

How Project Networks Develop (Through) Collaborative Paths: The Case of European Education Research

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Berlin, 31st May, 2004

Introduction: Network Research on Research Networks

For a long time, researchers have been interested in studying collaborative networks emerging in their own field – research (e.g. Smith 1958; Lotka 1926). In recent years, an increase of collaborative activities across disciplines has been observed. Reasons for this include the technical division of labour in scientific work, increasing specialization and changing funding policies (see in detail Katz and Martin 1997). However, the understanding of ‘collaboration’ as well as ‘collaborative networks’ in research is rather diverse given that studies have been done from quite different viewpoints. One strand focuses on *individual* collaboration of researchers which comprises all forms of working together to produce new scientific knowledge (Katz and Martin 1997). These include ‘weak’ and ‘strong’ forms of collaboration: ‘Weak forms’ often refer to participating in ‘communities of practice’ which allow for mutual learning and scientific innovation (Brown and Duguid 1991). In this context, also the term ‘invisible colleges’ is used to describe groups of researchers who regularly exchange information about their scientific progress (Crane 1972). ‘Strong forms’ are mostly related to joint publishing in a specific field. Accordingly, co-authorship networks have been studied to learn about the collaborative structure of research communities (Newman 2001).¹ Finally, taking part in collaborative projects has been suggested as a strong form of collaboration, whereby actors must be distinguished for the level of their contribution to the project (Katz and Martin 1997).

While these approaches have mostly neglected the *organizational* dimension of research collaboration, several studies focus explicitly on this level: In particular, inter-organizational networks of research and development partnerships have been studied extensively (e.g. Powell et al. 1996, Hagedoorn et al. 2000). These partnerships allow organizations to pool resources; exchange knowledge; and commercialize their scientific work (Hagedoorn et al. 2000). Accordingly, different dimensions of partnerships – funding, marketing, research and development – have been looked at between different kinds of organizations – research institutes, private companies and venture capitalists (e.g. Powell et al. 2004). However, the way these partnerships are actually ‘organized’ has not been examined by these authors. In particular, the very fact that most collaborative research takes place in projects, in accordance with rhythms of funding and practices of knowledge sharing, has largely been overlooked (but see Ernø-Kjølhede 2000). Interestingly, at a micro level, the way particular scientific projects are conducted and knowledge sharing between researchers takes place has, indeed, been scrutinized (e.g. Kraut et al. 1990; Melin 2000). However, the relation of (project-based) collaborative work and networks beyond (project-based) collaboration lacks understanding. Also, the way individual networks of researchers relate to organizational fields has rarely been examined. Finally, the way (inter-)organizational forms of collaboration emerge (and sustain) in research communities needs to be studied in more detail.

¹ These networks are said to feature characteristics that universally apply to all kinds of (large-scale) networks. Particular attention has caught the ‘power-law distribution’ of actor degrees, that is the fact that a high number of researchers have very few relations, while a low number have numerous relations. These networks seem to emerge through a mechanism called ‘preferential attachment’ which suggests that newcomers in the field would choose established researchers rather than peripheral ones to collaborate with (see e.g. Barabási et al. 2002).

Against this background, this paper looks at the (reflexive) development of *one* organizational form (Romanelli 1991) that might increasingly establish in the field of research: project networks. The concept of project networks is derived from the creative industries (Jones 1996; Grabher 2002a; DeFillippi and Arthur 1998), where collaborating actors maintain longer-term relationships which are actualized by and institutionalized through particular projects (Windeler and Sydow 2001). For the field of European education research, where inter-disciplinary and cross-national collaboration has gained significance in recent years (Lauterbach and Sellin 2000), this paper examines how project networks develop within (emergent) project ecologies of the field along (more or less reflexive) collaborative paths. Thereby the notions of ‘collaborative paths’, ‘project-based organizing’ as well as ‘reflexive agency’ in networks will be further elaborated (see also Sydow and Manning 2004). The data for the analysis has been collected from a comprehensive data base of projects and European researchers in vocational education and training.² The network analysis has been carried out with UCINET 6.0 and NetDraw (Borgatti et al. 2002). In addition, some multi-variate regression has been done with Eviews 4.0. The interpretation of data is based on expert interviews and informed by theories of structuration and (reflexive) path development (Giddens 1984; Garud and Karnøe 2001).

First, the concept of project networks will be introduced, in the context of creative industries. Then, the structural properties of the field of European education research will be examined. Next, a network analysis from different perspectives will be carried out on content and actor affiliations of 29 projects during the time period from 1995 to 2003. After that, an extended view of how project networks develop and sustain (through) collaborative paths in organizational fields will be introduced and discussed based on the empirical findings made. The article concludes with some implications for further research on the development of (project) networks in research and beyond.

Project Networks as Organizational Forms: Learning from Creative Industries

In creative industries, such as in advertising, event and film production, work is typically organized in projects. That is, the actors involved – suppliers, producers and customers – often collaborate on a temporary basis and thereby create a product which shows both standard and unique characteristics (see also Winch 2000). In the creativity literature, projects are further seen as a creative process of (re)-negotiation, mutual learning and sense-making which develops its own dynamics and can hardly be planned fully in advance (e.g. Unsworth 2001). In addition, the customer would often get deeply involved in idea development and implementation such that project organizing becomes even more difficult (Girard and Stark 2002). Once a project is finished, the project team would dissolve, and most, in particular creative, project workers would look for new opportunities in the market. This is because production companies employ only a few (team) members on a permanent contract basis, in order to

² The data base is maintained by Sabine Manning, who is coordinator of European projects at the Research Forum Wifo Berlin (www.wifo-gate.org). More information on the data bases and related network analyses is available here: <http://www.b.shuttle.de/wifo/vet-pr/networks.htm>

reduce fixed costs and to promote creative variety (see also Manning and Sydow 2003). At the same time, production companies must secure the transfer of knowledge (and creativity) from previous projects, to keep up quality standards and to meet special requirements of key customers, in order to commit them to follow-up projects. Also, in advance of any new project, coordinators rely on swift trust (Meyerson et al. 1996) between team members to get projects started and implemented. Both, knowledge and trust, however, are difficult to develop and sustain in project-based industries due to the very nature of project-based production (e.g. Grabher 2002b).

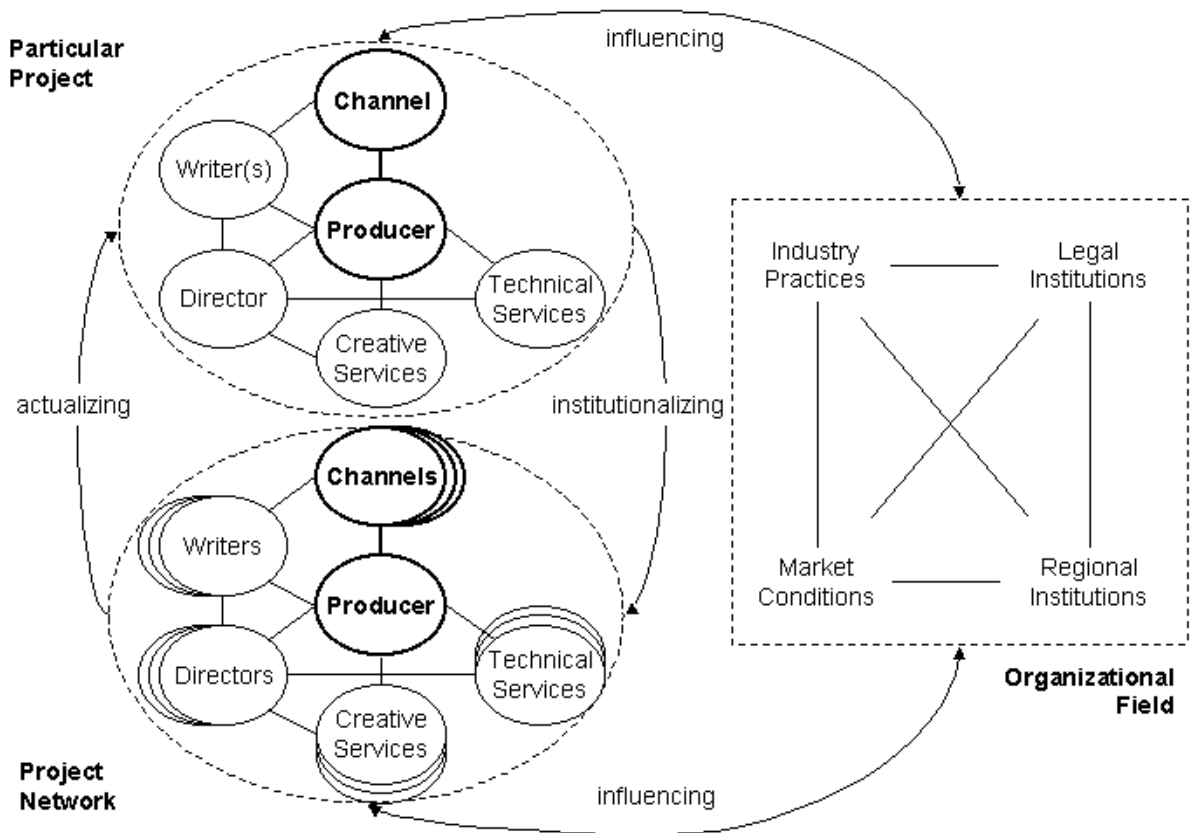
Against this background, the regional, institutional and organizational environment in which projects are embedded has received great attention from researchers. Most prominently, *organizational fields* (DiMaggio and Powell 1983) have been examined in terms of the way they ‘provide’ actors with common practices of organizing, role models and professions, as well as criteria of legitimacy and rationality (see also Phillips et al. 2000). Fields are sustained, in particular in creative industries, by communities of practice (Brown and Duguid 1991) which cultivate collective norms and standards through recurrent (rituals of) interaction (Cova and Salle 2000), and which ‘insiders’ individually enact as resources for collaboration. In addition, the importance of regional clusters has been stressed to show how actors would regularly meet up at certain locations and interpret rumours and signals – ‘noise’ – from crucial players in the industry, to identify opportunities for individual and collective action (Grabher 2002a; see also White 2002). Also, regional training schools and funding institutes would provide human and financial, as well as social, capital which can be enacted by competent actors, e.g. producers or talent scouts, for organizing projects (Lutz et al. 2003; Burt 1992). Over time, *project ecologies* of actual and potential project relationships of actors would develop as competitive, heterarchic forms of social organization which can also be regarded as representations – or: ‘prisms’ – of the organizational field at particular points in time and space (Grabher 2002a; see also Podolny 2001).

However, to reduce competitive pressure arising in project ecologies, production companies would aim for some degree of stability by controlling critical resource flows in those volatile environments (e.g. Pfeffer and Salancik 1978; Oliver 1991). To do so, they would engage in building up *project networks* as dynamic, yet relatively stable organizational forms that promise to secure critical resource flows over time (see e.g. Manning 2004). Project networks have been defined as more than temporary systems which materialize in longer-term, yet project-based relationships of actors that are reproduced by the very projects they collaborate in (Sydow and Windeler 1999; Windeler and Sydow 2001). They have been examined in the film industry (DeFillippi and Arthur 1998), in advertising (Grabher 2002a), and the TV industry (Windeler and Sydow 2001); but they promise to be a distinct, yet classifiable organizational form (Romanelli 1991) for other project-based industries as well.

To understand how project networks operate, three systemic levels must be distinguished: projects, project networks, and organizational fields. Taking the example of the TV industry (see Figure 1), TV *projects* are coordinated by TV producers, in close collaboration with (representatives of) TV channels. The project team consists of creative artists and technical service providers, most of whom work as self-

employed. Over time, producers would develop pools of creative and technical service providers they can draw from for particular projects. These pools, in conjunction with the producers and TV channels who coordinate them, constitute the *project network*. Unlike hierarchical forms of organization, however, project networks restructure themselves continuously, as new projects actualize (potential) relationships and, at the same time, institutionalize these relationships as part of the project network, depending on the imprint projects make on the production company (and the customer). In particular, a project would (re-)constitute the reputation of actors in the industry, as well as the relationship-based (and role-based) trust they enjoy in the network. However, relationships in the network embody only potential resources, which are enacted to different degrees: Some ties which develop over time may become latent ties (see also Grabher 2002b), while others are frequently enacted for follow-up projects. The probability of any one actor to get employed for follow-up projects by the same company, in turn, depends on his/her reputation, and hence accessibility, in the industry; the way his/her profile matches with the profile of the production company; and his/her commitment to paths of follow-up production (see below). Recurrent collaboration is further facilitated (and constrained) by practices of the *organizational field* which project networks are embedded in (see above). Yet, fields and networks influence each other, not least as powerful producers and customers shape the practices of the field.

Figure 1: Project Network in the Television Industry



The way project networks operate, however, is influenced by yet another mechanism: *collaborative paths*. These are self-reinforcing processes through which projects ‘follow’ one another, in terms of objectives, participants and practices of organizing (see Sydow and Manning 2004). More than singular projects, paths bind critical resources, as they develop mutual expectations by the actors involved and as they trigger transaction-specific investments (Manning and Sydow 2003). In the TV industry, production firms and TV channels would try to develop collaborative paths by establishing labels of TV production that help secure critical resource flows for path-affiliated projects. Together with *particular* creative artists, these actors would form ‘stable constellations’ which attract ideas and actors from the network as well as the organizational field for projects along the path, and which exercise ‘network-based control’ during project implementation (Manning 2004). At the same time, those projects which (significantly) differ from the (labelled) path become more difficult to organize. Still, despite the risk of becoming path-dependent, e.g. in the face of new trends of film-making in the industry, collaborative paths at least allow for some degree of stability in otherwise volatile and competitive environments. Furthermore, they embody the chance for ‘channelled innovation’ as they can be enacted for ‘novel’ projects which build on the trust actors have enjoyed and the knowledge they have accumulated along the path. That is, riding on the path always implies the opportunity to mindfully deviate from the path and thereby to create new branches of the path (Sydow and Manning 2004).

Leaving now the organizational field of creative industries, the question is whether project ecologies, networks, and paths as introduced above exist and how they develop in the field of research. Therefore, one might ask which practices of project (network) organizing exist in this field, and to what extent have central actors established as ‘network coordinators’? For the former, though research projects seem to last much longer than creative projects, at the same time research seems to get more projectified in the face of shorter innovation and funding cycles, so that, in turn, project (network) organizing might become more professional (see in general, Lundin and Hartman 2000). For the latter, studies suggest that project coordinators become very important in research, in particular for providing trust and expertise (see e.g. Ernø-Kjølhede 2000). Yet, to what extent – informal or formal – coordinating roles go beyond particular projects, remains to be explored. Also, in how far researchers might create collaborative paths, to sustain the delivery of trust and expertise, needs to be examined. Before doing so, however, the development of the field of European education research will be introduced in more detail.

The Organizational Field of European Education Research³

Research in vocational education and training aims at providing and evaluating concepts and tools for facilitating learning and qualifying in schools and companies within changing economic and social environments. Education research has long been established as a research discipline in a number of universities and institutes across Europe. Most of them had been traditionally active in shaping national

³ This section has been prepared in cooperation with Sabine Manning.

education policies. Yet some, notably CEDEFOP, have specialized in cross-national research. At the European level, however, cross-national education research got established only after two White Papers on this topic had been approved by the European Commission in 1993 and 1995. They were in particular concerned with implementing and evaluating measures for re-skilling across Europe, both to tackle unemployment and to strengthen the competitiveness of European enterprises.⁴ The year 1996 was even announced the ‘European Year of Lifelong Learning’ by the European Union which further promoted this new European research agenda. The interest in cross-national education research corresponded with a more general trend towards promoting ‘research collaboration’ at the European level (e.g. Lauterbach and Sellin 2001). Collaborative efforts would further enhance cross-national innovation and mutual learning amongst researchers and practitioners. Against this background, a community of European education researchers (FORUM) established in the mid-1990s which organized regular meetings and conferences on advances in the field.

Mostly, however, cross-national education research has been organized in European research projects which were designed to accompany and evaluate European vocational education and training measures. The projects have been funded mainly by three European programmes which have largely determined the conditions of the organizational field. Therefore, they need to be looked at in more detail: The programme LEONARDO became the ‘principal instrument’ for implementing a transnational European training policy under this new agenda (see in detail EC 2000). The first phase of the programme was launched in 1995 and adopted for a five-year period until 1999. The second phase was then adopted for 2000-2006. Research funded by this programme included surveys e.g. on quality and innovation in national training systems, access to training, language learning, transparency of qualifications and co-operation between universities and the industry. That is, this programme had a rather specialized design. To be supported, a research project had to last no longer than three years and had to involve actors from at least two member countries of the European Union. In the first phase, 175 research projects (‘surveys and analyses’, EC 2000) on the topics mentioned above were funded by the programme.

Another programme relevant in this field is SOCRATES – the so-called ‘European Community action programme in the field of education’ (EC 2002). This programme has promoted research at all levels of education, in particular on the teaching of languages within the European Union. Similar to LEONARDO, the first phase of the SOCRATES programme was launched in 1995, to last until 1999; the second phase was adopted for the period of 2000 to 2006. Unlike LEONARDO, however, this programme was not specialized in funding vocational education research. Therefore, applying for a SOCRATES project in this particular field was a rare and risky endeavour. Also, this programme thematically took a more general standpoint as it emphasized issues of social integration through education, rather than the improvement of education and training (E&T) systems as such (see above).

⁴ These are the White Paper on ‘Growth, Competitiveness, Employment’ and the White Paper on ‘Teaching and Learning – Towards the Learning Society’ (EC 1993, 1995).

Finally, many education research projects under the new agenda were funded by the Research and Technological Development (RTD) Framework Programme which supports European research in all kinds of fields, including IT, environment, energy, life sciences and targeted socio-economic research. The last sub-field, in particular, was aimed at funding research projects which include educational issues like lifelong learning, as well as implications of E&T systems on the labour market, economic growth and (other) societal developments. The first funding period under the RTD framework lasted from 1997 to 2000, the second started in 2000. During the first phase, more than 300 research projects were funded (see in detail EC 2004)

Comparing these programmes, they show several similarities: In general, they can be considered as the key providers of critical (financial) resources for European research projects in this field. They appreciate project proposals by various actors – practitioners as well as researchers – involved in vocational training across Europe. In order to promote ‘innovative’ research, they avoid repeat funding and further the engagement of newcomers in the field, such as researchers from young EU member countries. They differ, however, in terms of their thematic priorities: LEONARDO – in its initial design – was the most specialized programme, as it supported (research) projects on the quality, status and availability of effective frameworks for vocational training. In contrast, SOCRATES and, even more so, the RTD Framework Programme were more oriented at the socio-economic dimension of education and training systems and, therefore had a more general outline. Over time, however, the thematic focus of *all* programmes shifted towards a more general strand, allowing for more cross-disciplinary research. That is, in its second phase, even the LEONARDO programme would prioritize projects on the socio-economic dimensions of vocational training and education. At the same time, however, this programme abandoned its surveys and analyses strand and, thereby, lost significance as a funding institution for research projects in this field. Today, the RTD Framework Programme is the major commissioner when it comes to financing projects in education research at the European level.

This overview of the development of the organizational field gives rise to a number of questions: In what way do patterns of project participation differ across the three programmes? How has the change in funding policies influenced project partnerships as well as longer-term project-based relationships? Which role do affiliations of researchers with different research institutes as well as the FORUM community play in their collaborative efforts? These questions finally lead to a more theoretical concern: To what extent have collaborative paths and project networks developed in this field, and how have the (changing) conditions of the field been related to this development? To approach this issue, now the project ecology of European education research will be examined in more detail.

The Project Ecology of European Education Research

To analyse the development of networks and paths from the project ecology of European education research, content and membership affiliations of 29 projects have been examined for the time period from

1995 to 2003. That is, the basis for the network analysis is ‘objective’ archive data derived from different project data bases (Marsden 1990). The projects selected include all the ones presented at the Annual European Conference of Educational Research (ECER) in this time period. Out of these, 12 projects have been funded by LEONARDO, 1 by SOCRATES and 16 by the RTD Framework Programme. Based on the membership data, an actor-affiliation matrix was built and transformed into an actor matrix by project affiliation (Breiger 1974).⁵ In analogy, the content affiliations of projects have been analysed in terms of 24 matching descriptors. The selection of descriptors has been done in cooperation with a field expert.⁶ From these data a content-affiliation matrix of project relations could be created. Attribute data for the projects include the funding institution and the funding phase of the project, whereby three phases are distinguished: 1995-1997, 1997-2000 and 2000-2003. These phases correspond roughly to the start and end time as well as the duration of the projects under investigation. For the individual project members, attribute data include the country and organization they come from, their project role(s), and their membership in the FORUM community.

Based on this data set, a two-stage analysis has been done. First, the project ecology has been looked at from an aggregate perspective to find out about the structure of actor and content affiliations of projects in this ecology, and, hence, the existence of collaborative paths. The degree centrality of projects is then tested for the influence of several variables, e.g. the funding programme and participating actors. Next, the development of project networks, in terms of project-based actor relationships, along collaborative paths is scrutinized. To do so, the three project phases are analysed separately and successively for project affiliations of actors. At the same time, a potential central coordinator of a project network (focal actor) is identified, which allows to analyse the co-evolution of his/her ego-network and the whole project ecology. Finally, to study the development of the collaborative path, sustained by the focal actor (group), the actor flows from projects along and beside the path are analysed. Actor flows show to what extent the path expands or diminishes, which projects fuel or benefit from the path, and how the path interrelates with the project ecology of the field.

The Structure of the Project Ecology

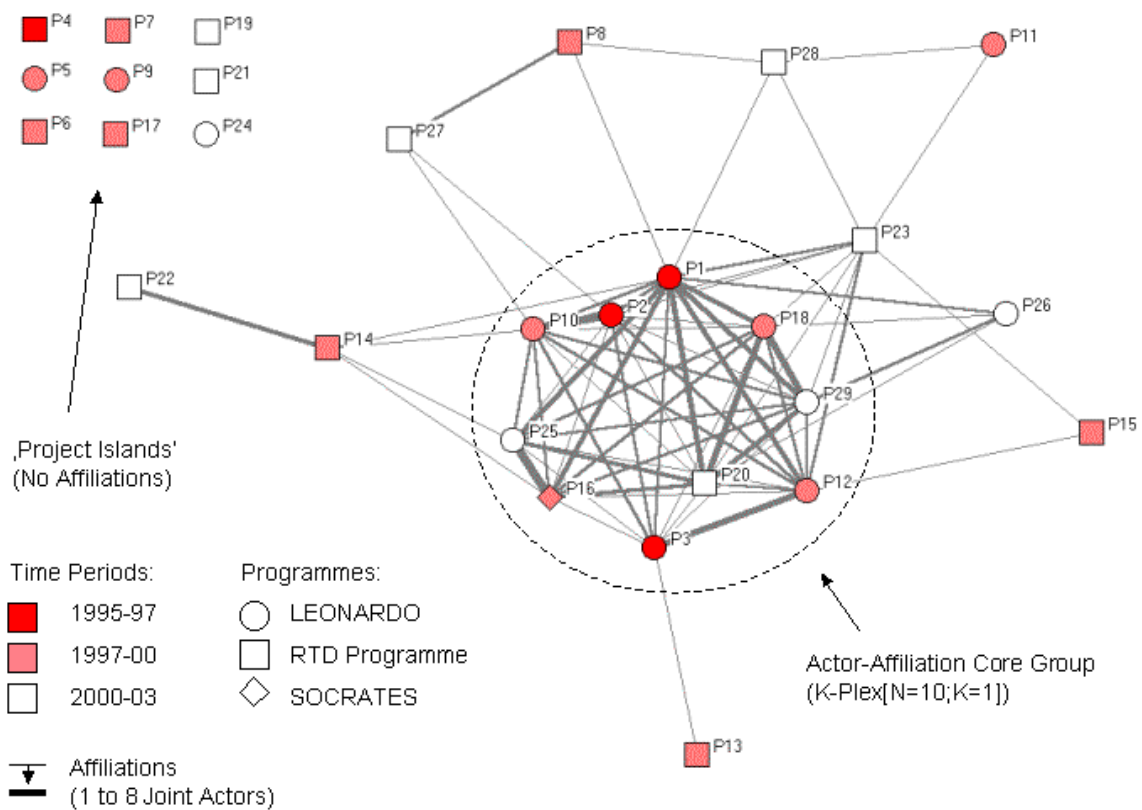
First, the project ecology of the field is looked at from an aggregate macro perspective. Figure 2 shows all projects under scrutiny as nodes and their actor affiliations as ties. The thickness of a tie between two projects corresponds to the number of researchers who participated in both projects. The project nodes differ in terms of colour and shape. The colour indicates the time period in which the respective project

⁵ Such project-affiliation matrixes have been used to represent and study project networks, empirically (see Manning 2003). However, these representations neglect to some extent the existence of ‘latent’ ties beyond prior project collaboration. To capture these and their influence on project staffing, semi-structured interviews need to be carried out (see e.g. Manning 2004).

⁶ The project descriptors are derived from an on-line database of the European Research Overview (ERO Base) provided by CEDEFOP (European Centre for the Development of Vocational Training) in the European Training Village (www.trainingvillage.gr). They have been adjusted for the analysis in cooperation with Sabine Manning. Each project is characterized by 5 (out of 24 possible) content descriptors (see in more detail below).

took place: White stands for 1995-1997 (Phase I), Gray [Light Red] for 1997-2000 (Phase II), and Black [Red] for 2000-2003 (Phase III). The shape indicates the programme which funded the respective project: Circle stands for LEONARDO, Square for RTD, and Diamond for SOCRATES. The labels of the nodes indicate the order of the starting dates of the projects, ranging from P1 (Start: December 1995) to P29 (Start: December 2001). Notably, the starting dates of projects within a time frame (same colour) are very close to each other, which means that these projects ran parallel in time. The network visualization was generated with NetDraw, using multi-dimensional scaling of geodesic distances with equal edge length bias (see also Scott 2000). This allows to show how strongly (or weakly) connected projects within this ecology have become, measured by actor affiliation (see below for content affiliation).

Figure 2: Actor Affiliations of Projects within the Project Ecology (29 Projects)



The actor-affiliation network of projects clearly shows a core-periphery structure. The core – which is surrounded by dotted lines – consists of 10 projects which form a perfect clique in which every project is connected to every other project. The reason for this is that there is one focal actor (FA) who participated in all ten projects (see in detail below). Taking out FA, still, nine projects would form a K-Plex for K=3 so that the core-periphery structure remains intact. The latter core, however, would include P23, but exclude P2 and P3 from the former core. In any case, the core consists of projects from all three time periods and therefore demarcates a collaborative path of actor affiliation. Obviously, an actor group has formed promoting repeated funding for collaborative projects. Interestingly, most of these projects have been funded by LEONARDO, two of them – P20 and P23 – by RTD and one – P16 – by SOCRATES. Arguably, all these projects have highly benefited from each other for knowledge and trust could be

‘saved’ and ‘transferred’ as critical resources, via individual researchers serving as ‘resource carriers’ along the path (see also Sydow and Manning 2004). Also, the transfer and adoption of practices, norms and values from project to project could be facilitated (Zeitz et al. 1999). That is, such a path entails – more than singular projects – socializing and learning opportunities for path-affiliated actors. Moreover, transaction costs could be lowered, at least for those researchers who have collaborated repeatedly in path-affiliated projects (see also Landry and Amara 1998).

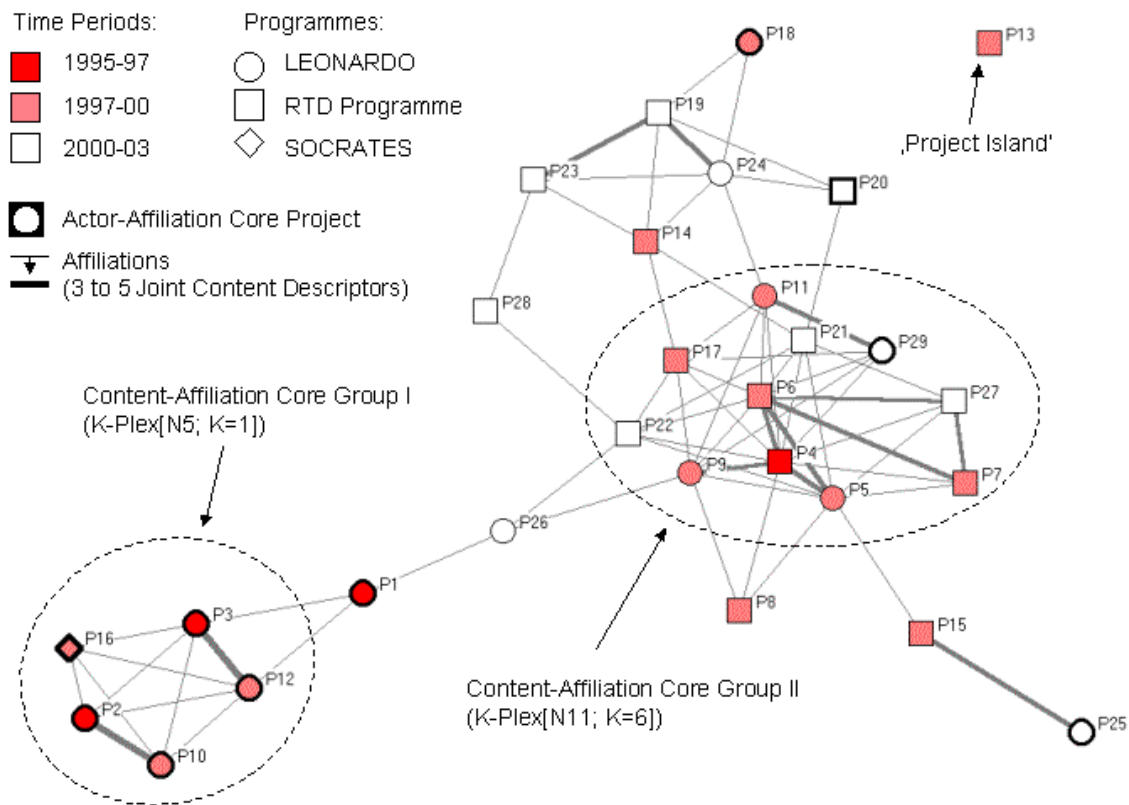
By comparison, the periphery of the project ecology includes two kinds of projects: Those – displayed in the upper left corner – which do not connect at all to any other project, and those which are loosely connected to the core (and to each other). The former, e.g. P4 and P5, can be called ‘project islands’ due to their (lacking) actor relations and opportunities for (individual) trust and knowledge transfer from/to other projects.⁷ The latter, in particular P23, P14 and P26, can be called ‘spin-off projects’ as they share members with path-affiliated projects from the first and second time period, who potentially have ‘carried’ knowledge, trust and project practices from the path to projects outside the path. Interestingly, most of these periphery projects have been funded by the RTD programme. This, in turn, gives rise to the question why LEONARDO and RTD projects differ so much in terms of their actor affiliation structure. One obvious reason might be the more general funding profile of the RTD programme, from the very beginning, as compared to the more specialized LEONARDO profile (see above). That is, being more specialized, the latter might have facilitated repeated actor collaboration in succeeding projects. Also, due to its thematic focus, this programme addressed a smaller group of specialists who might have had certain contacts already in their research area (see in detail below).

However, to what extent repeated actor collaboration has been in line with (paths of) knowledge creation depends on the content relations of the projects within the core and the ecology on the whole. It is assumed that the collaborative path of Figure 2 corresponds to a path of knowledge creation which has further stimulated project collaboration. To examine this relation, Figure 3 displays all projects according to their content affiliations. These are measured by shared descriptors, such as ‘competence/skills’, ‘career/occupation’ and ‘general/academic education’.⁸ The thickness of a tie between two projects corresponds to the number of joint content descriptors. Due to the (natural) similarity of the projects within this field, only those projects are connected which share three or more content descriptors (max. five), suggesting that strongly connected projects (re-)produce more or less the same knowledge base. The colours and shapes of the nodes correspond to Figure 2. Project nodes with a thick rim are those which belong to the core group of the actor-affiliation network.

⁷ This is, of course, not to say that these projects had no impact on scientific knowledge creation. As Dobers and Söderholm (2003) noted projects, in research and development projects, leave inscriptions in form of final papers, publications and so on, which, again, serve as templates for future project proposals. However, knowledge transfer is arguably facilitated by individuals who serve as ‘knowledge carriers’.

⁸ These descriptors have been treated equal, to simplify the analysis. However, for an advanced approach these indicators could be related to each other in form of a ‘semantic map’ or ‘knowledge tree’, to show degrees of generality and semantic containment.

Figure 3: Content Affiliations of Projects within the Project Ecology (29 Projects)



At first sight, the content-affiliation network differs quite substantially from the actor-affiliation network. Unlike the core-periphery structure of the latter, the former is characterized by loosely connected groups of projects. In particular two groups stand out: Content-Affiliation Core Group I and II. While Group I is fully connected, Group II shows medium coherence. The rest of the projects, apart from P13, are loosely connected to the latter, in particular, which suggests that Group II represents the ‘dominant’ scientific paradigm – or better to say: the leading path of knowledge creation in this field. This is further supported by the very fact that Group I contains only projects from the first and second phase (see below), while Group II covers projects from all three phases, starting with P4 in Phase I. Comparing the composition of both groups, Group I consists exclusively of projects funded by LEONARDO (or SOCRATES), whereas Group II contains projects funded by all programmes, but in particular the RTD Programme. This, in fact, supports the observation made earlier that the RTD Programme has taken over the role as the leading funding programme in this field.

Looking more closely now at the co-evolution of actor and content affiliations (and affiliation paths) in the project ecology, the three time periods must be distinguished. In Phase I, two *scientific strands* – a specialized and a general strand – existed in the field, supported by the LEONARDO and the RTD programme respectively (see above). However, only the former strand was reflected by strong content *and* actor affiliations (P1-P3), while the latter was represented actor-wise initially by only one isolated project (P4). In Phase II, projects of the specialized strand, funded mostly by LEONARDO, were again

both connected by actor *and* content affiliation (see Group I, Figure 3), while most projects supporting the general strand remained peripheral in the actor-affiliation network. In the course of Phase II, however, the organizational field changed as the profiles of the programmes merged towards the general scientific strand. As a reflection of the change, projects funded by the LEONARDO programme became more differentiated content-wise. Interestingly, however, they (partly) kept on being connected actor-wise. By contrast, RTD projects remained loosely related content-wise, and got slightly better connected actor-wise. In Phase III, only one scientific strand remained, mainly supported by the RTD programme, as reflected by the dominant Core Group II of Figure 3. However, the actor-affiliation path shown on Figure 2, which was initially supported by content affiliations through the specialized scientific strand, sustained even in Phase III, *beyond* the change in the organizational field.

This finding suggests that other factors – apart from the initial content affiliation in Phase I and II – helped develop the collaborative path of Figure 2, which will now be focused on.⁹ A regression analysis has been carried out to reveal which factors contribute to the centrality of projects in the actor-affiliation network and, hence, to the maintenance of the collaborative path. The results of the regression analysis are reported in Table 1.¹⁰ They show, first of all, that LEONARDO funding is positively related to the degree centrality of projects by actor affiliation (Model 1: Coeff 7.32, significant at 0.05 level). As has been assumed, regardless of the shift in funding policies, LEONARDO projects, over the whole time period, remain more tightly linked through collaborating actors than do RTD projects. (RTD funding is not significantly related to project centrality.) Second, the share of researchers from university research institutes (Model 2: Coeff 19.19, significant at the 0.05 level), as well as from the FORUM community (Model 2: Coeff 20.83, Model 3: 7.98; significant at the 0.05 level) is positively related to the centrality of projects. For the first, unlike university departments and (independent) research and development institutes, designated ‘research institutes’ at universities seem to provide resources (time, expertise) that favour multiple project engagements. For the second, multi-vocal ties of researchers through project collaboration *and* related communities seem to lead to stronger coherence and, hence, facilitate the maintenance of collaborative paths. Interestingly, participation of new EU countries¹¹ is also positively related (Model 1: Coeff. 9.11, significant at 0.05 level). Third, however, the participation of the focal actor (FA) in the project ecology explains a great deal of the variety of degree distribution of particular projects (Model 3: Coeff. 19.47, significant at 0.00 level; adjusted R²=0.90). As Model 3 suggests, taking the effects of all independent variables together, beside the participating focal actor only relative FORUM membership has a significantly positive effect on project degree centrality. This means that for reasons to be explored the focal actor and FORUM members have helped develop the collaborative path.

⁹ Although the collaborative path is defined predominantly over actor affiliations, content affiliations keep in the background as supporting, but not essential path-sustaining factors.

¹⁰ The regression has been done for a number of variables. However only those presented turned out significant for at least one of the three models. With regard to the low number of cases (N=29), the assumptions of the regression models have been tested for heteroskedasticity. For all models, the standard OLS method has been used. The constant has been included in the analysis, but is not reported here.

¹¹ These include European countries that joined the European Community in 1997.

Table 1: Regression for Project Degree Centrality by Actor Affiliation (Dependent Variable)

Independent Variables	Model 1		Model 2		Model 3	
	Coeff.	t-Stat.	Coeff.	t-Stat.	Coeff.	t-Stat.
LEONARDO Funding	7.32	2.15*	-	-	-0.46	-0.26
Coord. by Member of Uni Research Institute	10.36	3.21**	-	-	1.63	0.96
Participation of New EU Member	9.11	2.31*	-	-	2.76	1.43
Phase I Project	10.37	2.08*	-	-	2.27	0.86
Rel. Part. of FORUM Members	-	-	19.19	2.57*	7.98	2.29*
Rel. Part. of Uni Research Institute Members	-	-	20.83	2.77*	1.64	0.64
Participation of the Focal Actor	-	-	-	-	19.47	7.89***
R ²	0.55		0.48		0.92	
Adjusted R ²	0.47		0.44		0.89	
Log Likelihood	-101.01		-102.96		-75.33	
Observations	29		29		29	

*** Coefficient is significant at the .00 level
 ** Coefficient is significant at the .01 level
 * Coefficient is significant at the .05 level.

Therefore, the role of the focal actor and the FORUM community in the creation and maintenance of the collaborative path will be further scrutinized. Accordingly, the perspective of analysis shifts from projects to individual actors and their embeddedness in the project ecology and the field as a whole. This shift promises to give insights into the role of agency in accordance with and in contrary to the evolution of the field. Also, the emergence of project networks that sustain the collaborative path will be illustrated. The following interpretations, however, are preliminary and to be complemented by interviews with key participants of the projects and the focal actor (FA) himself.

The Development of Project Networks and Collaborative Paths in the Project Ecology

In the following, the project affiliations of researchers in the project ecology are looked at more closely. To capture the development of project networks, the three time periods introduced above are analysed separately and successively in terms of actor affiliations. This approach is designed to show how project-based relationships have developed over time. Thereby, the actors' affiliations with different kinds of research organizations and the FORUM community are looked at. Finally, the ego-network of the focal actor (FA), which constitutes the dominant collaborative path, will be looked at, in terms of its co-evolution with all project-based actor relationships in the project ecology.

Phase I: 1995-1997

In Phase I, 42 researchers across Europe participated in the first four projects under scrutiny (see also Figure 2, 3). Figure 4 shows all researchers as nodes who participated in these projects. The projects are demarcated by dotted lines. The ties indicate one or more joint project relationships of the connected

actors (thickness indicates the number of joint projects). The coordinators of the projects are represented as bigger nodes. The node shapes show the organizational affiliation of the individual researchers: Square nodes represent researchers from university research institutes, diamonds represent researchers from university departments who work as researchers *and* teachers, and circle nodes represent members of independent public or private research and development institutes. Nodes with thick rims are assigned to members of the FORUM. The focal actor is labelled 'FA'. He is member of a university research institute as well as the FORUM community.

Figure 4: Project Affiliations of Researchers from 1995-1997 (Phase I)

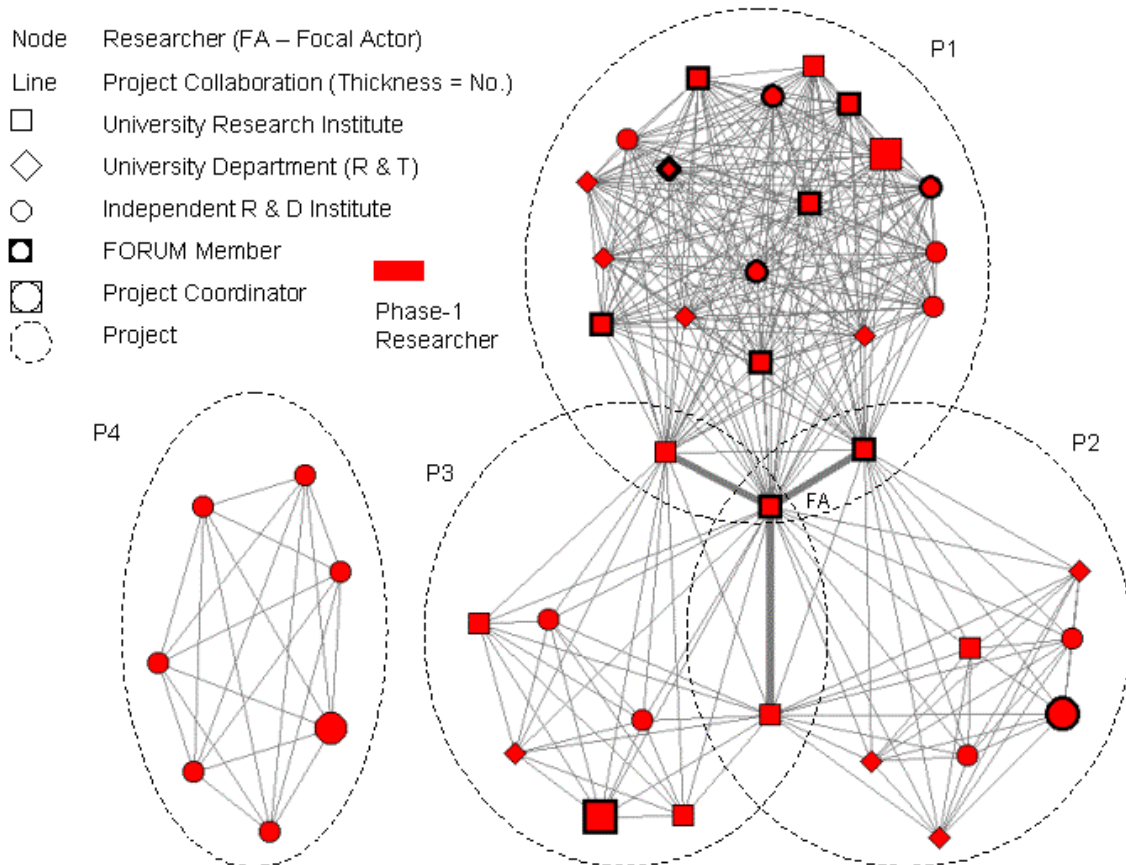


Figure 4 shows how the LEONARDO projects P1-P3 are connected through actor affiliations (compare Figure 2). Among these projects, P1, in particular, has turned out very important for the development of the collaborative path, and the project ecology as a whole, because it involved many FORUM members and university researchers, who have cultivated a community of practice in this field that helped sharing (and binding) knowledge and expertise (Brown and Duguid 1991). By contrast, the RTD project P4 which represented the starting point of the now dominant scientific strand (see above) engaged neither FORUM nor university members, at this point. Rather, the project was carried out by researchers from independent institutions who have never taken part in succeeding projects again.

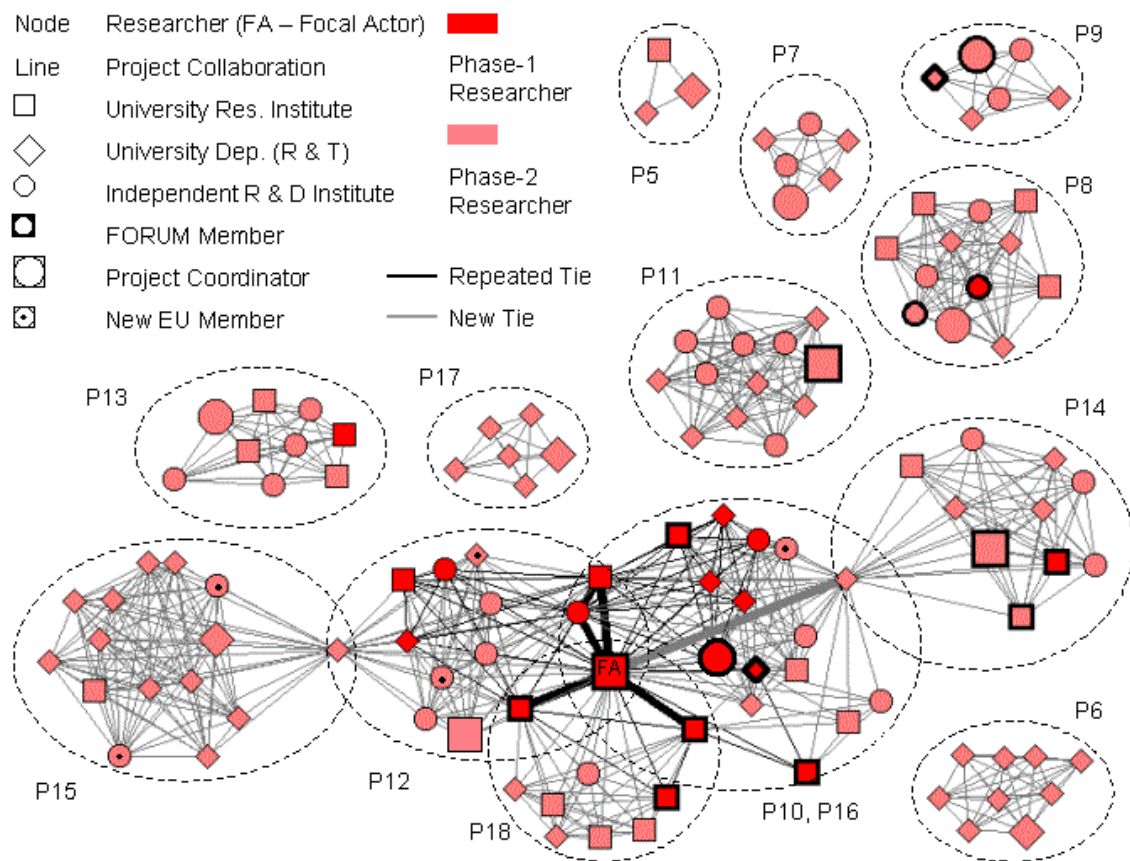
Looking more closely at the focal actor, he was the only one in this time period who participated in three projects, that is in all LEONARDO projects. In this position, he got into contact with all researchers supporting the specialized scientific strand and served as a 'boundary spanner' between these projects

(see also Aldrich and Herker 1977). Boundary spanning allows actors to be both insiders *and* outsiders (Garud and Karnøe 2001), which implies their potential to reflexively monitor the development of the project ecology. His membership at the university and the FORUM community further supported this (informal) role. However, in this phase he was ‘just’ a simple project member, while the projects were coordinated by others, notably FORUM or university members. Yet, in this period of time, FA managed to build up an ‘entrepreneurial potential’ through multiple contacts and, hence, a capacity for reflexive agency in the later development of the project ecology (Emirbayer and Mische 1998; Garud and Karnøe 2001; Burt 1992; see below). FA, however, shared his ‘boundary spanning’ role with three other researchers (FORUM and/or university members) who participated in two of the three LEONARDO projects, respectively. Arguably, at this time the joint affiliation of these actors might have been a coincidence, promoted by the similar objectives and the shared scientific strand of the projects as well as the small size of the specialized sub-community of participating researchers.

Phase II: 1997-2000

In the second phase, 14 projects were launched involving 125 researchers, including 105 newcomers. Despite the expansion of the whole ecology, however, the number of participants per project decreased (from 11.75 in Phase I to 9.64 in Phase II), which might indicate budget policies getting more restrictive. Notably, among the newcomers there were many representatives of independent research institutions who joined projects, mostly supported by the – more open – RTD Programme. Plus, unlike in the first phase, researchers from new EU member countries were allowed (and encouraged) to participate. Figure 5 displays the entire project ecology of this time period. To capture the transition of actor relationships from the first phase to the second phase, actor nodes are distinguished by colour according to the time period these actors entered the scene: Dark [Red] nodes are assigned to those actors who already participated in the first phase; gray [light red] nodes indicate those actors entering the project ecology in the second phase. Amongst them, some are from new EU member countries, marked by a black dot. Finally, those actors who already collaborated in the first phase and did so again are linked with a black line, while new project relations are coloured gray. Quite a similar graphical representation of network development is used by Powell et al. (2004).

Figure 5: Project Affiliations of Researchers from 1997-2000 (Phase II)



The figure underlines the core-periphery structure of actor affiliations identified earlier: While most new, in particular RTD projects, involved only newcomers and remained unconnected actor-wise, by contrast, most LEONARDO projects were connected and involved a number of researchers from the first phase. Among them, a core of collaborating actors had formed, most of whom enjoyed having multi-vocal ties through joint projects, university and FORUM membership. Like in the first phase, they took boundary spanning positions, between P10, P12, P16, and P18. Interestingly, among the (rather few) newcomers they attracted for their collaborative projects there were some from new EU member countries. When entering the community, these actors might have followed rules of preferential attachment by favouring ‘established’ researchers to collaborate with (see Barabasi et al. 2002; Powell et al. 2004). However, preferential attachment does not happen ‘naturally’, but seems very much promoted by ‘established’ researchers who reflexively enact new EU researchers to facilitate project funding. Interestingly, most of these newcomers would not re-appear in the third phase.

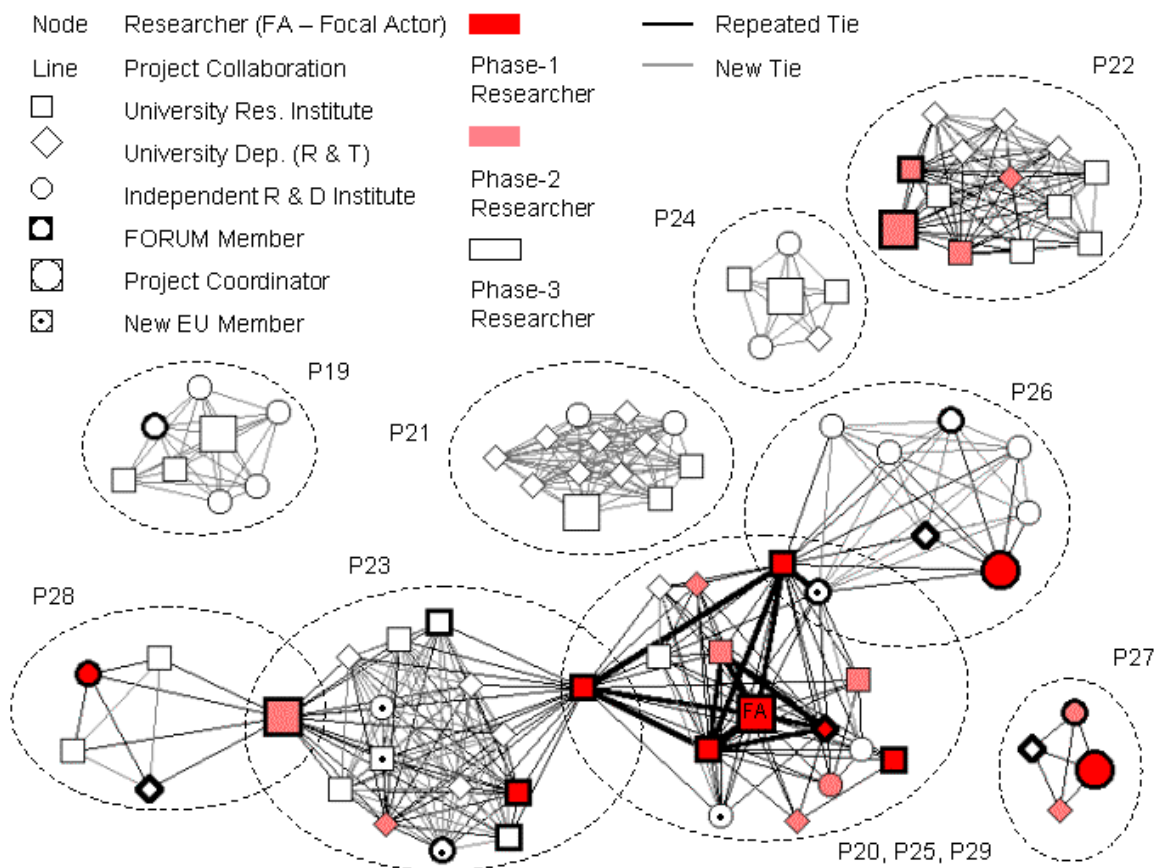
Looking at the focal actor and his ego-network, he was again the most important boundary spanner in the core actor group that emerged by then. While in the first two projects – P10 and P12 – FA was still a simple member, later – for P16 and P18 – he became official project coordinator. Interestingly, this role shift corresponded with the shift in the organizational field during this period. That is, P12 was the last LEONARDO project of the ‘old’ specialized scientific strand (see Figure 3). Though P16 followed this strand, P16 was in fact a project funded by the SOCRATES programme, which, normally, would not have

supported vocational education research (see above). However, FA as the coordinator made creative use of his authority position and his social capital he had accumulated through boundary spanning, to enact once more human and financial capital to pursue the collaborative path (see Burt 1992). As a trade-off, however, only a low number of researchers could be financed by the SOCRATES programme, which underlines the institutional constraints of agency in this field (Oliver 1991). By contrast, P18 was better staffed, not least by newcomers; however, in this case, the objectives of the project deviated substantially from the previous projects (see Figure 3). That is, FA's agentic capacity was confined to co-determining membership composition and project organizing, while the content domain was largely constrained by institutional pressures (Phillipps et al. 2000). However, by influencing the first two domains FA managed to respond strategically to changes in the field (see also Swidler 1986).

Phase III: 2000-2003

In the third phase, 11 projects were launched involving 85 researchers. The size of the project ecology has shrunk against the second and first phase. Again, a fair amount of newcomers (62) entered the scene, while the number of participants per project (8.82) decreased slightly against Phase II (9.64). Figure 6 shows all project relations of researchers in this time period.

Figure 6: Project Affiliations of Researchers from 2000-2003 (Phase III)



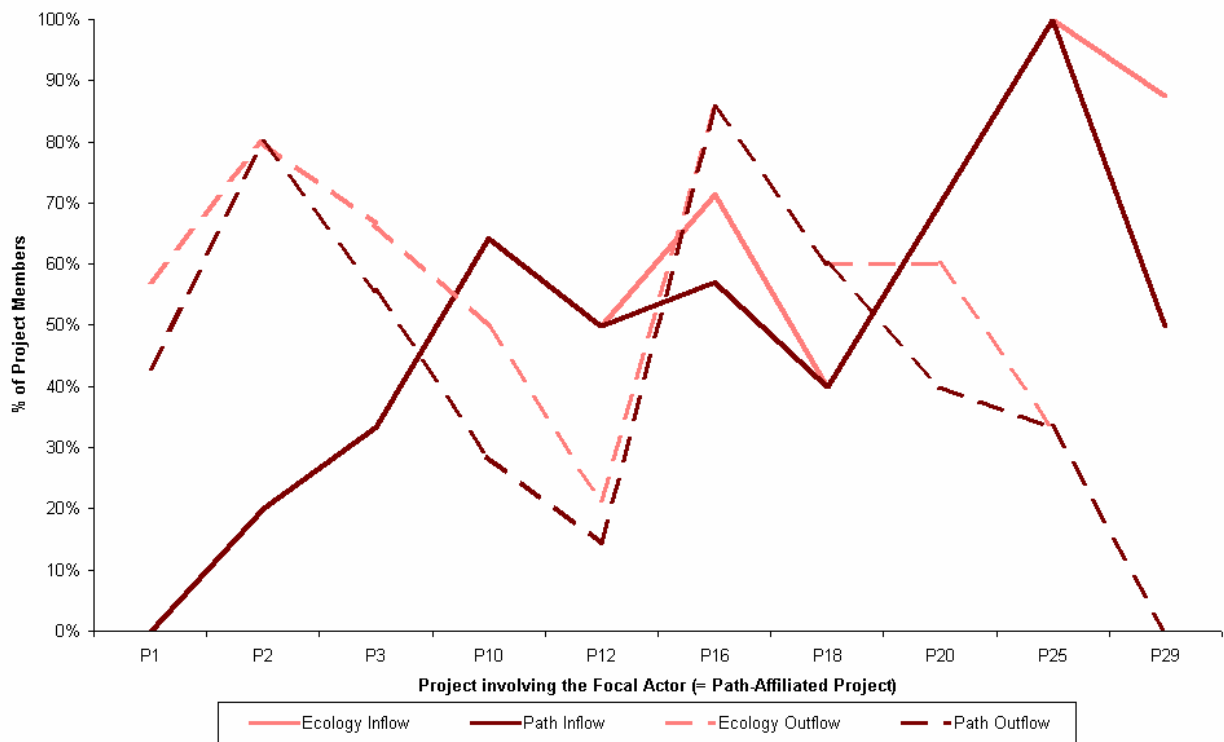
Looking at the macro structure first, a similar picture appears like in the second phase: While the project islands, mostly funded by RTD, are composed of newcomers to a great extent (P27 being an exception), those projects connected in the central component involve a number of researchers from previous projects. Interestingly, *all* remaining researchers from Phase I are FORUM members, which stresses the importance of the FORUM community for the cultivation of (project-based) relationships between these researchers. Amongst them, again, the central actor group stands out which has formed since Phase I. Their participation in projects, however, has concentrated to a great extent, such that three projects – P20, P25 and P29 – seem almost exclusively staffed with the core actor group. However, notably, some researchers from the second phase, one of whom seems to have ‘joined’ the actor group, as well as, again, two newcomers from new EU countries complement these projects.

The focal actor stands in the middle of the core group, having multiple project ties to five actors who participated in five projects in this period. Moreover, he shares FORUM membership with four other coordinators who, altogether were in charge of 8 out of 11 projects in this phase. That is, although, these projects, including those funded by LEONARDO, differ significantly content-wise (see Figure 3) they connect through multi-vocal actor ties, reflexively monitored by the focal actor. His strategic role, however, seems to have concentrated on pursuing the collaborative path with the help of the central actor group. Arguably, FA as the coordinating actor of all three projects along the path might have been quite competent in tailoring the objectives of the projects such that repeated funding was made possible and scientific collaboration could be continued (Oliver 1991). However, whether or not the focal actor has taken a role as a strategic network coordinator can hardly be seen from this data. Yet, an attempt will be made below to discuss his (growing) agentic potential in theoretical terms.

Figure 7 ‘summarizes’ and ‘extends’ the findings made so far. It relates the development of the ego-network of FA, which constitutes the collaborative path of Figure 2, to the development of the whole project ecology, which has been defined over the 29 projects under scrutiny. It does so by showing the actor flows from and to each project along the collaborative path. Actor flows are defined as moves of actors from previous to succeeding projects. The relative number of project members who *come* from previous projects are the ‘Inflow’ (connected lines); the relative number of project members who *go* to succeeding projects are the ‘Outflow’ (dotted lines). The entire Inflow and Outflow from/to the whole project ecology is coloured Gray [Light Red]. The Inflow and Outflow from/to projects along the path, that is those which FA participated in, is coloured Black [Dark Red].¹²

¹² The relative number of [path-affiliated] newcomers in projects amounts to 100 Percent Minus the Entire [Path] Inflow. The relative number of those who never participated in succeeding [path-affiliated] projects amounts to 100 Percent Minus the Entire [Path] Outflow.

Figure 7: Actor Flows along the Collaborative Path (see also Figure 2)



The figure shows, first of all, that dark lines (indicating path-affiliated flows) remain close to the light lines (indicating flows from/to the whole project ecology) which means that most actors flowing in and out of path-affiliated projects remain affiliated with the path, and only little fluctuation happens over time. However, some more actors seem to have out-flown from the path to non-affiliated projects (light dotted line) than have in-flown from non-affiliated to path-affiliated projects (light connected line). One reason for the ‘outflow bias’ might be that, while the path indeed attracted newcomers, e.g. from new EU member countries, those (non-affiliated) researchers established in the field would not join the path so easily (but see P16, P29). At the same time, path-affiliated researchers would make use of their FORUM contacts to enlarge their options for further collaboration and careers, in particular in the light of changing funding policies in the field. Over time, as the figure suggests, the collaborative path sustained by the core actor group has become rather concentrated, attracting foremost path-affiliated actors in the end (in P25 even 100%), which suggests that the path might diminish even further in the future.

However, following the zig-zag shape of the flow-graphs, it becomes apparent that collaborative paths like this one do not persist, expand or thin out continuously, but can be ‘re-created’ and ‘re-fueled’ over time. This is illustrated by the fact that projects differ in terms of their ‘flow relations’ to the path. While some projects, such as P10, P12 and P20 seem to ‘consume’ the path by recruiting more actors from previous projects than they pass to following projects (Inflow>Outflow), some projects, such as P1-P3, P16 and P18, ‘fuel’ the path by attracting formerly non-affiliated actors to join forthcoming path-affiliated projects (Outflow>Inflow). Among the latter, P16 and P18 seem particularly interesting as they, being coordinated by the focal actor, prevented the collaborative path from ‘dying’ in Phase II. That is, while

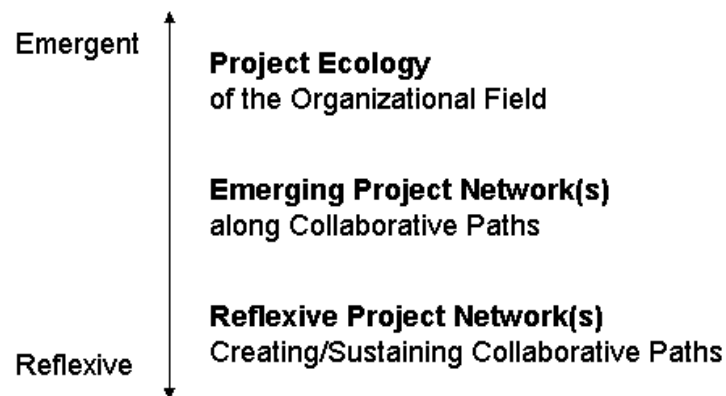
some path-affiliated members of P10 and P12 never joined a future project again, FA managed to attract newcomers for P16 and P18 who stayed with the – re-newed – collaborative path to the end. Yet, the question remains whether the reproduced path sustains in the long run, for projects have become disconnected content-wise in response to the institutional change. That is, for FA maintaining legitimacy and claiming coordinating roles might become difficult in the future. On the other hand, by bringing in new (established) researchers with competences that complement existing expertise (e.g see P29), a re-newed path of actor collaboration (and knowledge creation) could emerge.

Discussion: How Project Networks Develop (Through) Collaborative Paths

So far, simple analyzing techniques have been used to illustrate how project networks develop along collaborative paths within a project ecology. In this section, an attempt will be made to further theorize the empirical findings. In particular, the model of project networks derived from the creative industries will be extended and processualized, to capture different levels of ‘maturity’ of project-based fields. For, unlike in TV production for example, in research the roles of coordinating (strategic) actors that develop and sustain project networks seem to only emerge gradually. However, the empirical case suggests that, similar to collaborative paths of TV producers and TV channels, in research, collaborative paths emerge involving core actor groups which get repeatedly commissioned by particular funding programmes. Over time, these actor groups seem to make reflexive use of their social and human capital for attracting resources from the field. This capability, however, seems to have developed from emergent collaborative experiences. That is, *reflexive* (project) network management must be seen against a history of *emergent* (project) network development from collaborative paths.

In more general terms, the case of research tells much about the emergent potential for *reflexive agency* in networks. This term, as it is used here, refers to the (emergent) *capacity* of actors to monitor their environment, to gain relational power and to act competently in social practice (see also Giddens 1984). As Emirbayer and Mische (1998) point out, however, agency comprises habitual, projective and evaluative dimensions which do not necessarily have the same ‘weight’ in any situation. Rather, amongst other things, the (perceived) pressure of institutional changes embodies the *necessity* for entrepreneurial responses and, hence, ‘reflexive agency’ (Oliver 1991; Swidler 1986; Giddens 1984). In situations of change, in particular, reflexive agency refers to the ability to manoeuvre, to competently enact rules and resources to bind social, human, and financial capital, and to, thereby, safeguard relational autonomy (Emirbayer and Mische 1998; Garud and Karnoe 2001; Giddens 1984; Burt 1992). Following this notion, Figure 8 presents a model of project network development along collaborative paths which promises to capture the dynamics of (collective) agency in emergent project-based organizational fields. It will be discussed using results of this particular study.

Figure 8: The Development of Project Networks from Project Ecologies



Three levels of project network development, which differ in terms of the degree of reflexive agency, are distinguished here. (Yet, all three might exist parallel and interconnected in practice.) The first, least reflexive, level of project network and path development is termed *project ecology* as it refers to a mere population of projects and actors collaborating (potentially) in the organizational field. This stage can be found in Phase I of the empirical case. The reason why actors join (and coordinate) projects at this stage stems from individual, rather short-term interests and affiliations with particular topics and organizations that promote project-based collaboration. Also, the participation of actors in projects may co-evolve with their participation in specific communities of practice which facilitate and constrain the engagement in particular projects. The case of European education research has shown that membership in scientific sub-communities, notably the FORUM, shapes the collaborative pattern of actors in the field to a great extent. However, actor affiliations in project ecologies have not taken on any (longer-term) ‘organizational form’ at this stage (Romanelli 1991), neither have any (longer-term) actor groups emerged *from* and sustained *beyond* particular projects.

Over time, however, collaborative paths may emerge from repeat joint collaboration along scientific strands that facilitate knowledge exchange and sustain collaborative practices. As the project ecology of Phase II of the empirical case has shown, some actors, supported by multi-vocal ties in the community, may maintain contacts to others which they can enact for path-affiliated projects. These contacts are actualized by particular projects and may culminate in *project networks* of potential project collaboration. Unlike project ecologies, project networks do not come about ‘naturally’ in project-based fields but are reproduced (more or less routinely) by practices of repeat collaboration. They are supported by joint content or occupational affiliations of actors which facilitate subsequent project organizing. However, emergent project networks may collapse easily if follow-up collaboration is hindered, e.g. when funding practices change, like in Phase II of the case study. Yet, while collaborative paths exist, some actors, such as the focal actor in the case, who get highly embedded in path-affiliated project networks and who engage in multiple communities have a potential to monitor (and learn from) the field through boundary spanning activities. Thereby, they accumulate social capital (Burt 1992) and, hence, build up a *capacity* for critical and creative intervention (Emirbayer and Mische 1998).

As soon as institutional pressures rise or conditions change, such as in the course of Phase II of the empirical case, the continuance of collaborative paths is at stake. This *may* promote reflexive agency which ranges from low levels of intervention to complete rejection of field practices (Oliver 1991; Beckert 1999). For organizing projects, agency comprises the negotiation of collaborating domains, the composition of membership and the enactment of collaborative practices (Phillips et al. 2000). While, in the empirical case, the first seemed largely (pre-)determined by institutional conditions, the latter two turned out domains of active agency. In particular those actors, like the focal actor in the empirical case, who have gained authority and legitimacy through informal and formal coordinating activities, might engage in shaping domains of agency for their own and their partners' interest. They may do so by building up pools of experienced collaborators, as well as newcomers, to re-produce collaborative paths that resist institutional pressure to some extent. In other words, through collaborative experience those actors have developed a competence in coordinating a *reflexive project network* as a (self-sustaining) organizational form within the project ecology (Van de Ven and Garud 1989), which is capable of both *sustaining* existing collaborative paths by exploiting established competences, and of *creating* new paths as mindful deviations from the old ones, by exploring new opportunities for collaboration (March 1991; Garud and Karnoe 2001). For example, the case has shown how the core actor group attracted newcomers from new EU countries as well as established researchers from the field to join their projects, which facilitated funding and helped reproduce the collaborative path. Whether this potential is used in the long term, however, may depend on mutual expectations of the actors involved as well as the relational power of the (changing) focal actor (group) to navigate the path through the shifting organizational field.

Conclusions and Implications for Future Research

This paper has examined the development of project networks and collaborative paths in the project ecology of European education research. Having introduced the concepts of project networks, paths and ecologies from the field of creative industries, the project ecology of European education research has been scrutinized. To do so, a network analysis has been carried out on actor and content affiliations of 29 projects that constitute the project ecology of the field from 1995 to 2003. A collaborative path has been identified that initially emerged from repeated actor *and* content affiliations of projects funded by a specialized European programme (LEONARDO). The path seems to have reduced transaction costs of project organizing and helped 'save' trust and expertise for researchers collaborating along the path. However, in response to a shift in funding policies towards more inter-disciplinary research, projects along the path have become disconnected content-wise while keeping connected actor-wise. A multi-variate regression reveals that for the establishment and maintenance of the collaborative path two factors have been most significant: the membership of path-affiliated actors in a special research community (FORUM), and the participation of a focal actor in all path-affiliated projects (FA). A network analysis of project affiliations of researchers over three time periods shows that the focal actor has maintained strong ties to researchers from early projects, cultivated through repeated joint project collaboration and joint

membership in the FORUM community. This actor group has constituted a project network which has facilitated knowledge sharing and collaborating within *and* beyond particular projects. However, the path sustained by the actor group has concentrated over time, attracting few newcomers from the field. Yet, an actor flow analysis suggests that the path has been re-produced over time attracting *some* new researchers that kept affiliated with the path and, hence, joined the project network. This potential for reproduction might help the path (and the network) sustain in the long term. Theorizing the findings, a model of project network and path development is discussed. It explains how project networks can emerge as reflexive organizational forms from collaborative paths in organizational fields. In particular, boundary-spanning agents, like FA, seem to play a key role in this development. Having reflexive (and adaptive) capacity, these project networks seem capable of sustaining and (re-)creating collaborative paths that recursively reproduce the project networks, which thereby sustain in changing organizational fields.

These findings leave interesting questions for future research. First, the empirical case has stressed the importance of looking at reflexive agency in networks. Therefore, a ‘strong’ understanding of networks – in terms of sets of relationships that develop a ‘systemic’ or even ‘agentic’ character – needs to be employed to further study the dynamics of collaborative ecologies (Burt 1980; Emirbayer and Goodwin 1994). Second, the dynamics of networks that are reproduced through *temporary* collaboration needs to be examined further, both for research and other (project-based) organizational fields. To do so, different methodologies need to be applied that allow for a process-oriented macro and micro perspective of collaborative tie development. Third, the extent to which project networks have become institutionalized as organizational forms in different fields needs to be examined (Romanelli 1991). In this context, it may be interesting to study how far project networks leave traces in these fields, such that newcomers are attracted by those networks rather than by particular actors (Barabási et al. 2002). Finally, taking the concept of collaborative paths seriously, it remains to be asked what factors shape the development of such a path, *how* it relates to the properties and the evolution of the organizational field, and *how* it contributes to the emergence of (project) networks as organizational forms.

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