	36	22	3	1	2	18	50	132
	7.4	4.5	0.6	0.2	0.4	3.7	10.3	27.1
	27.3	16.7	2.3	0.8	1.5	13.6	37.9	
	27.1	21.0	27.3	9.1	15.4	30.0	32.3	
Bridge	14	14	1	3	2	7	8	49
	2.9	2.9	0.2	0.6	0.4	1.4	1.6	10.0
	28.6	28.6	2.0	6.1	4.1	14.3	16.3	
	10.5	13.3	9.1	27.3	15.4	11.7	5.2	
Sum	133	105	11	11	13	60	155	488
	27.3	21.5	2.3	2.3	2.7	12.3	31.8	100.0

Note: big : Big firms; sme : Small–medium firms; edu : academic institutions; rpr: private research laboratories; rpu, rmx: public research laboratories; oth: other institutions.

Among the Hub2 institutions instead, the relative frequency of universities is higher than average. Big firms, small firms and public research centers also exhibit a higher frequency than average, although not as pronounced as universities. The relative frequencies of all other institutional types is below the average for the block as a whole. Hence, Hub2 appears to be centered around universities. Correspondingly, these networks are likely to lean towards the basic research end of the spectrum. Firms, whether large or small, participate to the extent that they are interested in ”monitoring” the research that is going on inside the scientific community, and to the extent that they are performing themselves research of a more basic nature. Thus, most interestingly, the distinction between Hub1 and Hub2 is largely along public-private lines. The Isolated block is associated with small-medium firms, and ”other” institutions. This is the main characteristic of these networks. These are small-medium sized firms and other institutions that participate only occasionally in EU R&D tenders, and that are not linked to the core networks and institutions (Hub1 and Hub2). The Semi-Isolated group shows a higher relative frequency of universities, research centers and small-medium firms. The institutions in the Periphery block are spread across different types, with small-medium firms and public research institutions showing a slightly more pronounced participation. Finally, Bridge is associated with private and public research centers, and with universities.

As far as privateness is concerned, Table 7 and Figure 5 show that the Isolated block is either very “private” or very ”public”. This suggests that these are really ”isolated” groups of homogeneous institutions (either private or public) which are formed to create these networks, but that do not have significant interactions with other institutions in the program. The Periphery and Semi-isolated blocks are associated with the 0.2–0.4 and 0.4–0.6 levels, which suggests that there is a good mix of private and public organizations in these networks. Bridge is slightly more ”public”. Hub1 instead is associated with an index of privateness between 0.6–0.8, which follows from our earlier discussion about the role of firms in these networks. For the same reasons, Hub2 is more public, and it is associated with indices of privateness between 0 and 0.2. In both Hub1 and Hub2 however there are non-negligible frequencies of networks that are either more private or more public. This suggests that the two hubs do mix partners of different types. Indeed, as discussed earlier, some universities participate in Hub1 networks as provider of specialized services, and some firms participate in Hub2 networks.

Tables 8 and figure 6 look at the average size of the networks wherein the partners participate. The Isolated block is associated with networks with small number of participants (0–2, 2–4). Hub1, Semi-isolated and Bridge participate in networks of large size (6–8 and 8–10 participants), while the Hub2 institutions belong to smaller networks (2–4, 4–6). The Periphery institutions show a high proportion of

Table 7: Proportion of firms within the networks (PRIVAT)

Block	Proportion of firms					
Frequency Percent. Row Pct. Col Pct.	0–0.2	0.2–0.4	0.4–0.6	0.6–0.8	0.8–1	Sum
Isolated	13	0	0	7	29	49
	2.7	0.0	0.0	1.4	5.9	10.0
	26.5	0.0	0.0	14.3	59.2	
	17.8	0.0	0.0	5.5	31.2	
Semi-isolated	17	17	49	30	11	124
	3.5	3.5	10.0	6.2	2.3	25.6
	13.7	13.7	39.5	24.2	8.9	
	23.3	24.6	38.9	23.6	11.8	
Hub1	6	6	15	38	13	78
	1.2	1.2	3.1	7.8	2.7	16.0
	7.7	7.7	19.2	48.7	16.7	
	8.2	8.7	11.9	29.9	14.0	
Hub2	19	9	13	11	4	56
	3.9	1.8	2.7	2.3	6.8	27.1
	33.9	16.1	23.2	19.6	25.0	
	26.0	13.0	10.3	8.7	35.5	
Periphery	12	26	29	32	33	132
	2.5	5.3	5.9	6.6	6.8	27.1
	9.1	19.7	22.0	24.2	25.0	
	16.4	37.7	23.0	25.2	35.5	
Bridge	12	26	29	32	33	132
	1.2	2.3	4.1	1.8	0.6	10.0
	12.2	22.5	40.8	18.4	6.1	
	8.2	15.9	15.9	7.1	3.2	
Sum	73	69	126	127	93	488
	15.0	14.1	25.8	26.0	19.1	100.0

Table 8: Average size of networks

Block	Average size (SIZE)						
Frequency Percent. Row Pct. Col. Pct	0–2	2–4	4–6	6–8	8–10	>10	Sum
Isolated	11	22	16	0	0	0	49
	2.3	4.5	3.3	0.0	0.0	0.0	10.0
	22.5	44.9	32.7	0.0	0.0	0.0	
	64.7	24.7	7.4	0.0	0.0	0.0	
Semi-isolated	2	19	50	28	18	7	124
	0.4	3.9	10.3	5.7	3.7	1.4	25.4
	1.6	15.3	40.3	22.6	14.5	5.7	
	11.8	21.4	23.3	31.5	36.0	25.0	
Hub1	1	10	32	22	10	3	78
	0.2	2.1	6.6	4.5	2.1	0.6	16.0
	1.3	12.8	41.0	28.2	12.8	3.9	
	5.9	11.2	14.9	24.7	20.0	10.7	
Hub2	2	12	38	3	1	0	56
	0.4	2.5	7.8	0.6	0.2	0.0	11.5
	3.6	21.4	67.9	5.4	1.8	0.0	
	11.8	13.5	11.7	3.4	2.0	0.0	
Periphery	1	21	57	22	14	17	132
	0.2	4.3	11.7	4.5	2.9	3.5	27.1
	0.8	15.9	43.2	16.7	10.6	12.9	
	5.9	23.6	26.5	24.7	28.0	60.7	
Bridge	0	5	22	14	7	1	49
	0.0	1.0	4.5	2.9	1.4	0.2	10.0
	0.0	10.2	44.9	28.6	14.3	2.0	
	0.0	5.6	10.2	15.7	14.0	3.6	
Sum	17	89	215	89	50	28	488
	3.5	18.2	44.1	18.2	10.3	5.7	100

very large networks (greater than 10). Finally, table 9 and 7 show the association of our blocks and the average cost per participants in the project.

The Isolated block consists of participants with high average costs, while the Semi-isolated block consists of participants with low average costs. In all other blocks, the average cost per participant is spread, suggesting that the institutions in each network either cover a large share of the work, or they simply perform some specialized tasks. This would be consistent, for instance, with our earlier interpretation of the activities in the Hub1 and Hub2 networks, wherein big firms or universities are the leading partners, and the other institutions perform specialized services.

3 Discussion

The characteristics of our blocks are summarized in Table 10.

The most apparent feature of the table is indeed the distinction between the two Hubs and the other blocks. Hub1 and Hub2 cover about one fourth of our sample of institutions – 16% and 11.5% respectively. As discussed earlier, these are two sets of highly interconnected institutions, which are linked either directly or indirectly through many networks. This means that they are sometimes main contractors and sometimes partners of networks which are composed, by and large, of subsets of institutions belonging to the same Hub. Most notably, these institutions came predominately from technologically advanced regions.

The distinction between the two Hubs and the other blocks deserves further attention. In the first place, it suggests that complementarity in technological quality is an important determinant of the formation of research partnerships. This is probably not surprising, but it is not a trivial matter in the context of European research policy. For one reason, our result is consistent with the stated objectives of many EU R&D programs that the main criterion for selecting proposals is the quality of the project [5]. ”Cohesion” and more generally the match of higher and lower quality institutions is encouraged only as a subordinate criterion. This implies that the institutions applying to these programs form partnerships by taking into account primarily the potential quality of their partners, and hence – if complementarities in technological capabilities are important – by looking primarily at the expected outcome of the overall project. High quality institutions then seek partnerships with other high quality institutions, and the linkage with less advanced regions is a less fundamental concern.

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[5] For the BE program that we examined in this paper see for instance CEC, 1993, p.12.

Table 9: Average cost of participants (1,000 Ecus)

Block	Average cost (COST)					
Frequency Percent. Row Pct. Col. Pct	0–250	250–500	500–750	750–1,000	> 1,000	Sum
Isolated	15	16	11	2	5	49
	3.1	3.3	2.3	0.4	1.0	10.0
	30.6	32.7	22.5	4.1	10.2	
	7.3	8.9	16.4	7.7	50.0	
Semi-isolated	65	45	12	2	0	124
	13.3	9.2	2.5	0.4	0.0	25.4
	54.4	36.3	9.7	1.6	0.0	
	31.6	25.1	17.9	7.7	0.0	
Hub1	20	37	14	5	2	78
	4.1	7.6	2.9	1.0	0.4	16.0
	25.6	47.4	18.0	6.4	2.6	
	9.7	20.7	20.9	19.2	20.0	
Hub2	25	23	4	3	1	56
	5.1	4.7	0.8	0.6	0.2	11.5
	44.6	41.1	7.1	5.4	1.8	
	12.1	12.9	6.0	11.5	10.0	
Periphery	67	34	22	8	1	132
	13.7	7.0	4.5	1.6	0.2	27.1
	50.7	25.8	16.7	6.1	0.8	
	32.5	19.0	32.8	30.8	10.0	
Bridge	14	24	4	6	1	49
	2.9	4.9	0.8	1.2	0.2	10.0
	28.6	49.0	8.2	12.2	2.0	
	6.8	13.4	6.0	23.1	10.0	
Sum	206	179	67	26	10	488
	42.2	36.7	13.7	5.3	2.1	100

Table 10: Summary characteristics of the blocks

	Quality		Type		Size and Cost	
Blocks	Quality of participants	Average quality of main contractor	Type of participant	Private–ness	Size	Cost
1.ISOLATED (49 participants)	+	++	S,O	PR or PB	VS	H
2. SEMI-ISOLATED (124 participants)	+	++	E,R,S	MIX	LAR	L
3, Hub1 (78 participants)	+++	+++	B (S,RPR)	PR(-)	LAR	SPREAD
4, Hub2 (56 participants)	++	+++	E(B,S,RPU)	PB(-)	S	SPREAD
5. Periphery (132 participants)	+	+	MIXED	MIXED	VL	SPREAD
6. Bridge (49 participants)	++	++	MIXED	PB(–)	LAR	AV

H:high, , L:low, AV:average, S:small, LAR: Large, SS:very small, LL=very large
B:big firm, S:small–medium firm, E:educational, R:research lab
+, ++, +++ denote low, medium, high technological quality, (-) and (–) are qualifying signs, for instance PB(-) means ”public” but with some ”private” participations

At the same time, although Hub1 is centered around big firms, it also includes some smaller firms and research centers, and the corresponding networks are not completely ”private”, as shown at Table 7. Similarly, although centered around universities, the Hub2 networks include firms, and they are not completely ”public”. Thus, the two hubs also mix complementary institutional types, and they take advantage of the complementarity in the specialized expertise of different institutions [6]. Finally, note that while on average the Hub1 networks are large, the Hub2 networks are small. The former are most likely concerned with large industrial projects of technological development, which typically require a vast number of specialized assets and expertise. The Hub2 projects, which most likely focus on scientific research objectives, are typically accomplished by ”selected” groups of institutions.

One can speculate that groups of highly interconnected institutions, like Hub1 or Hub2, would probably be found in other EU research programs as well. More generally, research interactions in Europe are likely to occur primarily among restricted sets of qualified groups in well defined regions. This may have notable implications for innovation, technological development and economic growth in Europe. On the one hand, the formation of high quality networks is clearly a beneficial result of EU research programs, as this means that these programs do encourage high-quality research. Moreover, this suggests that the allocation of resources in EU R&D tenders does not necessarily follow ”national” and therefore ”political” boundary lines, but it is influenced by ”true” scientific and technological concerns. On the other hand, by encouraging linkages among high quality regions, these programs could reinforce differences in scientific and technological capabilities between the top regions of the Community and the others. For instance, this could give rise to what in other context as been labeled the ”Matthew effect” (Merton, 1958 ; see also David, 1994) – that is research group may develop differential capabilities over time not because of real differences in ”latent”, underlying quality variables, but because of the reinforcing effects produced by differences in initial conditions. Simply put, these programs could generate greater divergence in technological quality between the top and the average European regions than one would observe without them.

The Bridge institutions also play an interesting role in our program. They constitute about 10% of the institutions in the sample. As suggested in the previous section, these are institutions that belong both to networks composed of Hub1 institutions and to networks of Hub2 institutions. They may then act as a ”trans-

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[6] The spread of technological assets and services in the Hub1 and Hub2 networks is also illustrated by the fact that the participating institutions in these networks have different average costs, as was shown in Table 9. As noted earlier, this suggests that there are institutions that perform central tasks in the project, and institutions that perform specialized services.

mission mechanism” between the two Hubs. By working with Hub1 institutions they acquire information and gain expertise in technological development projects; by working in Hub2 projects they gain similar information and expertise in more scientific projects managed by universities. Apart from the presence of scientific institutions in Hub1 networks or of firms in Hub2 networks, the transfer of knowledge and other information between university and industry may then occur also because of the role played by the Bridge institutions. Moreover, although these institutions are slightly more ”public” (see Table 10 as well as Tables 6 and 7), they comprise a fair amount of different institutional types. The function of bridging the gap between high quality scientific research and high quality technological development projects is sometimes performed by public research centers like universities, and some other times by ”private” agents like small-medium or big firms.

Bridge, Hub1 and Hub2, which represent slightly less than 40% of the institution in our program, are then a set of institutions linked directly and indirectly in various ways. The institutions in each of the two Hubs are connected to each other, and the Bridge institutions connect the two. Moreover, a good share of the Bridge institutions also comes from fairly advanced regions – although some institutions from this block comes from less ”high-tech” regions as well (se Table 10, as well as Tables 4 and 5).

The institutions in these three blocks then provide a contrast with those in the other three blocks. Isolated, Semi-Isolated, and Periphery cover the remaining 60% of institutions in the program. As their names suggest they are not central to a large number of networks. They are linked primarily to the institutions in their own networks, and they are not highly interconnected with many other institutions. Most notably, both main contractors and partners from these institutions come predominately from regions that are technologically less advanced. As Table 10 suggests, they mix fairly different institutional types, and typically involve public as well as private research institutions. Thus, the only notable features of the institutions in these classes is indeed that they come from less high-tech areas of the Community.

Our findings about this program are therefore consistent with the idea of a ”two-speed” Europe, at least in research. Being from a technologically advanced region is a pre-condition for being ”plugged” in a larger set of interactions among institutions that partner among each other in many networks, or that link such high quality networks. By contrast, the institutions from less advanced regions belong, in large measure, to networks that are isolated or peripheral, in the sense of more limited direct and indirect linkages with a wider set of institutions. Ultimately, whether this distinction between highly ”linked” and more ”isolated” institutions is a desirable outcome of European research policy, is an open question. As we discussed in our previous paper (Gambardella and Garcia-Fontes, 1996), and as many EU R&D programs explicitly state, by favoring linkages between high quality institutions these programs are geared primarily towards enhancing the productivity of the funds invested in these research networks. This is because the networks composed of ”high-tech” institutions are more likely to produce better outcomes than linkages that encourage learning and transfer of knowledge and information between regions with higher and lower technological capabilities.

But the cost of attaining this larger output is a likely greater divergence between top research performers in the Community and other regions. In fact, as many authors pointed out, economic benefits from investments in research do not really arise from the generation of innovation, but from their development and commercialization on a large scale (e.g. Rosenberg, 1982). Moreover, successful development and commercialization of innovations often depend upon interactions with users since the early stages of the innovation process (Von Hippel, 1988). In this respect, if the sets of interconnected institutions comprises only few advanced regions, one wonders whether, from the point of view of widespread industrial competitiveness in the Continent, this process is taking advantage of broad interactions between users and producers of new technologies early enough in the innovation cycle. This would be an especially important concern for programs like BE which focuses on technologies like new material or manufacturing processes, that are germane to a large set of users and industrial applications. At the same time, one should note the limitation of our analysis, which focuses on one research program. The question is whether other research programs of the Community encourage the diffusion to a larger sets of regions of the results produced by the Hubs in programs like the one examined here. If anything, one would probably like to see, in this or in other programs, a greater percentage of Bridge institutions – but not just of institutions that bridge the two Hubs, but also of institutions that bridge the Hubs with the more ”isolated” classes of participants.

4 Conclusions

This paper studied the composition of the network financed by the EU Brite-Euram Program in 1990. We used network analysis to identify ”blocks” of institutions with similar characteristics, and correspondence analysis to identify the main characteristics of the six classes determined by the previous step.

Our main result is that in this program there were two sets of institutions that were highly connected with one another. These were connected because they formed several networks by partnering largely among each other. Moreover, while the first of these two ”hubs” is composed primarily by firms, and particularly by large firms, the second hub was centered around universities. We also found that a third class of institutions, which we labeled Bridge, belonged to either the Hub1 or Hub2 networks, thereby acting as ”links” between the two sets of institutions.

Most notably, a very large share of the institutions belonging to Hub1, Hub2, or Bridge came from the most high-tech regions of the Community. By contrast, the remaining 60% institutions in the program were classified in three classes, which we named Isolated, Semi-Isolated, and Periphery. Not only did a larger fraction of these institution come from less high-tech regions, but, as their names suggest, they were not interconnected with many other institutions in the program.

Our analysis suggested that, while the program appeared to be successful in encouraging partnership based on the complementarity of assets and capabilities of the participants, it was less effective in creating a larger set of interactions among institutions coming from a wider geographical base, and with more mixed scientific and technological skills. Put differently, the program enabled the creation of linkages that were mostly aligned with the incentives of agents to form partnerships with other agents of similar technological skills, and did not really alter these incentives.

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Appendix

A Correspondence analysis to visualize the association of the relevant variables and the clusters

Correspondence analysis is a multivariate technique useful to visualize the association between variables represented in contingency tables. We can think of the blocks as defining a contingency table for each relevant variable. The contingency tables are tables 4 through 9.

The principal output of correspondence analysis is a map where both the row variable, in this case the clusters, and the column variable, in this case variables related to the quality, the type, the size and cost of the networks, can be represented simultaneously. Association can be visualized by the corresponding deviation from the center of the map.

For each map we show the inertia, which shows the spread of the data across the map, and the quality of the map, which shows the explained variation of the data.

For the details on this procedure see Greenacre (1994).

Figure 2:

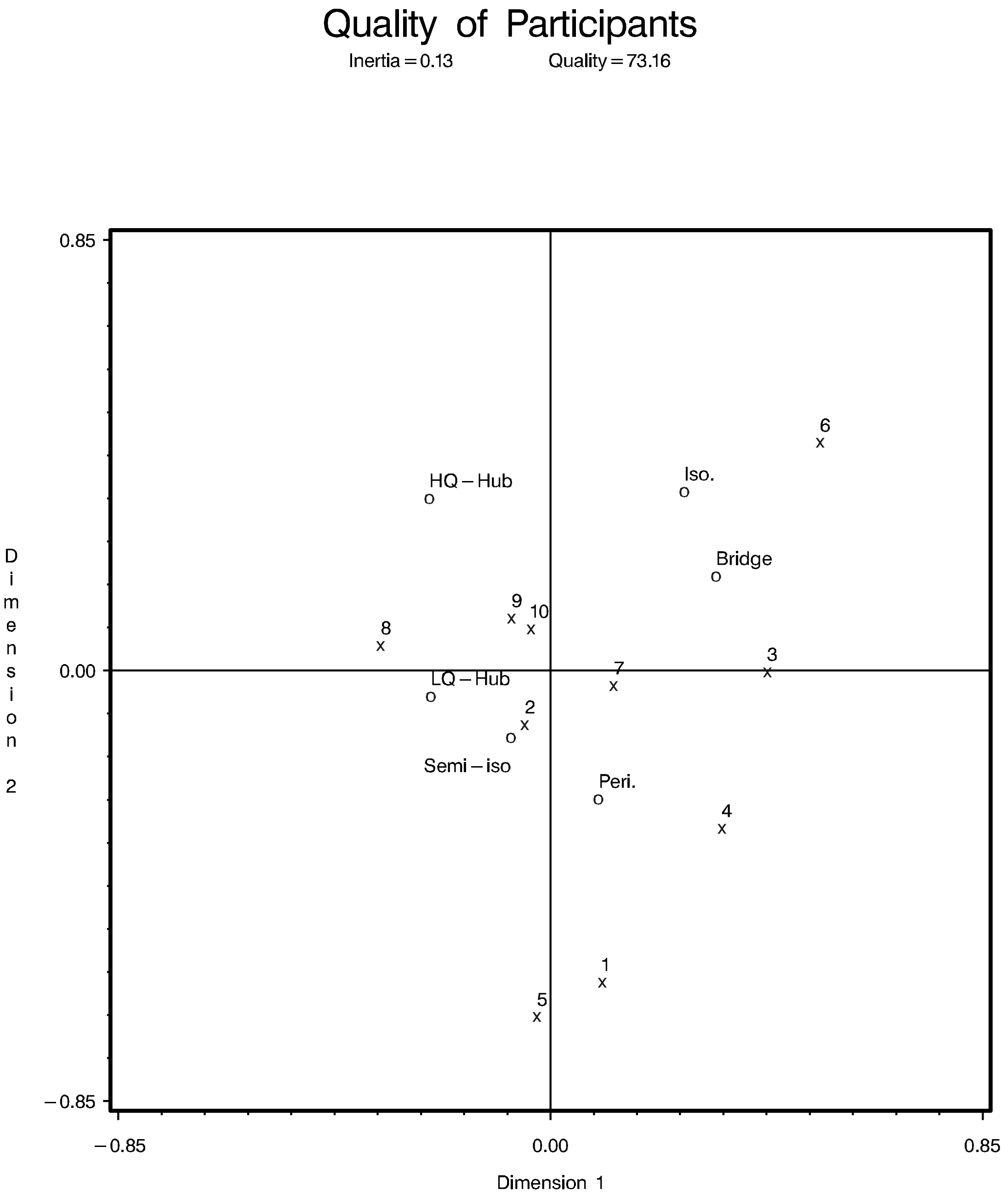
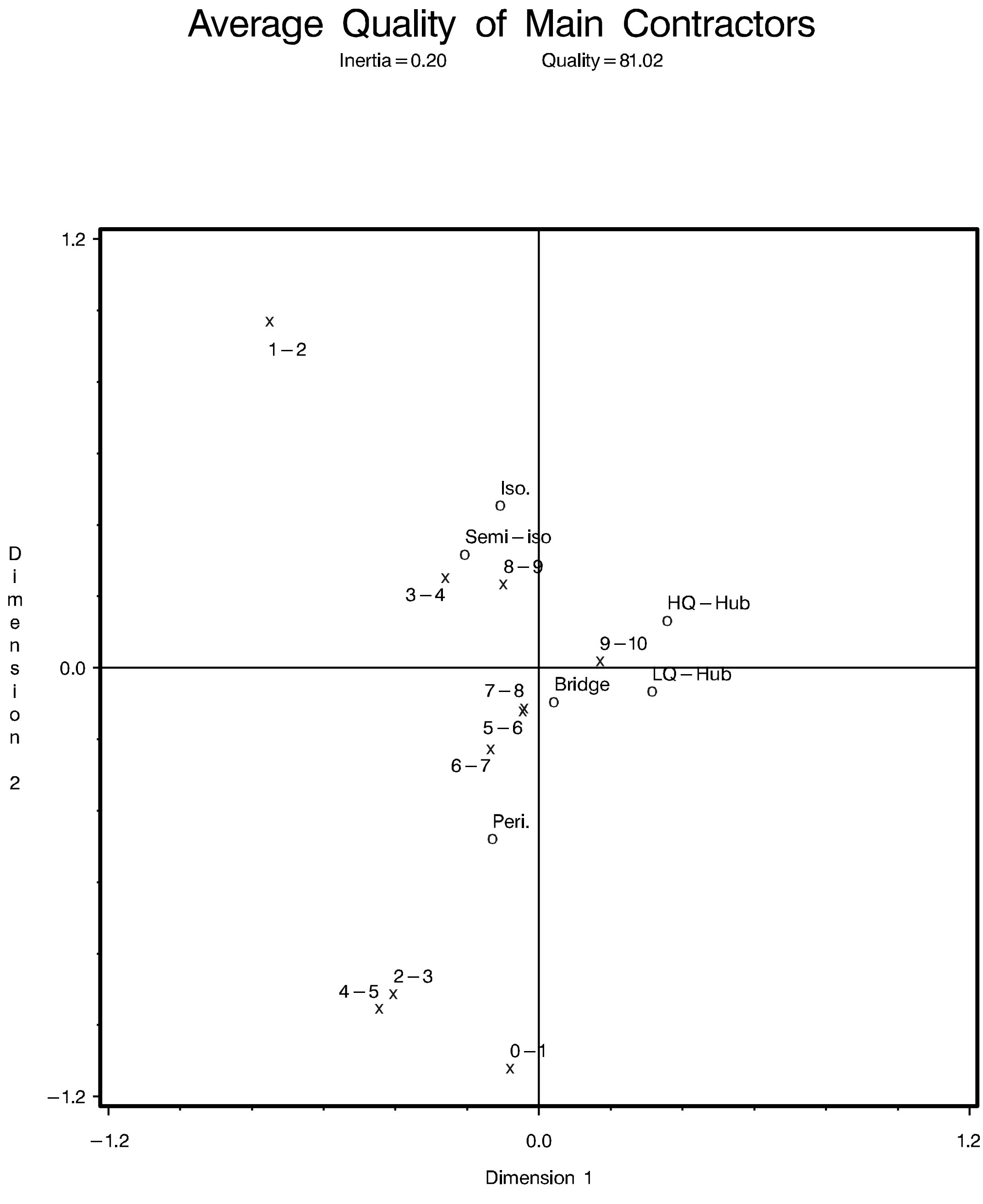

Quality of Participants
Inertia = 0.13
Quality = 73.16
0.85
0.00
−0.85
Dimension 2
−0.85
0.00
0.85
Dimension 1
HQ − Hub
Iso.
Bridge
LQ − Hub
Semi − iso
Peri.
1
2
3
4
5
6
7
8
9
10

Figure 3:



Average Quality of Main Contractors

Inertia = 0.20 Quality = 81.02

Figure 4:

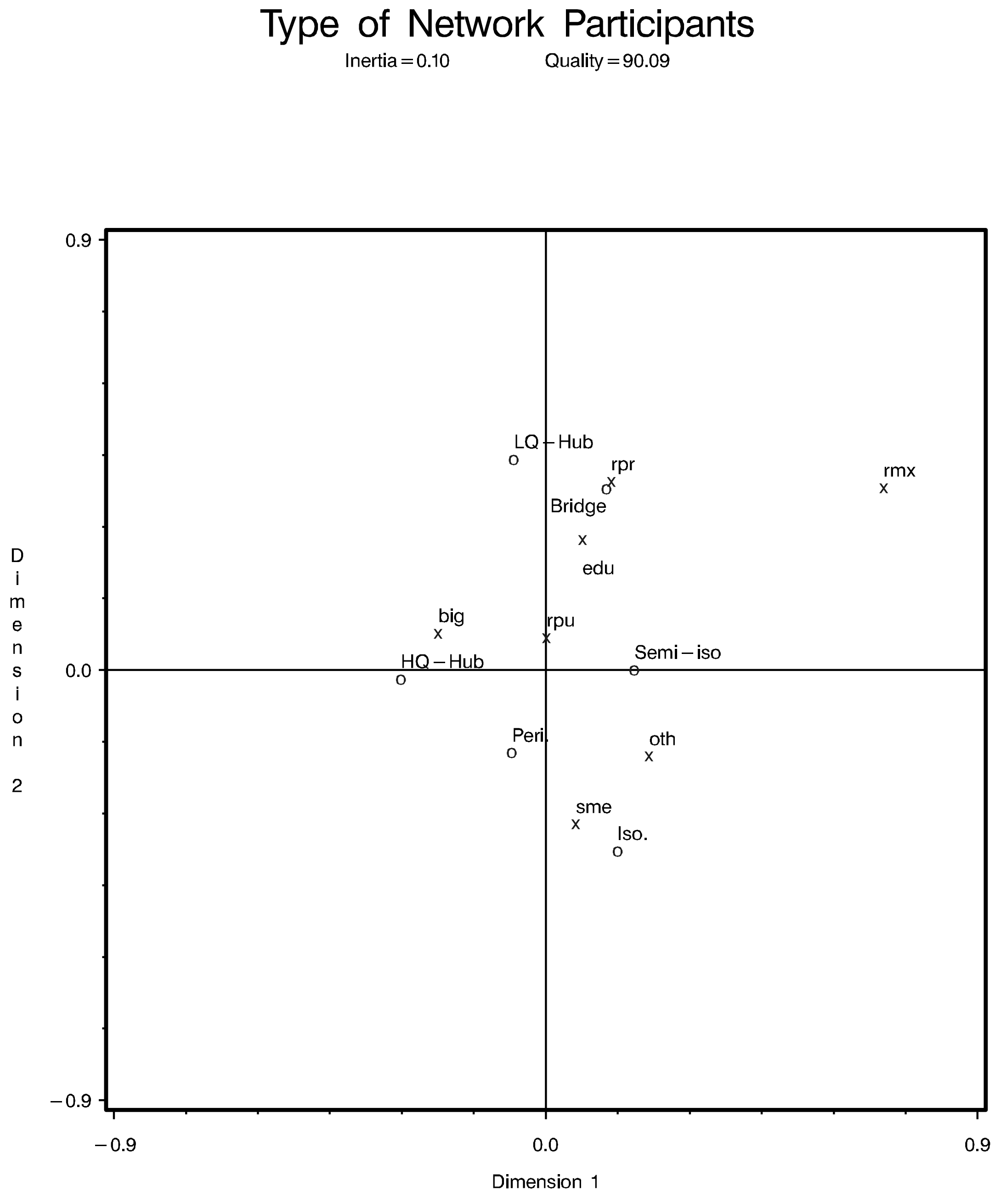

Type of Network Participants
Inertia = 0.10
Quality = 90.09
LQ – Hub
rpr
rmx
Bridge
edu
big
rpu
Semi – iso
HQ – Hub
Peri.
oth
sme
Iso.
0.9
0.0
– 0.9
– 0.9
0.0
0.9
Dimension 1
Dimension 2

Figure 5:

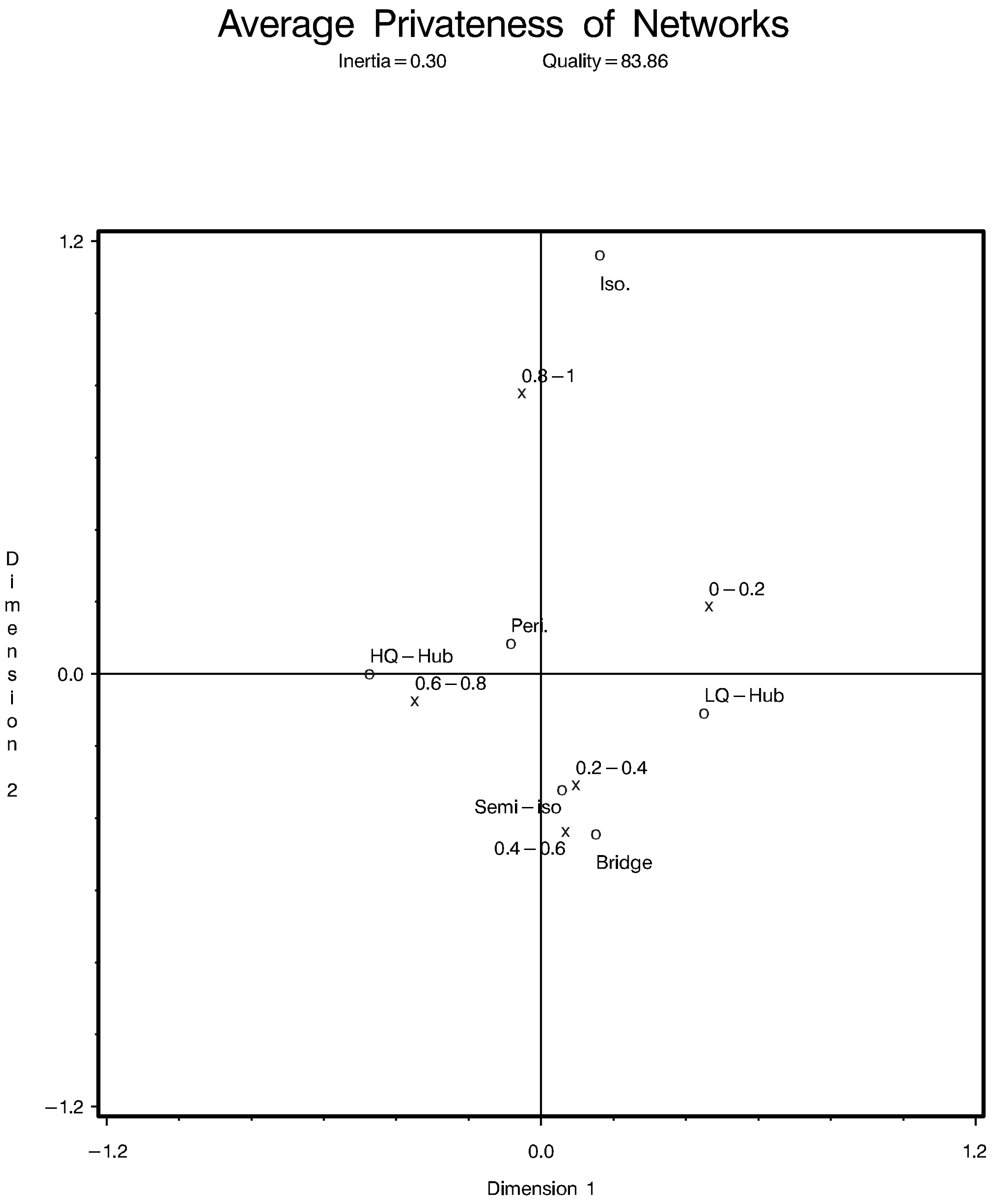

Average Privateness of Networks
Inertia = 0.30
Quality = 83.86
1.2
0.0
−1.2
Dimension 2
−1.2
0.0
1.2
Dimension 1
Iso.
0.8 − 1
0 − 0.2
Peri.
HQ − Hub
0.6 − 0.8
LQ − Hub
0.2 − 0.4
Semi − iso
0.4 − 0.6
Bridge

Figure 6:

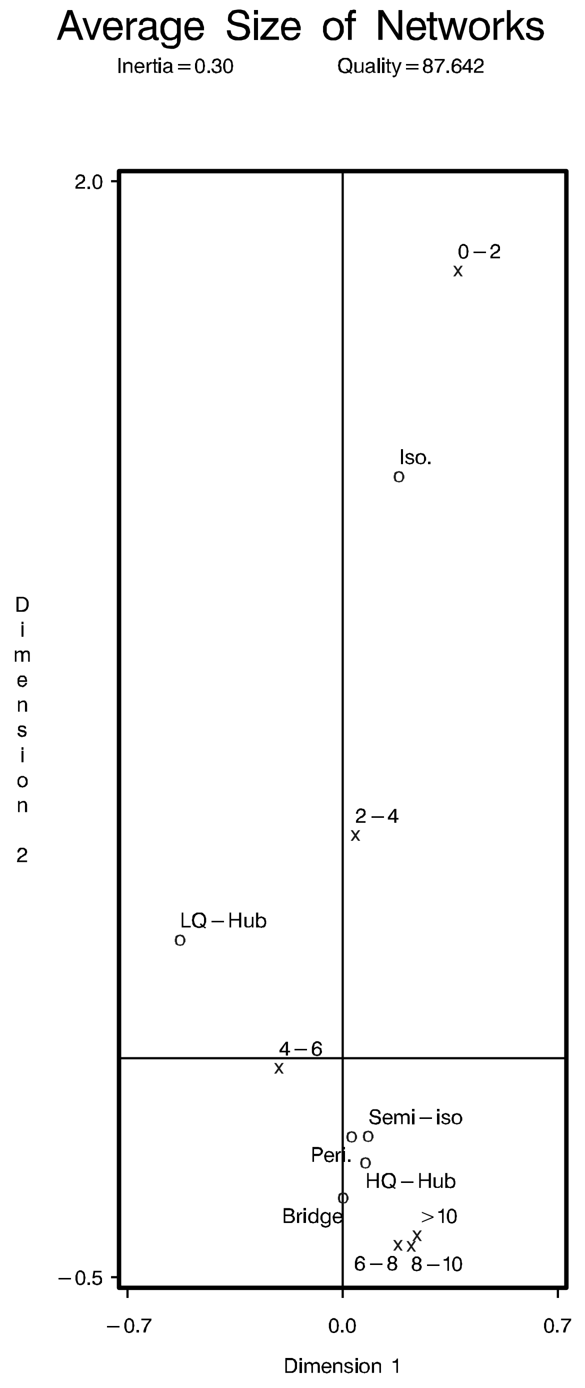
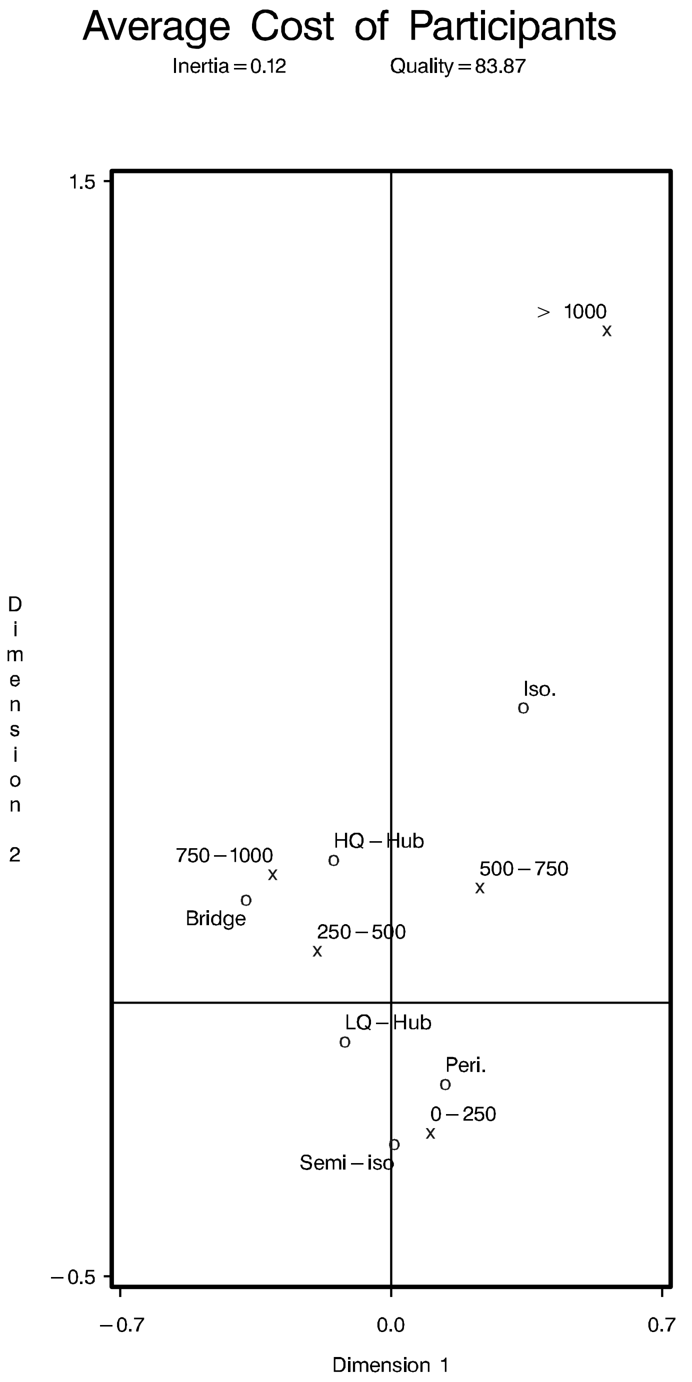

Average Size of Networks
Inertia = 0.30
Quality = 87.642
2.0
−0.5
Dimension 2
0 − 2
Iso.
2 − 4
LQ − Hub
4 − 6
Semi − iso
Peri.
HQ − Hub
Bridge
> 10
6 − 8
8 − 10
− 0.7
0.0
0.7
Dimension 1

Figure 7:



Average Cost of Participants
Inertia = 0.12
Quality = 83.87
1.5
−0.5
D i m e n s i o n 2
> 1000
Iso.
HQ − Hub
750 − 1000
500 − 750
Bridge
250 − 500
LQ − Hub
Peri.
0 − 250
Semi − iso
−0.7
0.0
0.7
Dimension 1