Networks of Innovation

in Information Society Development and Deployment in Europe

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Preface

This report presents the main results of the study **Networks of Innovation in Information Society Development and Deployment in Europe** conducted for the European Commission by the *Centre for Research on Innovation and Internationalization* (CESPRI) of Università Commerciale Luigi Bocconi, Milan.

This evaluation study concentrated on the assessment of the effectiveness of collaborative networks and of knowledge transfers between research, innovation and deployment activities related to Information Society and Technology (IST) at the EU and regional level. In particular, it highlighted the linkages and influences between the research networks built through FP6 funding in the thematic area 'Applied IST Research Addressing Major Societal and Economic Challenges', on the one hand, and the deployment networks built through EU programmes (eTen, eContent), structural funds and other regional funds, on the other.

Our findings are empirically-based - combining both quantitative and qualitative approaches - and allow deriving practical lessons for use in planning by the European Commission. In particular, our analysis applied the concepts of social network analysis, complemented by field interviews, to enhance and support IST monitoring and evaluation procedures as they relate specifically to the research and deployment activities within projects supported by both EU and local funding

The study was conducted between January and December 2006 under the direction of Peter Johnston, Head of Unit, and Frank Cunningham, Evaluation Specialist, Evaluation and Monitoring Unit of the Information Society and Media Directorate Generale, European Commission. A steering committee of experts guided the project, including: Mark Buchanan, Loris di Pietrantonio, Erastos Filos, Gareth Hughes, Neville Reeve, Andre Richier, and May Pettigrew.

The project team included CESPRI researchers and two experts of George Washington University: Franco Malerba (CESPRI - Director), Nicholas Vonortas (CESPRI and George Washington University), Lorenzo Cassi (CESPRI), Nicoletta Corrocher (CESPRI) and Caroline Wagner (George Washington University).

The interviews in the nine selected regions were carried out by the following national experts: Eric Zyla - Université Paris I Panthéon-Sorbonne, France; Carla De Laurentis – Centre for Advanced Studies, Cardiff University, United Kingdom; Hagen Work – Max Planck Institute of Economics, Jena, Germany; Bent Dalum - DRUID-IKE & CTIF, Department of Business Studies, Aalborg University, and Kristian Hegner Reinau - Department of Development and Planning, Aalborg University, Denmark; Tuomo Nikulainen - ETLA, Helsinki University of Technology and Helsinki School of Economics, Finland; Ricardo Mamede and Isabel Ventura – DINAMIA/ISCTE, Portugal; Yannis Caloghirou, Aimilia Protogerou and Evangelos Siokas - National Technical University of Athens, Laboratory of Industrial and Energy Economics, Greece; Lorenzo Novella - CESPRI, Bocconi University, Italy; Richard Woodward – CASE, The Center for Social and Economic Research, Warsaw, Poland.

During the course of the study, the project team received very valuable and helpful comments and suggestions on work-in-progress at two Workshops held in Brussels. Our analysis greatly benefited from these interactions.

This report reflects the results of research and analysis conducted by CESPRI. The results do not necessarily reflect the view of the European Commission, of the Steering Committee, or of any of the experts consulted during the course of the project. Comments on this report can be sent to Nicoletta Corrocher, CESPRI, Bocconi University, Via Sarfatti 25, 20136 Milan, Italy. Email: nicoletta.corrocher@unibocconi.it.

Executive Summary

Innovation is a complex socio-economic phenomenon that requires access to technological and financial resources, diverse capabilities and markets. Rarely all these are available in one place, are embodied in one person or are present in a single organisation. Indeed, most innovations appear to occur at the intersection of people, organizations, fields and functions. The role of networks in disseminating information and ideas, allowing access to resources, capabilities, and markets and integrating different pieces of knowledge has thus become of critical importance for innovation. And consequently, the viability of network connections has become an important determinant of economic competitiveness.

The EU Framework Programmes have provided a systematic process for reaching a number of goals including the integration of European research and technological development across member states; the wide diffusion of knowledge around centres of excellence; the increase in innovation and competitiveness by European-based firms; and the inclusion of peripheral countries and social groups (such as small or gender-based businesses) in European innovative research and development. Consensus among scholars and policy makers has recognized that networks are the single most effective way to encourage the development of new knowledge and the diffusion of knowledge into products and processes. Thus a key method for accomplishing these goals has been the use of collaborative research as a mechanism for linking together a large variety of knowledge centres within ERA. And in the pursuit of a competitive European economy, the European Commission has built research networks in IST to create and diffuse knowledge.

This evaluation study concentrates on the assessment of the effectiveness of collaborative networks and of knowledge transfers between research, innovation and deployment activities related to Information Society and Technology (IST) at the EU and regional levels. In particular, it highlights the linkages and influences between the research networks built through FP6 funding in the thematic area 'Applied IST Research Addressing Major Societal and Economic Challenges', on the one hand, and the deployment networks built through EU programmes (eTen, eContent), structural funds and other regional funds, on the other. The coalescence of these networks within nine selected regions of the European Community has received the bulk of our attention.

KEY FINDINGS

Regional networks are considerably strengthened by links into the IST RTD network. The research network complements the deployment network by adding links that allow many organisations to be connected. The research network brings an effective knowledge exchange among organisations and a fast diffusion of information within the network.

Both research and deployment network are highly connected. However, in the deployment network the number of organisations connected to others is proportionally smaller than in the research network and, even for those who are connected, the connection is weaker. If the research links are added to the deployment network, the structural properties of the deployment network are modified. In particular, the IST research network increases the number of the organisations of the deployment network that are involved in sharing and exchanging knowledge, and speeds up information transmission among its organisations. The overall network (the research and the deployment network jointly considered) is well connected and the average distance between organisations is 3.

Gatekeeper organisations play the key role of a bridge between the research network and the deployment network.

Most gatekeepers – organisations that participate in both networks – are universities or research centres (two-thirds of the total). Other organisations also play a relevant role, including SMEs. The population of gatekeepers includes a high number of network hubs: this significantly affects

connectivity. One-third of the links of each network (research and deployment) identify connections between gatekeepers and other organisations. This role goes a long way in terms of balancing the relatively limited number of organisations participating in both activities. So, gatekeepers seem to play effectively their role of bridge between networks.

Knowledge hubs play the critical role of network connectors, but the organizations operating as knowledge hubs in the research and deployment networks are different.

In the research network, universities play a central role, while in the deployment network the most important hubs are private companies. Private companies play a different role in the two networks, since they are more locally connected in the deployment network than in the research network. In the deployment network other organisations, such as city councils, play an important role especially at the regional level, as they connect the other actors located in the region.

It is rather easy to connect with organisations of the same region; however, it is the presence of a network hub that allows for a connection to the global network.

Each regional network has a higher density than the density of the overall network: being co-localized makes it more likely to be connected. However, a large number of organisations locally do not necessarily imply that the region has a higher number of connections to external hubs. It is the actual presence of hubs in a region (for the regions examined in our evaluation analysis this is the case of Attiki and Rhône-Alpes for the research network and Emilia Romagna for the deployment network) that increases the connectivity of the region to other external hubs. This suggests that regions should increase the number of hubs located within their territory in order to strengthen the regional innovation network and the deployment of research results.

The effectiveness of the deployment network depends upon the presence of two essential actors: multinational companies and SMEs. These can be engaged through links to the RTD.

Multinational firms participate in IST RTD projects and, thus, connect local organizations (often smaller organizations) with international networks and markets. They also are essential for strengthening the links between research and deployment: multinational companies in fact possess financial assets and human resources that are necessary in order to engage in large scale projects. SMEs are deeply rooted in the territory and represent very efficient players when it comes to deploy specific applications and to build relationships with regional authorities.

* * *

RECOMMENDATIONS

The stronger emphasis on innovation and the quest for balancing supply and demand side effects of technological advancement in Europe today implies that both research and deployment linkages become a core policy concern. On the basis of lessons learned from our analysis, the following policy recommendations point at strengthening the links between research and deployment, also including the linkages between European/national and regional activities.

1) Strengthen the links between research and deployment

While research across the ERA is highly networked, other parts of the system – namely those related to deployment – are less interconnected. Gatekeeper organisations in the networks play a critical role in that respect by providing interconnections across different networks. This implies that r*egions should involve more of these types of organisations (gatekeepers and hubs) in order to bridge research and deployment also at the regional level more effectively and to harness the results from FP6.*

While somewhat overlapping, deployment activities, capabilities and skills are significantly different from those relating to research. Therefore, when programme objectives include dissemination and applications, they could be enriched with a regional deployment strategy as part of IST-RTD projects. *In its programmes the Commission should ensure that opportunities for*

regional organisations to engage and participate to deployment activities exist, so that connections between research and deployment programmes are strengthened also at the regional level.

Both research and deployment networks appear to be effective in information dissemination, the latter more so at the regional level (as expected). Nonetheless, having a large number of organisations in the network does not guarantee extensive connections to the outside world: the inclusion of hubs does. The investigated regions are not hosts to either IST research hubs or deployment hubs, with the exception of Attiki and Emilia Romagna. *Since the presence of hubs in a region raises disproportionately the connectivity of the region with others, the attraction of such organisations regionally certainly makes sense. Even more so given that many hubs also play the role of gatekeepers.*

In our interviews, many organisations are unaware of opportunities for support to deployment. *The provision of information about these opportunities could be the first step in the direction of more awareness. In order to promote ICT deployment there is the need for national governments to play a catalytic role and provide significant value-added by initiating and supporting mechanisms for inter-regional cooperation and collaboration.*

2) Strengthen regional strategies for deployment of innovations

Regional strategies for economic development and ICT deployment are largely unknown to network participants. In many cases, participants are focussing on the global marketplace in their development process rather than on the regional level. This may be appropriate for frontier research, but it is not the most effective way for innovation diffusion and deployment. *The development of regional policies for an ICT-based knowledge society is essential for regional knowledge hubs to establish links at the regional level.*

Large multinational organisations play a central role in bridging research and deployment, as they possess financial, technical and human resources to enter research and deployment networks and to manage the complexity of collaborations. In this respect, *regions should support the presence of such large organisations that diffuse technological and market information, help define standards for emerging products, and provide demand (applications) for research results. Furthermore, they should strengthen links between multinational organisations and SMEs.*

In relation to this, knowledge about regional support systems (when they exist) is very spotty. In a number of cases, the interviewees did not know of regional structural programmes or opportunities for connections. *From a policy perspective, ensuring that this kind of information is available, possibly through a virtual clearinghouse, would be a step forward.*

3) Simplify the exploitation of IST networks and project coordination

The range of programmes and projects existing at the regional, national and European levels can be daunting and confusing to prospective participants, and may be a barrier to smaller enterprises. *The Commission together with regional agencies should provide clear information about the IST RTD activities as well as other EU programmes. This would greatly help organisations at the regional level.*

The costs of joining IST networks, particularly for smaller institutions, can be a barrier to participation. In particular, bureaucracy and difficulty in coordination constitute important obstacles to the use of IST networks. This issue is already well-known to the European Commission. Further efforts to ameliorate this problem should be considered.

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1 Introduction, Purpose, and Methodology

This evaluation study assesses the effectiveness of network collaboration and knowledge transfers within the Information Society and Technology programme for Research and Technology Development (IST-RTD) within the Sixth Framework Programme (FP6). The findings are empirically-based, combining both quantitative and qualitative approaches, to derive practical lessons for use in planning by the European Commission. In particular, our analysis applies the concepts of social network analysis, complemented by field interviews, to enhance and support IST monitoring and evaluation procedures as they relate specifically to the research and deployment activities within projects supported by both EU and local funding.

The EU Framework Programmes have provided a systematic process for the integration of European research and technological development across member states; wide diffusion of knowledge around centres of excellence; innovation and competitiveness among European-based businesses; and efforts to include peripheral countries and social groups (such as small or gender-based businesses) in innovative research and development. A key method for accomplishing these goals has been the use of collaborative research as a mechanism for linking together key knowledge centres within the European Research Area (ERA).

Networks encourage the flow of knowledge related to new ideas, technology, organisations, and markets. The relationships that enable knowledge flows can be characterized as a network structure. The structure, or topology, of the knowledge community gives us insight into the possibility of knowledge exchange. Even so, however, little is known about the value of network participation to participants and about the characteristics of the exchange within networks. Collaborative schemes present particular challenges to the evaluation process.

The rest of the report is organised as follows. The remainder of this section presents the purpose of the study and the methodology adopted. In particular it illustrates the rationale behind the choice of the technological domain, the data and the criteria used to select a relevant subset of regions to focus upon, and the organisations to be interviewed. Section 2 reports the main characteristics of research and deployment networks and also defines some key actors in our approach, namely network hubs. Section 3 analyses the complementarity and overlaps between the two types of networks. Section 4 summarizes the diverse interview material that our teams brought from the different regions, concentrating on the effects of IST networks on the deployment of information and communication technologies (ICT), the role of national and regional networks in technology deployment, and two key industrial players in deployment including multinational corporations and small and medium-sized enterprises (SMEs). Finally, Section 5 sums up the lessons learned and discusses policy implications.

1.1 Purpose

This evaluation study builds on earlier studies of IST-RTD networks to examine the extent to which networks are serving the purposes of regional reach and exchange. The three previous studies[1] have made significant steps in

[1] J. Stefan Institute: *Data Mining and Decision Support for Business Competitiveness: A European Virtual Enterprise* (Cordis Project reference: IST-1999-11495); RAND Europe: *ERAnets: Evaluation of Networks of Collaboration between Participants in IST Research and their Evolution to Collaborations in the European Research Area (ERA)* (Tender OJ 2004/S 177-151255); CESPRI: *Evaluation of progress towards a European Research Area for information society technologies* (contract number OJ 2004/S 177-151255).

mapping the IST research network in Europe, indicating its international reach, examining the patterns of link formation, identifying the important organisations (knowledge hubs) and examining their role as both network and knowledge gateways.

The study complements those earlier ones by going one step further to examine the link between research, innovation, and IST technology deployment activities at the EU, national, and regional levels. While research networks were the central focus of the earlier studies, the *effects* of networks on market application and deployment of new IST technologies become the central focus of the present evaluation study.

The core objectives of the study have been to assess the effectiveness of network collaboration and knowledge transfers between RTD, innovation and deployment activities related to IST and to suggest ways to strengthen the links between IST-RTD, innovation and deployment at the EU and regional levels.

This evaluation study combines quantitative network indicators and field interviews. Its limitations should be also stressed. Given the concentration of network indicators only on formal (observed) linkages and the limited number of interviews conducted, the study only evaluates a small part of the overall European picture of knowledge flows across networks and regions. Therefore, rather than aiming at generalization, the study purports to identify trends, issues, and to put forward observations regarding the efficacy of European IST-RTD and regional development programmes.

1.2 Methodology

The study focuses on the innovation and deployment projects within the technological domains of 'Applied IST Research Addressing Major Societal and Economic Challenges', i.e. the first IST Thematic Area of FP6. This Thematic Area is very appropriate to analyse the links between innovation and deployment, since it connects well to IST deployment programmes, especially eTen and eContent. eTen is designed to help the deployment of telecommunication networks based services (e-services) with a trans-European dimension. It focuses strongly on public services, particularly in areas where Europe has a competitive advantage. eContent is a market-oriented programme, which aims to support the production, use and distribution of European digital content and to promote linguistic and cultural diversity in the global networks. We identify organisations participating in FP6, eTen and eContent projects and use them as the initial sample of analysis, as Table 1 displays.

On the basis of information available, we build two partnership networks: research and deployment. In order to do that, we assume that if two organisations participate in the same project they are directly linked.[2] Following the economic literature, our analysis assumes that each of these partnerships links represents a channel of collaboration, knowledge exchange and information spillovers. Data concerning organisations and projects are elaborated using network analysis software tools. In particular, for each network, we examine their structural properties and their interactions and overlaps, as well as the specific role played by the organisations acting as hubs and/or gatekeepers.

In order to gain additional insights into knowledge networks within the ERA, we have investigated research and deployment activities within specific regions (NUTS 2 level). The regions were chosen to represent a spectrum of capabilities and capacities, by considering:

- geographic clusters of IST projects;
- networking within the region;
- occurrence of other European instruments to support regional growth; strength of science, technology and economic (STE) capability.

Correlations among these factors show different levels of development in different regions. For the current evaluation analysis, we have selected a subset of regions (Table 2) representing the spectrum of STE capabilities that could characterize European regions, and the different location: three are from Central Europe - Rhône-Alpes, Bremen and East Wales; two from Northern Europe – North Jutland[3] and Lansi Suomi;

[2] In analogy with previous works (see note 1), we have considered all the participants in a project having similar roles, i.e. we have not assigned any specific role to the prime contactor of the project.

[3] This region is NUTS 3 level.

TABLE 1 - DATA

	IST RESEARCH Projects	IST DEPLOYMENT Projects
Description	European network formed by organisations participating in *FP6 IST – TA1* projects	European network formed by organisations participating in *eTen* and *eContent* projects
Data source	Internal EC Database (not publicly available)	Internal EC Database (not publicly available)
Period	First 4 Calls of FP6 2002-2005	eTen: 2000-2005 eContent: 2002-2005

TABLE 2 - SELECTED REGIONS

East Wales (UK)	Rhône-Alpes (France)	Bremen (Germany)
North Jutland (Denmark)	Lansi Suomi (Finland)	Norte (Portugal)
Attiki (Greece)	Emilia Romagna (Italy)	Malopolskie (Poland)

three from Southern Europe –Attiki, Emilia Romagna and Norte; and one from a new accession country - Malopolskie in Poland.

By investigating networks and organisations within these regions, we identify different patterns of network collaboration and knowledge transfers between RTD and innovation and deployment activities. Network analysis and in-depth interviews are conducted to seek answers and insights into a range of evaluation questions that guided the project.

We study research and deployment networks (FP6, eTen and eContent) by looking at the position and role of regional organisations. We first identify networks in the selected thematic area at the regional level supported by EU structural funds (e.g. ERDF, LEADER+, and INTERREG). In addition, we identify other networks in the selected thematic area supported by Member State and Regional funds. This allows us to explore the relationships among different networks: FP6, eTen and eContent, regional networks supported by structural funds, and other networks supported by State and regional funds.

In-depth field interviews have been conducted with a set of carefully selected organisations in order to support the empirical network analysis. The questions have been aimed at projects that were carried out in different regions in order to understand the linkages between innovation and deployment processes at the regional level. The interviews add critical information on the value of links and connections within the ERA as provided by the EC-funded activities.

We selected two subsets of interviewees per region. The first subset comes from *the results of our network analysis*, which allows us to identify a group of large and small effective IST producers participating to FP6 and/or eTen and eContent projects. The second subset stems from *the investigation of the projects at the regional level*, which allows us to identify organisations that do not participate in IST research projects, but have strong IST deployment record in the examined thematic area. Emphasis is placed on interviews with key actors at the regional level: representatives of companies identified in the networks; representatives of public research centres and/or universities; representatives of government and quasi-government organisations that facilitate IST deployment in the selected thematic area and the selected Member State(s) and Region(s).

Table 3 illustrates the characteristics of the 62 interviewed organisations - on average 7 per region.

TABLE 3 – INTERVIEWED ORGANISATIONS

Type of Organisation	Number (Percent)
Industry (IND)	22 (35.4)
Research Centre (REC)	18 (29.0)
University (HE)	13 (21.0)
Other organisation (OTH)	9 (14.6)
Total	62 (100)

2 Research and Deployment Networks

The Sixth Framework Programme has continued the long tradition of supporting collaborative research at a wider and more integrative scale than its predecessors. Tighter, more extensive linkages have been viewed as vital to achieving critical mass for the effective use of knowledge resources for innovation as well as for more effective integration and inclusion within the ERA.

2.1 Research and deployment network characteristics

The basic characteristics of the research and deployment data concerning projects and organisations are displayed in Table 4.

TABLE 4 – RESEARCH AND DEPLOYMENT PROJECTS AND ORGANISATIONS

	IST RESEARCH Project	IST DEPLOYMENT Project
Participants	4198	2008
Projects	249	287
Participants per project	17	7
Organisations	2417	1634
Projects per organisation	1.7	1.2

Table 5 reports the main topology features of the research and deployment networks.

The differences between the structural properties of the two networks depend mainly on the size (number of participants) of each network. Indeed, the number of participants in research projects is more than twice as large as the number of participants in deployment projects.

Both networks are highly connected. Most participants are in the largest components, meaning that most of them are connected in some way to each other.[3] However, in spite of the high connectivity of both networks, the research network supports significantly higher exchange of information compared to the deployment network. In the first network almost all participants are connected to each other (as Table 5 shows, 98.8% of organisations are in the largest component). Deployment networks are less connected: the largest component contains 78% of organisations.

More striking differences between the research and the deployment networks emerge, if the giant bi-component is considered. The condition that a set of nodes have to satisfy in order be classified as a bi-component requires that all its nodes are reachable from any other node at least via two (and not only one) different paths.[4] This feature implies that organisations belonging to a bi-component have a higher probability to receive the information spreading around the network than an organisation belonging to a component.[5] The bi-

[3] More formally, a component is a subpart of a network where there exists at least one path (i.e. an alternating sequence of node and edges) linking all its nodes. In other terms, all the nodes belonging to a component have to be reachable at least in one way.
[4] The giant bi-component is the greatest one.
[5] Of course, this is true if all the other network features are equals.

TABLE 5 - NETWORK CHARACTERISTICS

	IST RESEARCH Network	IST DEPLOYMENT Network
number of nodes (organisations)	2417	1634
number of edges (links)	61686	7422
network density	0.02	0.006
size largest component (giant component)	2373 (98.18%)	1153 (70.56%)
Size largest bi-component (giant bi-component)	2340 (96.81%)	733 (44.86%)
average degree	51.04	9.08
average distance^	2.5	5.08
max distance^	5	11
clustering coefficient^	0.0377	0.1292

^ These indexes refers to the giant component

component of the *research network* has almost the same size of the component (2340 instead of 2373), while the bi-component of the deployment network is dramatically smaller: 733 organisations instead of 1154. This means that only 63% of the organisations belonging to the giant component have also *another* path connecting to the others. Therefore, in the deployment network the number of organisations connected to each other is proportionally smaller than in the *research network* and, even for those who are connected, the connection is weaker. These differences in the connectivity of the two networks reflect both the institutional features and objectives of the two programmes and probably the fact that the deployment network deals with more focussed activities regarding marketable products.

Information flows more easily in research networks than in deployment networks. The average distance in the research network is lower than the one in the deployment network: any node can reach any other node in the network in 2.5 steps on average. In the deployment network, the average number of steps needed to get from one node to another one is over 5 (this only applies to the nodes in the largest component).

On the other hand, deployment activities are locally more cohesive and dense? This is suggested by the value of the clustering coefficient for the deployment network which is greater than the same coefficient of the research network.

Despite these differences, however both networks are well structured to be effective and useful as knowledge systems. Their structural properties, *i.e.* low average distance and high clustering coefficient,[1] point out that both networks have *small world* properties.

If the IST research and deployment networks are considered together (Table 6) (*i.e.* all the organisations participating in FP6 *and* the organisations participating in eTen and eContent as members of the same network) the giant component* (which includes 3499 organisations (92.7%)), is characterized by an average distance of 3. This is a quite relevant result. It means that the overall network is well connected, as each organisation is on average three links away from any other. So each organization has a rather easy access to innovation and diffusion within the network.

However, the research network and the deployment network overlap very little. Only 277 organisations** participate in both networks. The two networks overlap even less in terms of links: the research and the deployment networks have only 131 links in common.**

[1] The clustering coefficient for a node is the proportion of links between the nodes within its neighbourhood divided by the number of links that could possibly exist between them. The clustering coefficient for the whole network is the average of the clustering coefficient for each node and gives the level of social capital, since it measures how many *direct* partners of a specific organisation collaborate with each other.

[2] Here *low average distance* means that the network has the same value of a random network with the same size and density, *high clustering coefficient* means that the network has a value that is much greater than the value of the random network.

* The giant bi-component is slightly smaller: 3150, i.e. the 90% of the size of the giant component.

** This includes 11% of the organisations participating in the Research Network, 16% of the organisations participating in the deployment network, or 7.5% of the total number of organisations (3774)

** There are 3011 links among the 277 organisations participating in both networks and these links can depend on a partnership either in a research project or in a deployment project. 2526 out of 3011 (83.89%) links are related exclusively to research project participations, 354 (11.76%) only to deployment project participations and only 131 (4.35%) depend on participations in both programmes. This means that the overlap in terms of links, is very poor.

TABLE 6 - GLOBAL IST RESEARCH AND DEPLOYMENT NETWORK: STRUCTURAL PROPERTIES

	IST Network
number of nodes (organisations)	3774
number of edges (links)	68977
network density	0.0097
giant component	3499 (92.7%)
giant bi-component	3150 (83.5%)
average degree	36.55
average distance*	3
max distance*	9
clustering coefficient*	0.0138

* These indexes refers to the giant component

2.2 The role of network hubs

Important actors within the networks are the so-called *network hubs*. A hub may be defined as a node with a large number of connections that is highly influential by playing the role of *network connector*, i.e. one that connects nodes that would otherwise remain unconnected. More formally, the notion of network hub can be captured by two indicators: (i) degree centrality, (ii) betweenness centrality. Degree centrality and betweenness centrality have been calculated for all organisations and a synthetic index has been created that ranks organisations according to their performance in terms of both these indicators. Hubs have been defined as the top two percent of the organisations on the basis of this ranking.[12] We chose this percentage, as the top two percent of organisations manage thirty percent of total links. This procedure has been applied to each network, resulting in the definition of two types of hubs: IST research hubs (48 organisations from FP6) and IST deployment hubs (32 organisations from eTen and eContent).

Hubs have an extremely important role in networks, as they facilitate more than other network participants the rapid and effective dissemination of knowledge even to the most peripheral sections of the network.

The analysis of the *hubs* in the different networks - research and deployment - shows highly functional structures. As expected, *research networks* are dominated by higher education and research institutions while *deployment networks* are dominated by industry (Figure 1).

There are important differences between the two networks. Higher education institutions and research organisations play a greater role in the research network, while private companies and other organisations have a more relevant role in deployment networks (as expected). It is interesting to notice however that higher education institutions are also active in the deployment network.

Five 'other organisations' that appear as hubs in the deployment network include three city councils, one regional government, and one a municipal company. These institutions promote economic growth, strengthening the networks at the local levels.

Differences in the role of hubs at the local vs. the national levels emerge when evaluating research and deployment hubs. Figures 2 and 3 consider the links of each hub, distinguishing between links with organisations located in the same country and links with organisations located in the same region (NUTS 2) of the hub. We have excluded from this picture organisations located in more than one location (i.e. multinational companies or National Research Centres) and have considered only the EU15 countries. We have thus obtained 28 research hubs and 26 deployment hubs.

Deployment hubs act more locally linked than research hubs. Note that national links in research are more than twice as many as national links in deployment, and regional links in research are more than three times as many as regional links in deployment.

There are also striking differences between the links of different types of hub organisations. First, in the research network private companies are less geographically limited, while the opposite is true for the deployment network. Second, in the deployment network, the 'other organisations' are those with the most localized links. In particular, the number of regional links is more than twice as much as the average number. These actors indeed play a key role in deployment at the regional level. Academic hubs, on the contrary, do not show any differences in the two networks as far as the localisation of their links is concerned.

[12] The two per cent cut-off is obviously arbitrary but this arbitrariness in the cut-off value is hard to avoid in similar exercises. We considered different values (both higher and lower then two per cent) in order to check for robustness. The main results are not affected. Alternatively, Hubs could have been defined on the basis of threshold values for centrality. This becomes impractical, however, because of the need to compare across different types of networks of different sizes.

Figure 1 - Network hubs (percentages of total)

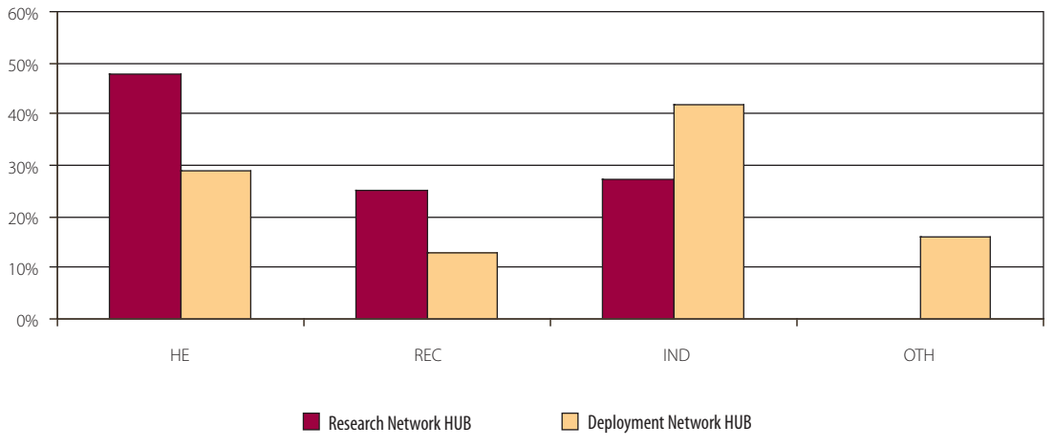
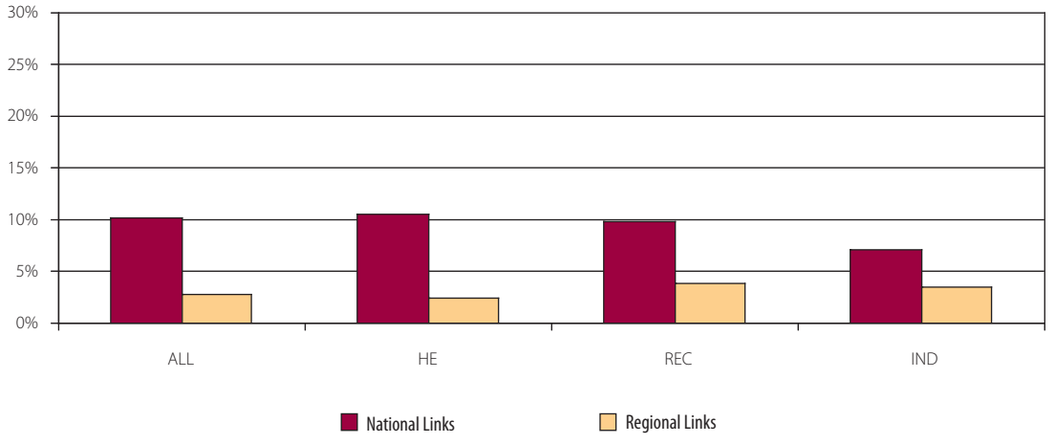
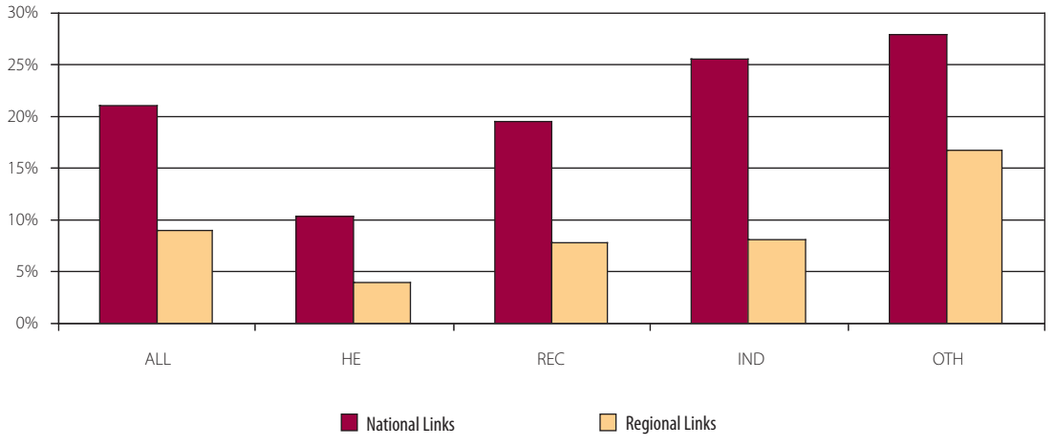


Figure 2 - National and regional links of research hubs (% of the total)*



* Regional links are a subset of national links, so that it does not make sense to sum them!

Figure 3 - National and regional links of deployment hubs (% of the total)*



* Regional links are a subset of national links, so that it does not make sense to sum them!

2.3 Research and deployment networks at the regional level

The research and deployment networks have been examined for each of our nine regions (Table 7). Each regional network has a higher density than the density of the overall network. This suggests that being co-localized makes it more likely to be connected. Attiki and Emilia-Romagna - the regions with low capability in science, technology and economy - have the highest number of organisations participating in IST research and deployment networks. The latter signals the important role of the European programmes in terms of inclusion and cohesion. The cases of Attiki and Emilia Romagna are illustrative examples of the effectiveness of the FP6 in strengthening the connection between research and deployment.

A large number of organisations do not necessarily imply that the region has a higher number of connections to external hubs. Hubs play this crucial role: in fact the presence of hubs in a region (this is the case of Attiki and Rhône-Alpes for Research and of Emilia Romagna for Deployment) increases the connectivity of the region to other external hubs (Table 8). Therefore in general regions should increase the number of hubs in order to strengthen the regional innovation network and the deployment of research results.

In summary, as far as the European networks are concerned, we can conclude that:

- Both networks display *small world* properties, even though the research network appears relatively more effective in information dissemination.
- The two networks overlap very little in terms of organisations and, even less, in terms of links. The overall network (research and deployment projects jointly considered) is, however, relatively well connected.
- The types of organisations working as *hubs* in the two networks are relatively different:
  - In the research network, universities play a central role, while in deployment network the more important hubs are private companies.
  - Private companies are more locally connected in the deployment network than in the research network.
  - In the deployment network other organisations, such as city councils, play an important role, but they play a negligible role in the research network.
  - 'Other' organisations are the most locally connected.

As far as the examined regional networks are concerned:

- Each regional network has higher density than the density of the overall network: being co-localized makes it more likely to be connected.
- A large number of organisations do not automatically translate into a higher number of connections to external hubs: it is the presence of hubs in a region that increases the connectivity of the region to other external hubs.
- As a rule, the investigated regions are not hosts to either IST-RTD hubs or deployment hubs, with the exception of Attiki and Emilia Romagna.

As we discuss in the next section, quantitative network indicators alone cannot fully reveal the usefulness of this mechanism to different regions. Qualitative analysis is also necessary.

TABLE 7 - REGIONAL NETWORKS: STRUCTURAL PROPERTIES

REGION	Location	STE Strength	IST network Organisations	RESEARCH		DEPLOYMENT	
				Organisations	Density	Organisations	Density
UK – East Wales	C	HIGH	2	1	-	1	-
FR – Rhône-Alpes	C	HIGH	20	12	0,15	9	0,11
DE – Bremen	C	HIGH	16	10	0,53	9	0,27
DK – N. Jutland	N	HIGH	3	3	0,66	0	-
FI – Lansi Suomi	N	HIGH	11	10	0,53	1	-
PT – Norte	S	VERY LOW	22	13	0,35	9	0,11
GR – Attiki	S	LOW	116	56	0,14	84	0,039
IT – Emilia Romagna	S	LOW	54	25	0,14	38	0,11

TABLE 8 - REGIONAL NETWORKS: HUBS AND EXTERNAL CONNECTIONS

REGION	Location	RESEARCH			DEPLOYMENT		
		Organisations	Hubs	Connection to external hubs	organisations	Hubs	Connection to external hubs
UK – East Wales	C	1	0	-	1	0	-
FR – Rhône-Alpes	C	12	2	0,11	9	0	0
DE – Bremen	C	10	0	0,06	9	0	0,021
DK – N. Jutland	N	3	0	0,09	0	-	-
FI – Lansi Suomi	N	10	0	0,075	1	0	-
PT – Norte	S	13	0	0,089	9	0	0,003
GR – Attiki	S	56	2	0,11	84	2	0,017
IT – Emilia Romagna	S	25	0	0,06	38	4	0,026

3 Complementarity between Research and Deployment Networks

3.1 The significant presence of gatekeepers

A key role in fostering complementarities between research and deployment networks is played by *gatekeepers*, i.e. organisations that link the two networks together and, by doing so, allow others to access information and capabilities developed in other networks and contexts. As seen in Figure 4, the gatekeepers sit between the two networks: they are positioned in both networks. In our analysis, 277 organisations are identified as having this bridging position. Some of these 277 organisations are also hubs which has implications regarding their connectivity within the network.[1] We hypothesise that gatekeepers are in a unique position to speed up the process of innovation and technology diffusion, since they work as bridge between the two different networks.

Different types of organisations act as gatekeepers within the two networks. Figure 5 shows that higher education institutions and research organisations are more numerous than others, but they are definitively not the only important ones. Industrial organisations are also quite active as gatekeepers and, within this group: in particular, SMEs play an active role, representing seventeen percent of these bridging organisations.

The variety of different organisational types acting as gatekeepers means that different kinds of knowledge will be shared across the various networks. It became evident in the interviews that different types of organisations play different roles within the networks. Higher education and research institutes develop and diffuse advanced and frontier knowledge to the network; businesses provide a major link to the market and provide information

[1] 29 out of 48 (56%) of hubs in the research network and 22 out of 32 (68.7%) of hubs in the deployment network are also gatekeepers. It is worth noticing that 11 organisations are hubs in both networks: they could be classified as the strongest gatekeepers in our sample.

Figure 4- Gatekeepers

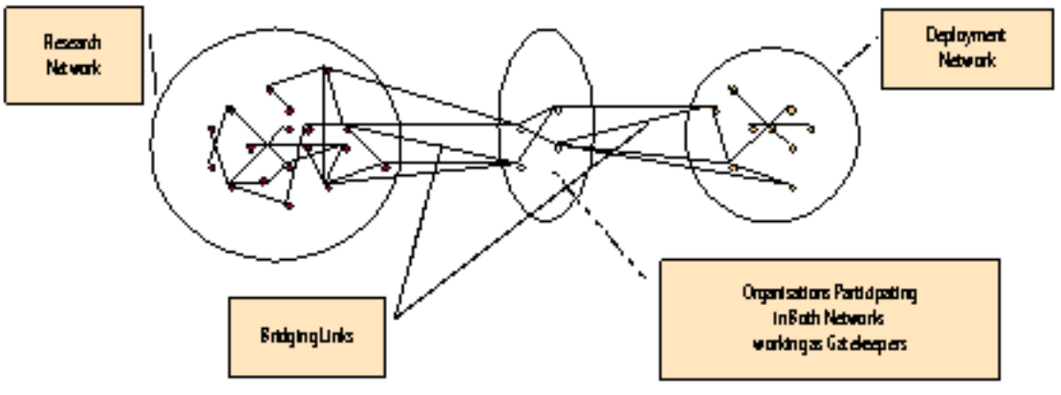
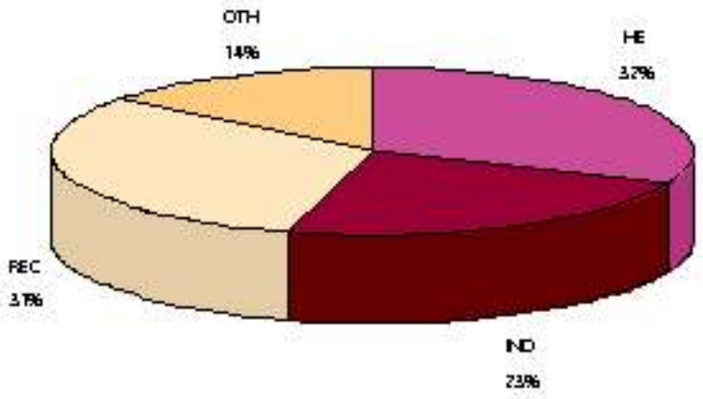


Figure5 - Gatekeepers by organisational type



feedback in order to focus research on market relevance. Thus, a highly functional network would need gatekeepers from the different sectors in order to exchange and integrate different types of information and knowledge. This appears to be the case in the examined networks.

3.2 The bridging role of gatekeepers

Just on the basis of the available quantitative data, gatekeepers appear to bridge research and deployment effectively.

It has already been shown in an earlier Section that the linkage pattern between the two European networks (research, deployment) is quite significant (Table 6). We can evaluate the key role of gatekeepers in that respect by considering the number of their links to the other organisations of the research and deployment networks. 20264 out of a total of 61680 (32,8%) links in the research network bridge gatekeepers with other organisations participating in that network. 2327 out of a total of 7422 (31,4%) links in the deployment network do the same there. In sum, more than one third of overall links bridge the two networks.

Gatekeeper organisations collaborate very frequently and actively in research networks, but they also work with private companies and public institutions that seek to deploy technologies. Their role is crucial since many organisations that are active players in the research networks are often not aware of deployment opportunities, as it has been evident from our interviews. Gatekeepers, on the contrary, are well aware of the deployment opportunities at the international, national and regional level. The opposite also happens frequently: poor links between research and deployment might arise in the case of organisations which are actively involved in deployment activities, but are not tied into the research network. The intermediary function of gatekeepers is therefore important and critical.

3.3 The complementarities between the two networks

In order to grasp even more the complementarities between the two kinds of networks and the role of gatekeepers, we have juxtaposed the research network (FP6) with a network representing the links of the same organisations, this time involved in the deployment projects (Table 9), as exemplified in Figure 6.

Figure6 - An example of how the IST RESEARCH plus DEPLOYMENT links are built up

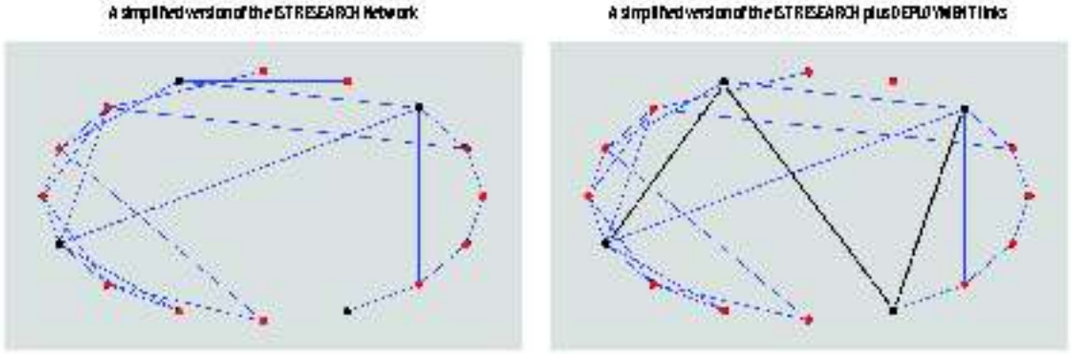


TABLE 9 - RESEARCH NETWORK AND DEPLOYMENT LINKS: STRUCTURAL PROPERTIES

	IST RESEARCH Network	IST RESEARCH plus DEPLOYMENT links
number of nodes (organisations)	2417	
number of edges (links)	61686	62040
network density	0.02	0.02
giant component	2373 (98.18%)	2375 (98.26%)
giant bi-component	2340 (96.81%)	2353 (97.35%)
average degree	51.04	51.34
average distance*	2.5	2.5
max distance*	5	6
clustering coefficient*	0.0377	0.0375

* These indexes refer to the giant component

Similarly, we have juxtaposed the deployment network and a network representing the links of the same organisations, this time involved in the research projects (Table 10).

A striking result is how little the research network is affected by the inclusion of the technology deployment linkages of its participants. All the structural properties barely change (Table 9).

In contrast, the inclusion of the research links raises the degree of connectivity of the deployment network. The structural properties of the deployment network change significantly when the research links of its participating organisations are introduced (Table 10). Both the sizes of the giant component and bi-component increase significantly. Furthermore, it reduces the average distance between the participants. Therefore, an important effect of the IST research network is the enlargement and widening of the number of organisations involved in sharing and exchanging knowledge and information and the speeding up of knowledge circulation among the deployment network organisations.

One also notices in Table 10 that the clustering coefficient decreases with the inclusion of the research links. This should not be interpreted as if the social capital of individual organisations drops. The lower clustering level

TABLE 10 - DEPLOYMENT NETWORK AND RESEARCH LINKS: STRUCTURAL PROPERTIES

	IST DEPLOYMENT Network	IST DEPLOYMENT plus RESEARCH links
number of nodes (organisations)	1634	
number of edges (links)	7422	9948
network density	0.006	0.007
giant component	1153 (70.56%)	1401 (85.74%)
giant bi-component	733 (44.86)	1072 (65.6%)
average degree	9.08	12.17
average distance*	5.08	3.65
max distance*	11	9
clustering coefficient*	0.1292	0.0434

* These indexes refer to the giant component

TABLE 11 - OVERLAP BETWEEN RESEARCH AND DEPLOYMENT NETWORKS BY REGION

REGION	Location	STE Strength	OVERLAP between RESEARCH and DEPLOYMENT network		OVERLAP between IST and STRUCTURAL FUNDS	
			Organisations	Links	Research	Deployment
UK – East Wales	C	HIGH	0	-	-	-
FR – Rhône-Alpes	C	HIGH	1	0	1	2
DE – Bremen	C	HIGH	3	0	1	2
DK – N. Jutland	N	HIGH	0	-	0	-
FI – Lansi Suomi	N	HIGH	0	-	3	0
PT – Norte	S	VERY LOW	0	-	6	3
GR – Attiki	S	LOW	24	8	17	16
IT – Emilia Romagna	S	LOW	7	0	5	8

also depends on the greater size of the component. More individuals can be reached, but only through one path. The decrease in the clustering coefficient depends mainly on arithmetical properties.

For the regions examined in this evaluation analysis, the complementarity between the two networks is confirmed by the limited overlap between the research and deployment networks. As Table 11 shows, only in Attiki there is a substantial overlap of organisations and links between research and deployment networks and between IST and structural funds. However, one may recall that Attiki is a capital city region with a major concentration of national industry, quite different from the rest of the regions examined. Furthermore, Greeks are in relative terms the most frequent postgraduate students abroad and this helps establish social networks which allows them to make connections within Europe. Finally, structural funds within Greece are strongly supported by government intervention.

Thus, the empirical analysis of network data regarding the complementarity between IST research and deployment indicates that:

- There is relatively little overlap between IST research and deployment networks, which, however, may vary across regions.
- Several gatekeepers – organisations that participate in both networks – are universities or research centres (two-thirds of the total). However other organisations seem to play a relevant role, including SMEs.
- The population of gatekeepers includes a good number of network hubs: this significantly affects connectivity.
- The intense activity of gatekeepers – as observed through their linkages with other organisations – goes a long way in terms of balancing the relatively limited number of organisations participating in both activities. Put otherwise, gatekeepers play effectively their role of network bridge. For instance, one-third of the links of each network (research, deployment) correspond to connections between gatekeepers and other organisations.

4 The Viewpoint of Practitioners: Networks and Deployment

A lot of linkages and relationships among actors that are quite relevant for innovation and diffusion escape from the aggregate quantitative examination. They can be identified only through in-depth case analysis. While the relatively limited set of interviews conducted in a selected set of regions means that our results can be taken as indicative rather than representative of the whole population of European organisations, some clear indications emerge from the field evaluation.

4.1 Effects of IST networks on ICT deployment

Networks were reported to play an important role in raising research diversity by allowing the involvement of more sectors, to make research more relevant to problem-solving, and to increase the research quality. In cases where there is potential for market application, the networks are also viewed as very important. As one gatekeeper organisation told us: "*Yes, they (networks) do have a role (in deployment opportunities) since they allow us to integrate our competencies with foreign public institutions which can provide insights and experience… we apply the know-how developed within the research network to specific regional projects.*" Although interviewees are nearly unanimous in saying that the IST-RTD networks play an important role in information exchange critical to product and process deployment, in some cases they report that IST projects are too much focused on research and do not provide support to deployment activities and market commercialisation.

In cases where projects had an explicit goal that included product development or deployment, specific new products or processes did result from IST research projects. More frequently, however, interviewees mentioned that many projects aim at improving the deployment of an existing product or process. A person from a gatekeeper organisation said that their organisation participated in IST projects because the networks offer the opportunity to cooperate with other institutions such as universities which aim at achieving different research goals than their own. This person also said that, while universities are the main source of research, they also play a role in deployment in cases where a research allows the university to establish its own company.

A number of interviewees emphasised that the information that came through the networks also helped them to gain a better understanding of the markets that they are preparing products for. One interviewee in particular mentioned that the IST research network has helped to speed up diffusion of knowledge, and that this same network connected with a regional promotion agency aimed at diffusion in the region. However, interviewees stress that the physical location of the partners is less important than the existence of complementarity between capabilities among network participants.

In any case, a number of interviewees claimed that the IST projects encourage links among the institutions that interact across different types of programmes. The requirement to find partners from different sectors, for example, is seen as a point that strengthens regional links. Multinational firms participate in IST RTD projects; as a result, some smaller institutions had access to these firms in a way they otherwise would not have had under national or regional projects. They may represent a

unique opportunity for local organizations to broaden up their connectivity.

However, the interviewee from one of the gatekeeper organisations reports that the deployment of the products and processes developed within research networks is not always possible. Quite interestingly, this case refers to an IST network that had successfully accomplished the development of a product. The interviewee said that there had not been sufficient infrastructure for using the application and introducing it into the market. In this case, even the existence of an IST network could not advance the deployment. The problem appears to be one where the institution is not aware of other organisations that could help bring the product to market.

4.2 The role of national and regional networks in deploying ICT products

ICT diffusion activities are not always closely tied to regional strategies. In this respect, there seem to be some differences between the examined Northern European regions, where there is little coordination with regional strategies, and the examined Southern European regions, where coordination activities take place more frequently. In general, large organisations are informed of and exploit regional links, while SMEs are often not aware of the existence of regional strategies for ICT deployment and do not have resources and capabilities to efficiently use them. Creating a critical mass of resources and competencies therefore seems to be a necessary condition for exploiting regional policies aimed at connecting IST research and deployment. Very often interviewees cannot name a regional strategy to which they are linked. In many cases they did not have precise information about where they could go to get help with regional deployment and were not aware of direct links between national and regional networks in deploying ICT products developed within IST research projects. This is probably due to the fact that organisations are aware just of first tier linkages, but are less conscious of the second and third tier participants. In other words, while the global network (research and deployment) appears to be well connected when looking at the quantitative data, information about deployment projects and about potential indirect linkages with hubs and gatekeepers still remains scarce, especially for small organisations.

Most interviewees were not aware of explicit links between the participation in IST networks and the use of structural funds. In this respect, one interviewee said that the structural policy instruments focus mainly on funding projects and general concepts that improve the level of employment in a region, while programmes such as the FP6 prioritise different thematic topics. However, the priority for regional funds is to help the transition to knowledge society and sustainable development. Therefore, using structural funds to harness the research results of the IST networks for regional deployment should represent a major issue in the agenda of regional authorities. An interviewee from a hub told us: *"Theoretically there certainly are (such explicit links). However, at an operational level there are none. The institutions are invited to participate during the starting period, but during the execution period there is no participation at all."*

Most of the interviewees report very little connection with regional networks in deploying products. As one interviewee told us: *"The lack of significant regional economic agents to finance local deployment projects is a barrier". "The resources to finance the higher educational institutions are also scarce at the local level, which has negative implications on working conditions".* There are also cases where local connections appear to work, and where the local hub brought together a lot of local resources. For example, this is the case with the University of Cardiff, which actively coordinates a number of local and national activities in addition to EU projects. Although it does not show up as highly networked, this university clearly helps the local region by acting as a connecting point.

IST network participation is seen by several interviewees as less advantageous for the local region than for the European or international level. As one gatekeeper institution told us: *"The network had an advantage in identifying deployment opportunities at the European level. The advantage at the regional level was less significant. The network supported the partners to build thematic communities... this kind of community building occurred at a national or international level rather than at the regional level."*

From these reports it follows that opportunities exist for improving the linkages between the research and deployment networks at the regional level. In order to promote the development of IST networks at the regional level there is the need, on the one hand, for national governments to play a catalytic role and provide significant value-added by initiating and supporting mechanisms for inter-regional cooperation and collaboration – (this point is particularly important when regions have rather limited political power and a very limited budget). On the other hand, a clear understanding at the regional level of the concrete benefits resulting from the participation in the IST networks is required. Bureaucracy and difficulty in coordinating across the network are mentioned a number of times as obstacles to the integration of the IST networks. Other obstacles include the transaction costs (travel, staff time) associated with involvement in IST-RTD networks. As one highly-connected hub institution says: *"The main obstacle to participating in research, diffusion, and deployment networks is usually the cost associated with coordination. Bringing people together can be costly and time*

consuming…' This also becomes an issue when looking for links between research and deployment networks. In this respect, regional agencies can play an important role as brokers and matching institutions, emphasising the value of collaborations. Indeed, even if there may be high costs in entering the network, the benefits of deployment projects in general are quite high and usually greatly compensate for them.

4.3 Two key industrial players: multinationals and SMEs

Many interviewees stressed that the participation of large multinational firms is a very important part of the deployment phase of the projects. Multinational companies are able to connect local organisations with international networks and markets. However, nobody mentioned any policy instrument adopted to tie large multinational corporations to some regional strategy. This may be one area in need of improved institutional context.

Several interviewees also mentioned that SMEs are important partners at the deployment stage. This has been so because SMEs represent the large majority of organisations in the regions and are spread over a variety of applications and markets. One gatekeeper institution stated that SMEs are very flexible in applying the developments in different fields, but their activities are at the same time often restricted to a specific region. This is because the cost of being involved limits SMEs to participate to small scale projects.

The natural conclusion is that in order to achieve sufficient market penetration with global reach, both large multinational companies and SMEs are essential. Multinational companies possess financial assets, human resources and a global reach that are necessary in order to engage in large scale projects that link research and deployment. SMEs are deeply rooted in the territory and represent very efficient players when it comes to deploying specific applications and to building relationships with regional authorities.

5 Lessons Learned and Policy Implications

Innovation is a rather complex socio-economic phenomenon that requires access to technological and financial resources, diverse capabilities, and markets. Rarely are all these available in one place or embodied in one person or organisation. Indeed, most non-routine innovations appear to occur around the intersection of fields and functions. The role of networks in disseminating information and ideas and allowing access to resources, capabilities, and markets has, thus, become of critical importance. So much so, it could be argued, that the viability of network connections has become an important determinant of economic competitiveness.

The recognition of the importance of networks has led the European Commission to encourage the development of research and deployment networks across the ERA, as is currently evident in the parallel introduction of the Seventh Research Framework Programme (FP7) and the Community Innovation Programme (CIP). A complementary step has been the creation of incentives to motivate individual researchers to link together and, more generally, to increase the mobility of professionals across the continent.

Going beyond previous appraisals of research networks in IST, this evaluation study has concentrated on the assessment of the effectiveness of network collaboration and of knowledge transfers between RTD, innovation and deployment activities related to IST at the EU and regional levels. It has done so by focusing on the intersection of research, innovation, and technology deployment networks at the EU, national, and regional levels. We have tried to point out the linkages and influences between the *research networks* built through FP6 funding in the thematic area 'Applied IST research addressing major societal and economic challenges', on the one hand, and the *deployment networks* built through EU programmes (eTen, eContent) as well as at the regional level through structural funds or other member state and regional funds, on the other. The coalescence of these networks within nine selected regions of the European Community has received the bulk of our attention.

It must be stressed that the empirical network analysis has been paired with a significant set of interviews in the selected regions. The former (quantitative) kind of analysis captures aggregate tendencies in terms of network characteristics, network participants' characteristics, and network linkages. The latter (qualitative) kind of analysis captures the strength of ties and their qualitative features, as well as the contextual environment in which these ties are built as this environment is perceived by those who take action.

The key findings of our analysis are the following:

1. Regional networks are considerably strengthened by links into the IST RTD network. The research network complements the deployment network by adding links that allow many organisations to be connected. The research network brings an effective knowledge exchange among organisations and a fast diffusion of information within the network. Both research and deployment network are highly connected. However, in the deployment network the number of organisations connected to others is proportionally smaller than in the research network and, even for those who are connected, the connection is weaker. If the research links are added to the deployment network, the structural properties of the deployment network are modified. In particular, the IST research network increases the number of the organisations of the deployment network that are involved in sharing and exchanging knowledge, and speeds up information

transmission among its organisations. The overall network (the research and the deployment network jointly considered) is well connected and the average distance between organisations is 3.

2. *Hub organisations* play a critical role in maintaining the ties of the smaller and more isolated members of the networks. They diffuse technological and market information, help define standards for emerging products, and provide demand (applications) for research results. It is the actual presence of hubs in a region (among the regions examined this is the case of Attiki and Rhône-Alpes for Research and of Emilia Romagna for Deployment) that increases the connectivity of the region to other external hubs.
3. *Gatekeepers* have a uniquely important role of bridging research and deployment networks, thus helping both to disseminate knowledge of all kinds through various knowledge channels and to provide access to resources and opportunities. The intensity of the activity of individual gatekeepers – as observed through their linkages with other organisations – goes a long way in terms of balancing the relatively limited number of organisations participating in both activities. Thus gatekeepers play effectively their role of network bridge. From our quantitative evaluation analysis, we have found that one-third of the links of each network (research, deployment) correspond to connections between gatekeepers and other organisations.
4. Multinational firms participate in IST RTD projects; as a result, some smaller institutions have access to these firms in a way that otherwise would not have been possible under national or regional projects. Multinational companies possess financial assets and human resources that are necessary in order to engage in large scale projects that link research and deployment.
5. SMEs are key players in deployment. They are deeply rooted in the territory and represent very efficient agents when it comes to deploy specific applications and to build relationships with regional authorities.
6. In order to promote the development of IST networks at the regional level there is the need, on the one hand, of national governments to play a catalytic role and provide significant value-added by initiating and supporting mechanisms for inter-regional cooperation and collaboration (this point is particularly important when regions have rather limited political powers and a very limited budget). On the other hand, a clear understanding at the regional level of the concrete benefits resulting from the participation in the IST networks is required.
7. Bureaucracy and difficulty in coordinating across the network appear to raise barriers to the integration of the IST networks. Other obstacles include the transaction costs (travel, staff time) associated with involvement in IST-RTD networks.

The stronger emphasis on innovation and the quest for balancing supply and demand side effects of technological advancement in Europe today implies that both research and deployment linkages become a core policy concern. On the basis of lessons learned from our analysis, the following policy recommendations are aimed at strengthening the links between research and deployment, also including the linkages between European/national and regional activities.

1) STRENGTHEN THE LINKS BETWEEN RESEARCH AND DEPLOYMENT

✓ **Lesson:** While research across the ERA is highly networked, other parts of the system – namely those related to deployment – are less interconnected. Gatekeeper organisations in the networks play a critical role in that respect by providing interconnections across different networks.
Policy recommendation: Regions should involve more of these types of organisations (gatekeepers and hubs) in order to bridge research and deployment also at the local level more effectively and to harness the results from FP6.

✓ **Lesson**: While somewhat overlapping, deployment activities, capabilities and skills are different than those relating to research to a significant extent.
Policy recommendation: When programme objectives include dissemination and applications, they could be enriched with a local/regional deployment strategy as part of IST-RTD projects. In its programmes, the Commission should ensure that opportunities for regional organisations to engage and participate to deployment activities exist, so that connections between research and deployment programmes are strengthened also at the regional level.

✓ **Lesson**: Both research and deployment networks appear to be effective in information dissemination, the latter more so at the local level (as expected). Nonetheless, having a large number of organisations in the network does not guarantee extensive connections to the outside world: the inclusion of hubs does.
Policy recommendation: The investigated regions are not hosts to either IST research hubs or deployment hubs, with the exception of Attiki and Emilia Romagna. Since the presence of hubs in a region raises disproportionately the connectivity of the region with others, the attraction of such organisations locally is very important. Even more so given that many hubs also play the role of the gatekeeper.

✓ **Lesson**: Many interviewed organisations are unaware of opportunities for deployment.
Policy recommendation: The provision of information about these opportunities could be the first step in the direction of more awareness. In order to promote ICT deployment there is the need for national governments to play a catalytic role and provide significant value-added by initiating and supporting mechanisms for inter-regional cooperation and collaboration (this point

is particularly important when regions have rather limited political powers and a very limited budget).

2) STRENGTHEN REGIONAL STRATEGIES FOR LOCAL DEPLOYMENT

✓ **Lesson:** Regional strategies for economic development and ICT deployment are largely unknown to our interviewees. In many cases, participants are focussing on the global marketplace in their development process rather than on the local level. This may be appropriate for frontier innovation, but it is not the most effective way for innovation diffusion and deployment.
Policy recommendation: Development of regional policies for an ICT-based knowledge society is essential for regional knowledge hubs to establish links at the regional level.

✓ **Lesson:** Large multinational organisations play a central role in bridging research and deployment, as they possess financial, technical and human resources to enter research and deployment networks and to manage the complexity of collaborations.
Policy recommendation: Regions should support the presence of such large organisations that diffuse technological and market information, help define standards for emerging products, and provide demand (applications) for research results. Furthermore, they should strengthen links between multinational organisations and SMEs.

✓ **Lesson:** Knowledge about regional support systems (if they exist) is very spotty. In a number of cases, the interviewees did not know of local structural programmes or opportunities for connections.
Policy implication: Making this kind of information available, possibly through a virtual clearinghouse, would be a step forward.

3) SIMPLIFY THE EXPLOITATION OF IST NETWORKS AND PROJECT COORDINATION

✓ **Lesson:** The range of programmes and projects can be daunting and confusing to prospective participants, and may be a barrier to smaller enterprises.
Policy recommendation: The Commission together with regional agencies should provide clear information about the programmes available within the IST RTD activities as well as other EU programmes. It would also greatly help organisations at the regional level

✓ **Lesson:** The costs of joining IST networks, particularly for smaller institutions, can be a barrier to participation. In particular, bureaucracy and difficulty in coordination constitute important obstacles to the use of IST networks.
Policy recommendation: This issue is well-known to the European Commission and comes up again in this study. Further efforts to simplify participation and provide easy access to research results should be made.

European Commission

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