

Building Networks for Innovation Diffusion in Europe: Learning from the SPRINT Programme

FRED STEWARD and STEVE CONWAY

ABSTRACT *This paper concerns the building of organizational networks for the diffusion of innovation across national boundaries. In particular, it reports on an investigation of the Specific Project Action Line (SPAL); an exploratory initiative within the SPRINT programme which sought to improve the understanding and operation of the diffusion of innovation across national boundaries in Europe. The paper draws upon social network theory and evaluations of earlier networking initiatives within the SPRINT programme in order to inform the analysis of three SPAL projects. An important aspect of the study was the development of the network graphic as an analytical tool for the representation and comparison of project networks over time and between project. It is concluded that network diversity, network configuration, and the management of the networking process are all key and inter-related network themes that influence the diffusion of innovation across national boundaries. However, the cases highlight the problem of prescribing a single 'best' network structure for diffusion. It was found, for example, that the more 'distant' the innovation was from the market place, the more constrained the network needed to be, both in terms of size and diversity.*

Key words: Innovation Diffusion; Innovation Networks; SPRINT Programme; Cross-National Networks; Network Mapping; Network Graphics.

1. Network Based Innovation Policy

International competition and the global speed of technical change are major dynamic factors that are encouraging the formation of both cross-national and cross-sector innovation networks within the European Union (Wells and Grieco, 1993; Boekholt, 1994). Indeed, international competition is increasingly viewed as taking place at the level of organizational networks rather than at the level of the individual organization (Soeters, 1993). Such a trend is illustrated by research such

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as Hagedoorn and Schakenraad's (1992) longitudinal study of strategic alliances among leading companies in information technologies.

In tackling these challenges there has been a shift away from large-scale mission-oriented actions or 'big science' by the European Commission, accompanied by an increasing recognition of the importance of diffusion, networking, and SMEs for employment creation, economic renewal and innovation (Rothwell, 1991; Boekholt, 1994). This has yielded a number of schemes directed toward promoting innovation and regional networks, and improving the innovative capacity and impact of SMEs within the European Union. One such scheme was the SPRINT programme (Strategic Programme for Innovation and Technology Transfer), launched in 1983. This scheme represented a significant shift in European innovation policy toward a programme explicitly organized on the 'network template' (Wells and Grieco, 1993). It also reflected a move away from traditional policy instruments based on the 'linear model' of innovation, to those based on the 'interactive model', where diffusion is no longer considered a distinct last phase of the innovation process, but integrated into the process as a whole. The SPRINT programme has since ended, and has been subsumed within the Innovation theme of the Framework 5 Programme.

Bianchi and Bellini (1991) make the distinction between industrial policies aimed at individual agents in a given sector or geographical area and those interventions directed at influencing the set of relations between these agents; they term these 'individual' interventions and 'structural' interventions, respectively. The SPRINT programme incorporated both of these types of policies. On the one hand, there existed a range of actions aimed at improving the technology absorption capacity of firms through advisory centres and consultancy, and the provision of resource support through science parks, for example. On the other, there were a number of structural initiatives aimed at promoting the creation and development of project specific, generic technology and regional networks. Bianchi and Bellini (1991) argue that such structural intervention must consist of actions to make the system as a whole explicit, encouraging agents to see themselves as part of a single network; involve a multiplicity of actors; give direction to the specializations of the local agents in order to permit greater articulation of the division of labour, and lower the costs of coordination.

Designing policies to promote technological innovation and diffusion requires an appreciation of both the potential barriers to network formation, and the desirable network characteristics, such as membership diversity and optimum growth dynamics. Bianchi and Bellini (1991, p. 489) argue that 'historic experience has taught us the need for a systemic approach to industrial organization' and that 'the "network" is a stylized concept which we can use both as an analytical tool to understand economic reality and as a reference for political action in order to modify that reality.' That is, the network concept is a useful framework for evaluating the configuration and operation of existing networks, and for highlighting factors that might improve their networking performance. Networks are more than portfolios of links between a group of people or organizations: they imply structure and synergy. DeBresson and Amesse (1991, p. 364) support this view, arguing that, 'Because interactions between firms . . . are iterative and broad in content, time and space, what matters is the complete set of relationships.'

Central to an understanding of the process of cross-national diffusion of technological innovations is an appreciation of the patterns of communication between actors within and across national boundaries. Research has indicated, for example,

that effective communication occurs most frequently between ‘homophilous’ actors, that is actors who are similar in certain attributes such as nationality, education and social status (Rogers and Bhowmik, 1971). Iterations of interaction between a group of actors leads to a convergence of norms, values, beliefs and behaviour. This process of convergence or ‘isomorphism’ leads to the formation of densely connected groups of actors, termed ‘clusters’ or ‘cliques’, within rather than across boundaries; these may be organizational, regional, industrial sector or national boundaries. Hofstede (1980) found both differences in national culture and in the cultural distance between nations. The greater the cultural distance between two nations the more significant are likely to be the difficulties for effective communication and cross-national network formation.

On the other hand, interactions that lead to innovation are often those that are between ‘heterophilous’ actors and hence less frequent. This would suggest that cultural diversity may have considerable innovative potential. A key issue is how communication difficulties might be overcome in order to build cross-national networks? The first step would be to actively encourage the construction of a network with a cross-national membership. The second would be to reduce any cultural misconceptions or ignorance that may exist in the network (Soeters, 1993). That is, the aim should be to improve understanding and tolerance within the network, without reducing the innovative potential of diversity. Such objectives underlie a range of initiatives to promote cross-national networks between actors in different European Union member states to facilitate the diffusion of technological innovation. As a result there is an extensive set of accumulated experience from such initiatives. Building upon the insights of social network theory, recent analyses of innovation networks have sought to document and learn from this experience of creating and nurturing effective networks (Freeman, 1991; Kreiner and Schultz, 1993; Steward and Conway, 1996; Conway, 1997a).

2. Network Concepts

In this analysis, we draw upon three concepts from the literature on social networks that are particularly relevant for understanding the creation and performance of transnational networks for the diffusion of innovations across national boundaries:

- The diversity of a network’s membership, which is a core consideration for reasons of communication and innovativeness;
- The configuration of a network, which concerns its overall patterns in terms of the type of actors and their relationships with each other; and
- The networking process, which focuses upon the management and mobilization of linkages, and the flows through a network.

2.1. Network Diversity

Although networks embracing a diversity of nationalities, industries and organizational types (manufacturers, end-users, and research organizations, for example) can create practical problems in relation to network cohesion and survival, their potential for innovation and diffusion can be powerful. Although studies have shown that ‘homophily (the similarity of actors) and effective communication breed each other’ (Rogers and Bhowmik, 1971, p. 529) this can also lead to the pooling of ignorance. Indeed, it is argued that the ideas and information that pass between

‘sociometrically distant’ heterophilous (dissimilar) actors are more likely to be ‘new’ and ‘fresh’ (Granovetter, 1973; Rogers and Kincaid, 1981). In fact, these two factors need to be balanced such that network members are sociometrically close on some variables and distant on others (Rogers and Bhowmik, 1971). Successful cross-border diffusion is aided by the incorporation of actors who are ‘embedded’ in the market-place of other countries; not only does this allow the network to span cultural boundaries, but it is able to plug into existing networks in these markets.

Diversity may also be influenced by size. Bianchi and Bellini (1991, p. 491) also argue that:

The optimal number of members and the free-rider problem are strictly connected: when the number of entrants is rapidly increasing, and existing members are not able to select new, entrants through a method of co-optation (involving the acceptance by the entrant of the existing rules), the entrants become free-riders and the transaction-cost advantages based on common language and reciprocal reliability fall down.

2.2. Network Configuration

Rogers (1987) contrasts the relational approach to the analysis of networks with the structural tradition. The relational approach emphasizes the importance of the configuration of networks for the understanding of the technology transfer process. Diffusion is best facilitated by ‘open’ networks, providing bridges to other cliques (Rogers and Bhowmik, 1971; Granovetter, 1973; Rogers and Kincaid, 1981; Conway, 1997b). In their work concerning the diffusion and communication of innovation, Rogers and Kincaid (1981, p. 347–48) distinguish between what they term ‘interlocking’ networks and ‘radial’ networks. Here they define interlocking networks as those ‘in which an individual interacts with a set of dyadic partners who interact with each other’, and radial networks as those ‘in which an individual interacts with a set of dyadic partners who do not interact with each other’. Thus, interlocking networks can be seen as synonymous with cliques and, in contrast to radial networks, are dense and highly connected. With respect to the innovative and diffusion capacity within these types of networks, Rogers and Kincaid (1981, p. 136) argue that:

... interlocking personal networks are more numerous than radial networks. The reasons for this tendency toward integration in personal networks may be the same as those facilitating the homophily principle ... Unfortunately, the ingrown communication patterns in interlocking personal networks discourage the exchange of new information with the environment beyond the personal network. Interlocking personal networks lack openness ... (and) may simply facilitate the pooling of ignorance among the individual members.

Combining the concepts of the ‘radial’ network, ‘openness’, and ‘embeddedness’ in local markets, it is possible to visualize a network that incorporates a series of ‘zones’. Drawing from Barnes (1969), the ‘primary zone’ embraces the core of the network, in which each of the actors are directly linked to each other. In the ‘secondary zone’, each of the core network members are embedded in other networks, whose network members are only linked to the core network indirectly through themselves. Thus, the network members act as bridges or liaisons to other

networks (Conway, 1997b). By distinguishing between the primary and secondary zone of the network, it is possible for the core network membership to be densely connected and kept at an optimal size, whilst at the same time being 'open' and linking it indirectly to many other actors, in a 'hub and satellite' network formation.

2.3. *The Networking Process*

Whilst the configuration and membership of a network is important, it is the process of networking that releases the 'potential' of the network. That is, the utility of the network lies not in the 'dormant' structure, but through the interaction of network members. Thus, the mobilization of linkages within the network, and the facilitation of flows through these activated links, are key tasks that need to be managed within the network.

Bianchi and Bellini (1991, p. 490) contend that 'the existence of a network requires a sort of self recognition by the participants, and therefore a slow evolution of common traditions and language.' Research has indicated that regular contact between actors on an equal footing and with shared interests, supported by institutional arrangements, will serve to promote such a feeling of commonness (Allport, 1958). This is particularly important where network partners have been drawn from a range of cultural backgrounds. Indeed, Soeters (1993, p. 645) argues that 'only under these conditions are prejudicial attitudes likely to be reduced'. Thus, there needs to be a proactive approach to the nurturing and maintaining of the network and the individual relationships within it.

3. The SPRINT Specific Projects Action Line (SPAL) Scheme

The Specific Projects Action Line (SPAL) scheme was an exploratory action within the SPRINT programme which sought to improve the understanding and operation of the diffusion and transfer process of technology across industrial sectors and national boundaries within the European Union. As well as taking account of many of the above factors in building project networks, this particular scheme is interesting in that as an exploratory action it has had the opportunity to incorporate a number of innovative elements in project management and network formation: a 'hands-on' approach to project construction and steering via a Technical Assistance Unit; the running of Goal-Orientated Project Planning Seminars for network partners; and the creation of add-on peripheral 'observer groups' to maximize diffusion potential. The SPAL scheme was administered by a number of Project Officers from both the SPRINT Technical Assistance Unit (TAU) and the European Commission DGXIII. The initiative encompassed a broad range of organizations from businesses to trade unions.

In addition to the technological merits of project proposals, a number of network criteria were required to be satisfied for a project to be considered for selection in the initial 'Definition Phase' of the SPAL scheme:

- A partnership must involve independent organizations from at least two member states: the EC only has a mandate to finance transnational projects. Since the aim of the programme was to promote diffusion, a broader European project group was encouraged to foster a broader diffusion of the technology across the EU.
- Membership should incorporate technology providers, end users and intermediaries (operating in a facilitating capacity) to make full use of the advantages

to be derived from the collaboration between complementary sources of expertise.

- The project should involve ‘near-market’ technology and be diffusion orientated.
- It was recommended that in the earlier stages of the project the membership should be between three and five partners.
- During the second ‘Implementation Phase’, project groups were required to be supplemented and complemented by an ‘observer group’, made up of observers from two to four EU countries not currently represented in the project. The Commission saw this group as providing a ‘multiplier effect’ on the diffusion of the technology within the EU (Boylan, 1995).

The SPRINT SPAL scheme provides a valuable test bed for the investigation of the relevance of network concepts to actual cases of transnational technology diffusion networks.

4. Methodology

The investigation was undertaken as part of a study to assess the potential of visual network mapping methods for facilitating the management of European Commission sponsored networks to promote innovation (EIMS, 1996). An initial review was made of the accumulated experience of the establishment and operation of networks within the Specific Project Action Line. This was based on interviews with core staff involved with managing the SPAL scheme (i.e. two Project Officers at the SPRINT Technical Assistance Unit) and on the analysis of the results of prior studies on programme evaluation and best practice which had been commissioned for the action line.

Following this review of network management experience an empirical investigation was made of a selection of SPAL innovation diffusion projects using a network mapping methodology that was developed to enable the key elements of network formation and dynamics to be analysed. Data on the participants and performance of each project were obtained from documentary sources produced by each project-team and from interviews with key project members.

4.1. Selection of SPAL Projects for Investigation

The Specific Project Action Line was explicitly diffusion-orientated, seeking to improve the transfer of technology across industrial sectors and national boundaries. However, the technologies in different projects varied in their level of technical development and in their direct transferability between various industries and nations. A small number of projects were ‘upstream’ in nature and required quite substantial technical development in order to become commercially viable. Another group of technologies had reached the point of commercial application in a particular national or sectoral context, but still required quite substantial adaptation to new and different ‘local’ conditions. A third group of technologies were more ‘downstream’ in nature, commercially established, and more amenable to diffusion across sector and national boundaries whilst remaining essentially ‘intact’.

Three projects were chosen to represent the varying degrees of adaptation required for ‘local’ conditions and ‘nearness to market’ of the technologies:

- (1) Foundry water-jet cutting – this project required basic developmental work to be undertaken prior to the process of diffusion;

- (2) Urban drinking-water distribution management system – this project required the adaptation of the technology to enable its diffusion; and
- (3) Non-toxic cleaning agents for off-set printers – this project involved the diffusion of an ‘intact’ technology.

4.2. Mapping Innovation Networks

The power of the network graphic, over and above textual and matrix illustrations, lies in its ability to incorporate and encode a variety of quantitative and qualitative information. This is possible through the representation of various facets or characteristics of both the nodes and the relationships that link them by a palette of what Bertin (1983) terms the retinal variables (size, value, texture, colour, orientation and shape). The network graphic is also able to reveal and highlight the dynamic nature of networks, through the comparison of ‘snap-shots’ of a network at various points in time. However, for the network graphic to be a useful analytical tool, it is important that the network graphic conventions adopted are those that reflect the interests of the network researcher. That is, the nodal and linkage characteristics of greatest salience should be represented by those retinal variables that make their differences and similarities most obvious to the eye and therefore more immediately comparable (Steward *et al.*, 1994, 1995).

As part of the study, a set of graphic conventions were developed to aid such a comparative network analysis (see Appendix). These conventions were determined for a number of salient actor, link and flow variables, and include, for example: actor dimensions – organization type (e.g. consultancy, technology transfer organization, university), project membership status (e.g. original network member, member of observer group, new member), and nationality; linkage dimensions – intensity of interaction; and flow dimensions – direction of flow. A template for the positioning of actors was also designed to facilitate the analysis of proximity to market of the technological development and the supply chain location of different actors (i.e. most importantly, the x-axis from left to right of the graphic, represents the supply-chain from ‘up-stream’ to ‘down-stream’, from developer to user). The method has been more fully discussed elsewhere. (Conway and Steward, 1998)

5. Results of the Investigation

The lessons for networking from the SPAL scheme are discussed in two ways: firstly, through a general evaluation of the network and project management techniques employed under SPAL, that were originally derived through self-reflection and analysis of earlier SPRINT initiatives; and secondly, through a more detailed focus on the network development of three SPAL projects through time.

5.1. Managing the SPAL Project Networks

The experience of network-building had been considered within the SPRINT programme, with the assistance of consultants who surveyed project participants and managers. (Coopers and Lybrand, 1994; Technopolis, 1995) A range of features had been identified through this process.

5.1.1. External Mentoring. Proactive mentoring of projects by TAU (Technical Assistance Unit) Project Officers was introduced for a number of reasons: to allow for best-practice and experience gained under the action line to be diffused to all SPAL projects; to influence the shape, composition and management of individual projects in line with the overall objectives of the scheme; and to exert influence where projects had lost direction or momentum. Initially, the Definition Phase was seen as a stage of refinement of the original project proposal, but in practice it was far more fluid in relation to both project goals and composition. This fluidity was largely the result of proactive mentoring. Experience from the scheme highlights the delicate balance in the level of mentoring between what is considered interference and what is considered useful and constructive guidance: too much, and the project members may feel frustrated and a loss of project 'ownership'; too little, and the project group may become isolated and insular. The TAU was proactive in suggesting partners in EU countries not represented by selected project proposals. SMEs in particular found this guidance very useful as their own networks were often under-developed. However, there were cases in which similar project proposals were merged by the TAU in the hope that the new group would come together as a larger consortium: in practice the original groups in these cases did not interact with each other, tending to work in parallel. This illustrates that groups have their own internal dynamic that is difficult to influence or administer externally.

5.1.2. Building Consensus within the Project Team. Each project team was strongly encouraged (though not required) to attend a Goal Orientated Project Planning (GOPP) Seminar/Session. GOPP is a structured management technique for the planning and management of projects and aims to promote 'transparency' between partners, identify problems, strengthen the consensus of opinion within the group, and establish a work-plan. Most groups attended the GOPP sessions, though feedback on their merit was mixed. Those partners with little experience of collaboration, including many of the SMEs, felt that GOPP helped them surmount cultural differences and clarify project goals and objectives. But at the other extreme, those partners with extensive experience of collaboration felt either that GOPP was too rigid and that informal approaches were better for consensus building, or that alternative structured approaches were more appropriate. SMEs in particular were concerned about the time and resource requirements of GOPP workshops.

5.1.3. Expanding the Network through Peripheral Membership. Although the 'observer group' concept appears attractive on paper, in practice the requirement for the creation of this peripheral group during the Implementation Phase created a number of practical and 'political' problems: not all of which may be overcome easily. There existed no clearly defined role for observer group members and no extra funds were made available to cover their expenses occurred through attending meetings. Issues of administration and group dynamics associated with increasing network membership by incorporating observers meant that in many projects this group was kept at arms-length. Furthermore, many 'core group' end-user partners had become involved in the project in order to gain competitive advantage by implementing the technology first and therefore, unsurprisingly, were often resistant to involving observer groups who were populated by other end-users and end-user

associations. However, the observer group concept worked extremely well in a number of instances, even though some grew to around twenty partners. In addition, many projects found it extremely effective to expand the core of the group by drawing from their observer group.

5.1.4. Expanding the Core Membership of the Network. The average number of participants of successful projects during the initial Definition Phase was 4.6, compared with 6.1 for unsuccessful projects (Technopolis, 1995). As projects progressed and stabilized during the second Implementation Phase many successfully expanded the core membership of the network. This recruitment often occurred from existing members of their project observer group, who were already familiar with the technology, the core members, and the project structure. However, in some cases new members remained on the periphery of the original project network.

5.1.5. Overcoming Cultural Differences. Some 15 nations were involved in the SPAL scheme overall, incorporating a range of cultural differences at the level of individuals, organizations, institutions and business practices. Thus, it was not surprising that culture-bound obstacles arose, particularly with respect to newly formed relationships. In most projects these cultural differences were not a major problem, but in others they provided quite severe barriers to effective network interaction. As noted above, the GOPP sessions helped to articulate and clarify many of the cultural differences in a number of projects and this proved very useful in overcoming potential barriers. Project partners also spoke of the value of building more informal relationships and developing trust, often through socializing following formal project meetings.

5.2. Case-Study 1: Foundry Water-Jet Cutting

The foundry sector is one of Europe's traditional industries that has come under increasing threat from low-wage economies. In order to survive, modernization and automation have become paramount. However, at the time of the project, although considerable progress had been made in a number of foundry tasks, such as casting and die making, other areas of the process had not been improved. The first case-study focuses on a project that aimed to develop new technology to improve the process of fettling, the removal of unwanted metal, a difficult and often dangerous task that exposes workers to risk of injury.

5.2.1. Network Formation. This project group was brought together for the Definition Phase (Figure 1) following a survey of the foundry market by BHRG, a British hydromechanics research organization (the lead partner) which sought to identify companies interested in marrying water-jet and robot technology to automate fettling. Other than Hammelmann who had supplied equipment prior to the project, BHRG had had no previous relationships with the project partners. At this stage the project incorporated six members from three nations: four German (represented by two pressure-pump suppliers, a research organization, and a foundry/end-user), one British and one Danish (both research organizations).

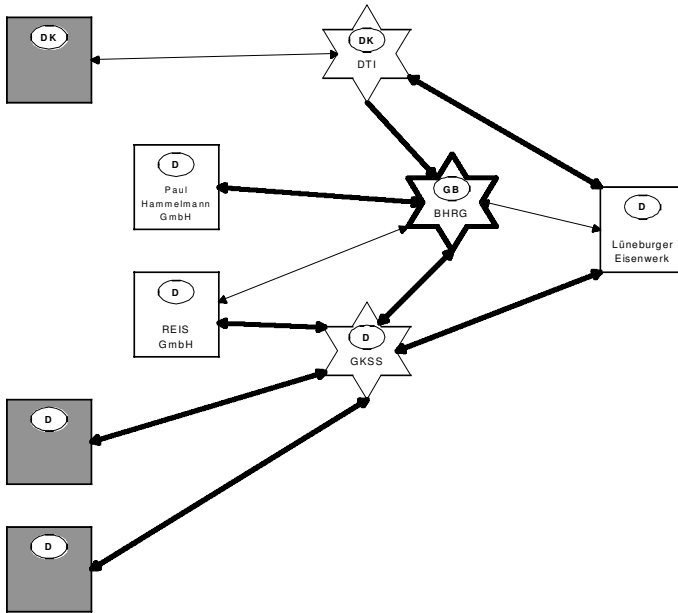


Figure 1. Foundry water jet cutting project – network formation.

5.2.2. Network Development. The development work involved the merging of three types of technology to form a work cell: water-jet, robotics and pressure pump. Funding was provided to create two working cells from alternative technologies. Technical coordination for these two cells was split between the DTI (Danish Technological Institute) who were working on a kinematic robot employing a low pressure water-jet cutting device, and GKSS (a German research organization) who were working on a six-axis robot employing a high pressure water-jet cutting device (Figure 2). Both cells were implemented within the one end-user member of the project: a German foundry. Administrative co-ordination for the overall project was undertaken by BHRG, the British contract R&D organization. The two technical hubs of the project network were also linked to other actors outside the project who were directly involved in the development of the cells. In addition, BHRG was itself at the hub of an international water-jet technology community, involving research organizations, universities, manufacturers and end-users. In this sense all three key actors provided links to other sources of technological inputs.

5.2.3. Network Extension. The observer group formed in the Implementation Phase was made up of 10–12 organizations, largely from EU nations not represented by the core group: including four foundry associations from the UK, Spain, Sweden and Portugal; the remainder being foundries (end-users) (Figure 3). No relationships existed with these organizations prior to the formation of this observer group, though the four foundry associations were subsequently asked to join the core group for the Diffusion Phase of the project. Up to this point the observer group had met only once and then separately from the core group. Thus, the observer group could not really be described as a clique, but did provide weak links between the project network and other user networks. This liaison role was

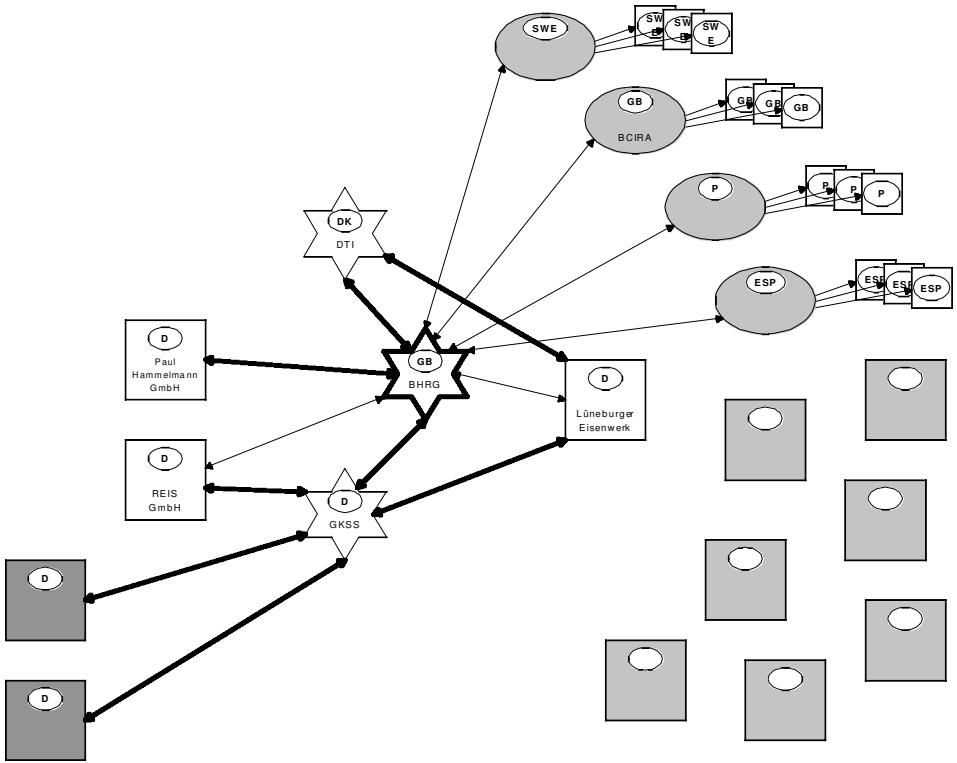


Figure 2. Foundry water jet cutting project – network development.

particularly evident in relation to the foundry association members. Due to the immaturity of the technology the observer group provided little input to the development process.

5.2.4. Network Summary. The core network remained stable throughout the first two phases of the project (Definition and Implementation): a total of around 2–2.5 years. This may in part be attributed to the newness of most of the relationships in the project network, requiring a period of learning to work together. Furthermore, the network composition remained biased toward upstream organizations: suppliers and research organizations rather than end users. This is not surprising as end users are often unwilling to become involved where the technology is still relatively immature. This factor probably also led to the lack of focus of the observer group network, which had no real practical role to play. However, four new members (all foundry associations representing end users) joined the core group for the final stage: the Diffusion Phase. The inclusion of foundry associations rather than end users provided the project with an excellent opportunity for the rapid diffusion of the technology, since each association was well embedded within the user population of their respective nations. Thus, alongside the growth of the core clique as the project shifted from development mode to diffusion mode, was the rise in the importance of the four new foundry association members as ‘diffusion hubs’, and a fall in the importance of the ‘technical hubs’, in particular DTI and GKSS.

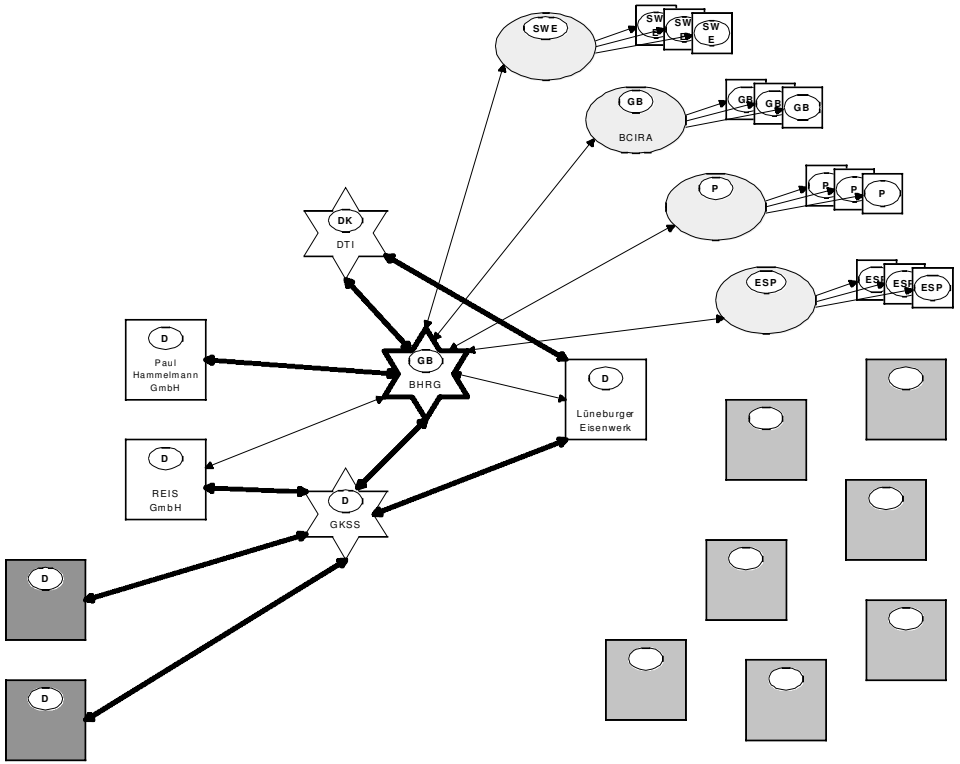


Figure 3. Foundry water jet cutting project – network extension.

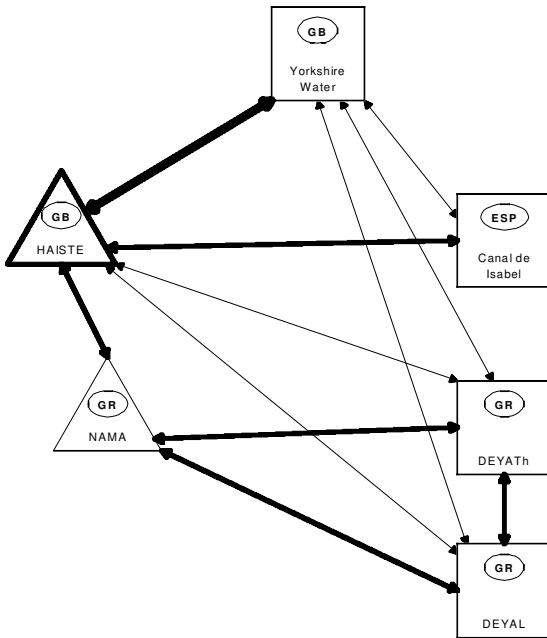


Figure 4. Urban drinking-water project – network formation.

5.3. Case Study 2: Urban Drinking-Water Distribution Management System

Whilst the consumption of water for both domestic and industrial uses is increasing in most European countries, there is a limit to existing water sources, and new sources are often difficult and expensive to develop. Furthermore, water distribution systems typically suffer from leakage, and losses may be as high as 30%. The second case-study focuses on a project designed to adapt technology developed in the UK for leakage control in fresh water distribution systems, to allow its diffusion to Southern Europe. Prior to the initiation of the project, the technology had been successfully adapted for use in a number of Northern European countries, reducing leakage by around 15%. Although the technology is not complex, accuracy is essential if it is to be successfully adapted to local water distribution systems, and this requires close interaction between the technology provider and technology user.

5.3.1. Network Formation. The origin of this project network was essentially derived from the bringing together of a number of existing dyadic links between water supply companies and technical consultancies in 1991: Yorkshire Water and Haiste, Haiste and Nama, Nama and DEYATH, DEYATH and DEYAL. At the Definition Phase of the project, the network included six partners from three nations (the UK, Greece and Spain), incorporating two consultancies (Haiste and Nama) for the provision of technical support and training, and four end-users, Yorkshire Water as a provider of implementation knowledge and experience and the remainder as technology implementors (Figure 4). The key actors in this network were: Haiste, as project coordinator, provider of technical support, and trainer for Nama in mathematical modelling; and Nama who created the mathematical models for DEYAL and DEYATH and played a liaison role between these companies (creating a Greek sub-network) and Haiste, largely because of Nama's language capability and project experience.

5.3.2. Network Development. There existed very close 'on-site' interaction between a number of the actors in the project group that helped to build the cohesion of the newly formed network. This was largely in the form of intense two-way communication at the level of the engineer: Haiste engineers sat down alongside Nama engineers to take them through some of the early models that the latter had built; Yorkshire Water sent out a number of experienced staff to work alongside DEYAL engineers (Figure 5). In addition, Haiste as lead partner sought to remove one potential cultural barrier to the success of the project: from their experience they knew that the implementation of the technology was a very interactive process between technology provider and implementor; they also knew from their experience that such interaction was different to traditional practices in Greece. To overcome this perceived barrier, Haiste sent out one of their engineers to impress upon the engineers at DEYAL and DEYATH the importance of their role in the process of model building, in order to prepare the ground for when Nama would need to work closely alongside these two companies in the implementation of the technology. From the original core of six partners brought together for the Definition Phase in 1991, the network expanded in two stages: in early 1994 with the addition of a German water distribution company (Stadwerke Chemnitz AG); and in late 1994 with the addition of six new partners; three Irish, one Greek and

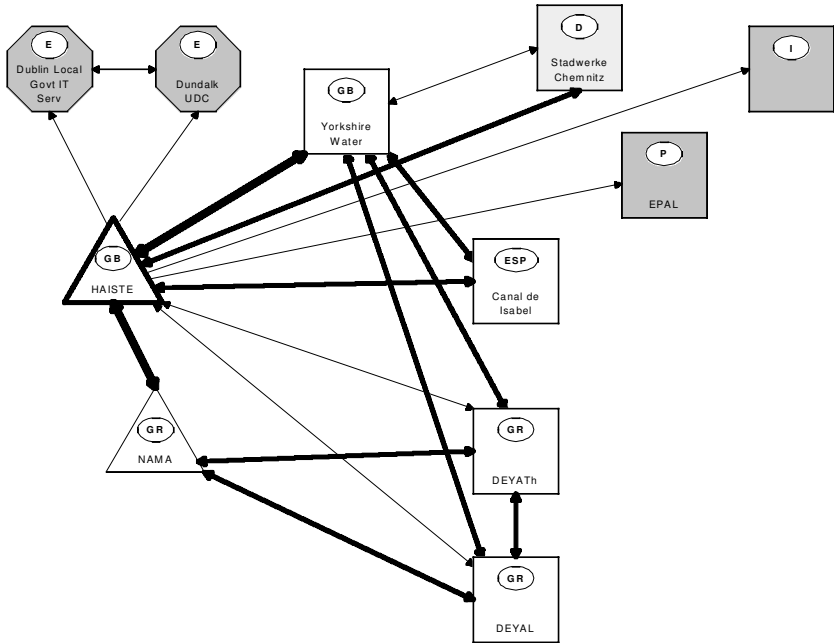


Figure 5. Urban drinking-water project – network development.

one Portuguese. This brought the core network size to 13 partners from six nations. Three of these were drawn from the project observer group: Dundalk Urban District Council, Dublin Local Government Computer Services Board and EPAL. The addition of these new project members extended the number of pilot projects from three to seven, and incorporated, Larissa (DEYAL) and Thiva (DEYATH) in Greece; Madrid (Canal de Isabel) in Spain; Chemnitz (Stadwerke) in Germany; Lisbon (EPAL) in Portugal; and Dundalk and Meath in Ireland. The final two members LNEC (a Portuguese trade association) and EDEYA (the Union of Greek Municipal Water Enterprises) were recruited to aid in the diffusion of the technology rather than to become involved in the implementation of the technology.

5.3.3. Network Extension. The observer group was originally formed with four members: an Italian multi-utility company based in Verona; a Portuguese water distribution company based in Lisbon (EPAL); and two Irish organizations: the Dundalk Urban County Council represented by the town engineer; and the Dublin Local Government Computer Services Board (Figure 6). The complexion of this observer group was partly in response to requests from the SPAL project officers to include several ‘peripheral’ EU member nations. The relationships were new and established through various other contacts in the water industry. A number of these observers were later recruited into the core group as noted in the above section.

5.3.4. Network Summary. The original project network took around 2 years to consolidate. This was due to the newness of many of the relationships; language

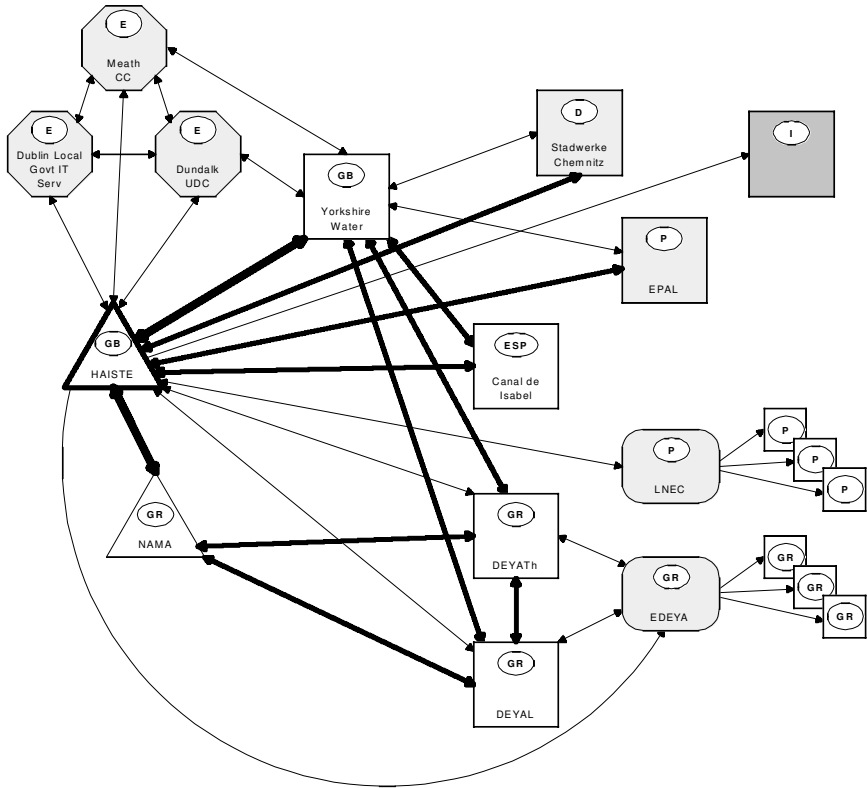


Figure 6. Urban drinking-water project – network extension.

barriers to direct communication among all partners; cultural differences in work practices; and the need for the technology to be adapted to 'local' conditions. However, following this period of technical and group consolidation the network expanded quite rapidly after 1994, enabling the project group to diffuse and implement the technology fairly widely in a short period of time.

5.4. Case-Study 3: Non-toxic Cleaning Agents for Printing

The use of organic solvents for the cleaning of off-set printing machines has major impacts on worker health and the environment. The third case-study focuses on a project designed to reduce this impact through the diffusion of non-toxic vegetable oil cleaning fluids. This technology had been developed and successfully introduced in Denmark, but had not been diffused readily into other European countries. Since the main reasons for the poor diffusion of this beneficial technology were believed to be a lack of awareness or a suspicion of the new technology, a key role of the project was to pool and transfer information with regard to its benefits and costs.

5.4.1. Network Formation. The origination of the project can be traced to a conference on the work environment, where a Danish technical school KTSK was demonstrating the technology: non-toxic vegetable oils for cleaning printing machines. At this stage the technology was in use in Danish industry and functioned

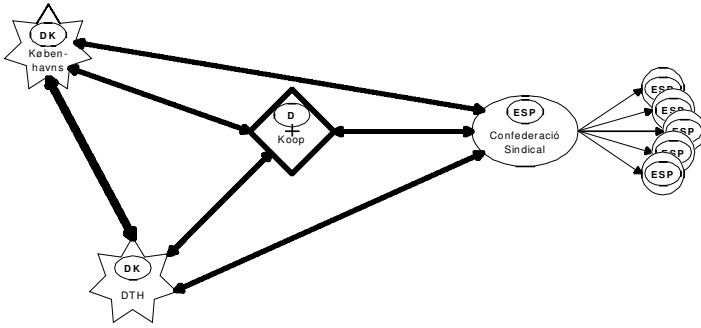


Figure 7. Non-toxic cleaning agents for printing project – network formation.

well. Kooperationsstelle DGB (a technology transfer organization under the German Ministry of Science and Research) was impressed by the technology and after receiving literature on the SPRINT programme by coincidence decided to put in a proposal. The original proposal included three partners: Kooperationsstelle (the lead partner), KTSK and DTH (the Technical University of Denmark). The German-Danish links were new, originating from the conference. Following submission of their proposal they were asked to supplement the group with partners from southern Europe, which they did with some difficulty: Confederació Sindical (a Trade Union) and SERMASA (which subsequently left due to internal problems). Thus, at the start of the initial Definition Phase in 1992, the project group was effectively made up of four members from three nations (Figure 7). In this early phase of the project the emphasis was on the application of the technology to various industrial environments. The organizational mix incorporated both technology providers and technology diffusion intermediaries.

5.4.2. Network Development. The SUBSPRINT project quickly developed into quite a substantial network with the core project partners acting as a steering committee for the coordination of overall diffusion activities (Figure 8). Following the success of the early phases of the project, EU funding was doubled allowing the recruitment of five new partners in late 1993/early 1994, representing the addition of four nationalities to the team: two British, one Italian, one Dutch, and one from Luxembourg. Within the project, the new members all acted as technology diffusion intermediaries; each developed their own national network which they coordinated, and each acted as liaison between the core project team and their national ‘satellite’ project. Thus, each of these sub-networks was a national satellite promoting the diffusion of the technology in their respective countries and incorporating a range of organizations. Taking the example of the Dutch satellite network, we have: Chemiewinkel, the sub-project leader (Occupational Health and Environment Department, University of Amsterdam); KVGGO (an employer’s organization); Druk Papier FNV (a trade union); GOC (a vocational training centre for the printing industry); Tetterode (the leading supplier of printing equipment in the Netherlands and itself part of a network of Dutch suppliers of cleaning agents); and VROM (the Dutch Ministry of the Environment). Each of these organizations in turn directly represent and/or have access to many end-user organizations.

formal members of the SUBSPRINT project team, the network configuration provided a dramatic multiplier on the effectiveness of the EU project funding, whilst also allowing many actors to become involved without the core project size becoming too unmanageable. In addition, the configuration also helped to reduce national cultural barriers by limiting the interaction between the national satellites and the core team to the intermediaries, that acted as gatekeepers. This allowed a smaller multi-national team to build understanding and linkages within the core group.

6. Concluding Comments

There are a number of inter-related messages that can be extracted from the SPAL experience for the building of networks for the diffusion of innovation across national borders. These focus on network diversity, network configuration and the management of the networking process. With regards to the diversity of network membership, the cases demonstrate that technology diffusion is promoted by the inclusion of actors from along the supply-chain, including technology providers, technology intermediaries and end-users. However, the Foundry Water Jet project suggests that where the technology is still under development, the role of end-users needs to be defined more carefully. The establishment of a multi-national project team was also found to be key to the success of each of the projects: in the Foundry project, national diversity allowed bridges to a broader set of technological competences; in the Drinking Water project, national diversity enabled the technology to be adapted accurately to a range of local conditions; whilst in the SUBSPRINT project, the multi-national membership allowed far more rapid diffusion of the innovation. Nevertheless, network diversity necessitates clearer goals and roles, as well as purposeful management, since conflicting goals and cultural variations are likely to exist both between organizations along the supply-chain, as well as between organizations from different nations. The role of 'Lead Partner' appears to have been vital in this respect, that is, Koop in the SUBSPRINT project, Haiste in the Drinking Water project, and BHRG in the Foundry Project. Haiste, for example, played a particularly important role in overcoming national cultural differences in working practices, that otherwise might have undermined the success of the project. The highlighting of network management issues, including training sessions on consensus building, and external mentoring by the Technical Assistance Unit appeared to have had a beneficial impact on the projects, although the experience and reaction of different partners varied; it was found that a balance needed to be made between external mentoring and perceived interference, and allowance made for the networking and project experience of partners.

With regard to network configuration, the cases highlight the problem of prescribing a single 'best' network structure, particularly for the range of projects under the SPAL scheme. It was found that the more removed the core innovation was from the end user, the more constrained the network needed to be, both in terms of size and in diversity. Thus, whilst in the Foundry project, where the technology was still being developed, the network remained fairly closed, in the SUBSPRINT project, where the technology could be diffused intact, the network developed rapidly to incorporate many of the observer group organizations, through an 'open' core and satellite configuration. Furthermore, developing and maintaining an 'appropriate' network configuration requires proactive network management.

Thus in conclusion, the designing of policies to promote technology diffusion across national boundaries requires an appreciation of the potential barriers to such network formation. Language, and cultural differences at the level of individuals, organizations, institutions, and business practices between nations need to be recognized and addressed. In relation to effective network formation, past experience and social network theory provide guidance on desirable network characteristics: optimum network size and configuration, membership diversity, network management, and the importance of creating informal relationships and consensus within the network. With reference to the SPRINT Specific Projects Action Line, a number of innovative techniques were discussed and evaluated with respect to improving network performance and aiding partners to learn to work together: these include external mentoring, structured project management techniques to improve project cohesion and consensus, and the use of observer groups to maximize diffusion. Although in this particular programme the success of these initiatives was mixed, the examples of success indicate that they offer great potential.

The three case-studies discussed in this paper illustrate the inverse relationship between the nearness or ease of implementation of a technology and the growth of its diffusion network. The wide and rapid diffusion of the new cleaning agent for printing was also aided by the recruitment of key national 'umbrella' organizations (such as trade unions) rather than end-users; a strong co-ordinating core network with a strong sense of purpose and direction; and the decentralization of national diffusion activities to national satellites or sub-networks. Thus, network composition, network configuration, network management, and the nature of the technology itself are all important factors that influence the speed and success of cross-border technology diffusion.

References

- Allport, G. (1958) *The Nature of Prejudice* (New York: Doubleday Anchor) cited by J. Soeters (1993) Managing Euregional Networks, *Organization Studies*, 14(5), pp. 639–56.
- Barnes, J. (1969) Networks and Political Process, in J. Mitchell (ed.) *Social Networks in Urban Situations* (Manchester: Manchester University Press), pp. 51–76.
- Bertin, J. (1983) *Semiology of Graphics: Diagrams, Networks, Maps*, translated by W. Berg (Wisconsin, USA: University of Wisconsin Press).
- Bianchi, P. and Bellini, N. (1991) Public Policies for Local Networks of Innovators, *Research Policy*, 20(5), pp. 487–97.
- Boekholt, P. (1994) The European Community and Innovation Policy: Reorienting Towards Diffusion, Unpublished PhD Dissertation (Birmingham: Aston Business School).
- Boylan, T. (1995) The Role of Observers in Technology Transfer Projects, Unpublished paper.
- Conway, S. (1997a) Informal Networks of Relationships in Successful Small Firm Innovation, in D. Jones-Evans and M. Klofsten (eds) *Technology, Innovation and Enterprise: The European Experience* (London: MacMillan), pp. 236–73.
- Conway, S. (1997b) Strategic Personal Links in Successful Innovation: Link-pins, Bridges, and Liaisons, *Creativity and Innovation Management*, 6(4), pp. 226–33.
- Conway, S. and Overton, M. (1994) Constructing the Network Graphic: A Palette of Options, Doctoral Working Paper Series, 15 (NS) (Birmingham: Aston Business School).
- Conway, S. and Steward, F. (1998) Mapping Innovation Networks, *International Journal of Innovation Management*, 2(2), pp. 223–54.
- Coopers and Lybrand (1994) Good Practice in Managing Transnational Technology Transfer Networks: 10 Years of Experience in the SPRINT Programme, Volume 1/Subject Papers.
- DeBresson, C. and Amesse, F. (1991) Networks of Innovators: A Review, *Research Policy*, 20(5), pp. 363–79.
- EIMS (1996) *Computer Based Modelling, Simulation and Graphic Representation of Technology Innovation Networks Project EIMS 94/118: EC DGXIII* (Luxembourg: European Commission).

Freeman, C. (1991) Networks of Innovators: A Synthesis, *Research Policy*, 20(5), pp. 499–514.

Granovetter, M. (1973) The Strength of Weak Ties, *American Journal of Sociology*, 78(6), pp. 1360–80.

Hagedoorn, J. and Schakenraad, J. (1992) Leading Companies and Networks of Strategic Alliances in Information Technologies, *Research Policy*, 21(2), pp. 163–90.

Hofstede, G. (1980) *Culture's Consequences: International Differences in Work-Related Values* (Beverly Hills: Sage).

Kreiner, K. and Schultz, M. (1993) Informal Collaboration in R&D: The Formation of Networks Across Organizations, *Organization Studies*, 14(2), pp. 189–209.

Rogers, E. (1987) Progress, Problems and Prospects for Network Research: Investigating Relationships in the Age of Electronic Communication, Paper Presented at the VII Sunbelt Social Networks Conference, Florida, February 12–15th.

Rogers, E. and Bhowmik, D. (1971) Homophily-Heterophily: Relational Concepts for Communication Research, *Public Opinion Quarterly*, 34, pp. 523–38.

Rogers, E. and Kincaid, D. (1981) *Communication Networks* (New York: Free Press).

Rothwell, R. (1991) External Networking and Innovation in Small and Medium-Sized manufacturing Firms in Europe, *Technovation*, 11(2), pp. 93–111.

Soeters, J. (1993) Managing Euregional Networks, *Organization Studies*, 14(5), pp. 639–56.

Steward, F., Conway, S. and Overton, M. (1994) Depicting Innovation Networks, in A. Francis, S. Horte and J. Pedersen (eds) *Designs, Networks and Strategies*, volume 1 (Luxembourg: European Commission), pp. 185–201.

Steward, F., Conway, S. and Overton, M. (1995) Actors and Interactions in the Management of Innovation: Analysing Network Nodes and Links, in D. MacLean, P. Saviotti and D. Vinck (eds) *Designs, Networks and Strategies*, volume 2, Social Sciences Series (Luxembourg: European Commission Directorate General XIII), pp. 133–51.

Steward, F. and Conway, S. (1996) Informal Networks in the Origination of Successful Innovations, in R. Coombs, P. Saviotti, A. Richards and V. Walsh (eds) *Technological Collaboration: The Dynamics of Cooperation in Industrial Innovation* (London: Edward Elgar), pp. 201–21.

Technopolis (1995) *The Evaluation of the Specific Projects Action Line, Report No. EUR 15931 EN* (Luxembourg: European Commission).

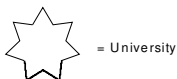
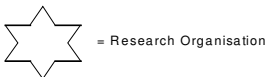
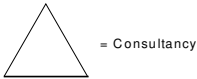
Wells, C. and Grieco, M. (1993) Spinning a Web? Networking the Technical Convergence of Europe, *Organization Studies*, 14(5), pp. 621–37.

Appendix

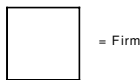
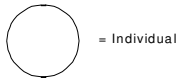
Key to actor variables

ACTOR VARIABLE: Organization Type

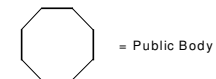
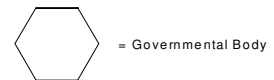
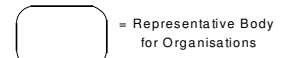
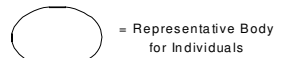
Knowledge Creators,
Transferers & Supporters




Technology Creators
& Users



Institutions &
Representative Bodies




ACTOR VARIABLE: Project Membership Status


 = Original Network Member

 = New Project Member


 = Observer Group Member


 = Non Project Member


ACTOR VARIABLE: Project Role


 = Lead Partner in Project


ACTOR VARIABLE: Nationality


 = Austria


 = Greece


 = Belgium


 = Italy


 = Switzerland


 = Luxembourg


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 = Portugal


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
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Figure 9. Key to actor variables.