ERC Starting Grant
Research proposal (Part B2)

Section 2: *The Project proposal*

i. State-of-the-art and objectives

New scientific paradigms, new issues on the public agenda, and new products and services are key areas of innovation, with a fundamental impact on societal development. To identify the right track to promote innovation, one needs to understand the structures and mechanisms that lead to the creation and implementation of a new idea. While it has long been recognized that innovation is intimately connected with social embedding, it is only now with the emergence of network science that we can analyze the actual patterns of connections and their dynamics, in large datasets. By borrowing methods and techniques from physics and biology, the new interdisciplinary field of network science carries great potential in developing new theories for social phenomena as well. Current research in the social sciences predominantly focuses on how innovations *spread*, but not how innovations are *generated* in the first place. This project would open new horizons in understanding mechanisms in the generation of innovation, with specific insights into the kinds of organizational structures and networking practices that maximize innovation potential.

It has long been recognized that trends in innovativeness are more favourable in the USA and Japan, while Europe is falling behind, to a large part due to fragmented institutional networks. While network science is a burgeoning field in the USA, in Europe it is yet fragmented into local initiatives. A concentrated research project, proposed here, would not only help understanding innovation better, but would also contribute to the consolidation of network research in Europe. I am uniquely positioned to initiate such a project, as someone embedded into American network science, and working in Europe, and as someone publishing in the leading social science outlets, but also connected to research in the natural sciences via engagements with interdisciplinary institutes.

This project analyzes the network foundations of innovation in three domains – academic production, social movements, and business groups –using both quantitative methods of group evolution, and qualitative case studies of innovations. Innovation is the lifeblood of the academic, civic and business fields: Innovative academic work attracts citations, prestige, and resources, and ultimately leads to the emergence of a new paradigm. Innovations in the civic domain activate participants; attract activists, and donations, and results in generating new forms of representation in the political domain. Innovations in business groups lead to increased profitability, the creation of new markets, and the establishment of new product and service categories. While analyzing innovation in *each* of these three fields individually carry considerable intrinsic interest, testing how patterns of network ties promote or hinder innovation in *all* three fields offers an unprecedented possibility to formulate a general theory of network mechanisms in the creation of new ideas, transcending the specific context of any field.

The aim of the project is to formulate a new argument about the sources of new ideas, based on the intersection of cohesive network groups – intercohesion –, and to test this argument against established expectations based on long reaching circuits of weak ties. This established argument, widely shared and recently elaborated in sociology, asserts that innovation happens when actors combine long reaching weak ties to import new ideas, and local, strong cohesive ties to implement them. The argument that I am proposing is about the importance of overlapping, interpenetrating groups: I argue that innovation happens when actors combine resources, understandings, and practices from two strongly cohesive communities that they participate in at the same time. The concept of intercohesion refers to this process of generative tension in overlapping social groups. Returning to the original insights of Georg Simmel, I argue that group overlap is the generative tension, where, by the recombination of resources and practices, new ideas can be generated and

implemented with trusted partners. While I argue for the creative potential of intercohesion, I also expect that group overlaps strain group cohesion, so that groups with overlapping memberships would be less stable than exclusive ones.

To operationalize intercohesion I reach out to methods recently developed in physics, as methods currently available in the social sciences are insufficient. Clustering algorithms used by social network analysts typically parse cohesive structures into separated communities with a resulting blind spot to multiple group membership. Thinking of even the simplest examples from our experience with social groups makes it clear that partitioning into disjunctive social groups is artificial, driven more by limitations of methodological vision than by sociological insight. Joint appointments in academic departments constitute an overlap of two or more departmental groups. Nuclear families form as the overlap of maternal and paternal kinship groups. It is not exceptional to participate in more than one circle of friends. A more realist perspective thus acknowledges that social groups can be cohesive and overlapping. To step outside methodological limitations in the social sciences I turn to clique percolation method and algorithm recently developed in physics, adjusting parameters to the purposes and kinds of data that I will be working with.

The research proposed here aims at fully developing the theoretical idea of intercohesion, building on discoveries in a previous project. In that research project with David Stark (NSF SES-0616802, $189,346) we mapped the historical dynamics of Hungarian business groups using quantitative techniques. We discovered that overlapping groups experienced higher revenue growth. This research project goes significantly beyond previous research in that it is not restricted to the business context, but considers academic production and social movements as well. This project is also not restricted to quantitative methods (that led to the discovery of intercohesion as a hypothesis), but incorporates qualitative methods to understand the mechanisms of intercohesive creativity. In sum, this project aims at fully elaborating the mechanisms of intercohesion, rather than just testing it a correlational hypothesis.

For each of the three domains I propose to gather data on network ties in a historical perspective – recording the time of creation and dissolution of specific ties – in order to identify emergent and dissolving groups. Academic production is increasingly a team-based effort, where teams are often not named entities, but can be recognized from patterns of co-authorship, co-participation in projects, collegial ties, and co-organization of academic conference panels. Social movements are typically loose alliances of organizations, woven together by ties of co-organized protest action, co-sponsored petitions, projects, and actions. Business groups are strategic collectivities of firms linked by personnel ties, ownership shares and projects.

In each of the three domains I choose specific cases. In academic production I consider two fields: complexity science, and migration studies, both interdisciplinary and with active group formation. In the civic domain I propose to analyze the evolution of social movements in Hungary and Poland from 1988 to 2008. In terms of business groups I will collect data on business groups around firms in the Fortune Global 500 lists from 2005 to 2008, and I will relate these groups with local business dynamics in Hungary, one of the most open economies in the world in terms of foreign ownership. I will apply historical sequencing methods that I developed in preceding publications, methods of group identification from physics and general methodologies from historical sociology to analyze cohesive group evolution and long-reaching weak ties in these quantitative historical network datasets.

Existing research on networks and innovation

Innovation happens by solving the twinned problems of recognizing novel ideas and securing the means to implement them. In short innovation takes solving the “idea problem” and the “action

problem" (Obstfeld 2005). Network analysis contributed to understanding innovation by uncovering the structure of ties that channel new ideas. To understand the spread of new ideas, one needs to understand the positions of individuals in networks of flow (Rogers 1995). When adoption involves taking risk (as adopting a new idea often does), social actors consider the decisions of those that are positioned similarly in the network (Coleman et al 1966).

Network analysis also contributed to a better understanding of the action-element of innovation by highlighting the importance of cohesive groups. Such groups provide safe grounds to the risky endeavor of implementing a new idea by fostering mutual trust, and providing reciprocal assistance in case of failure. While in many cases social groups are institutionalized (as the Chicago Department of Sociology, the Charter 77 group of dissidents, or the Parmalat business group), groups relevant to innovation are most often not named. Network analysis provided tools to recognize unnamed communities from the patterns of ties between the members that make it up. Clique identification methods make it possible to recognize packets of high density within a network (Alba 1973), and subsequent developments relied on clustering techniques to identify groups at various levels of cohesion (Everett and Borgatti 1998). In the academic context for example, a network perspective helped realizing the creative potential of *invisible colleges*, un-institutionalized collectives of researchers (Price 1963, Crane 1972, Zuccala 2005). In the business context, network approaches to links between managers via co-participating in directorship boards contributed to identifying core economic elite groups (Useem 1980) or business groups (Granovetter 2005).

In sum, the current consensus sees two separate network structures relevant to the idea problem and the action problem of innovation: connectivity outside the community helps securing the import of new ideas, while dense ties of cohesion within the community helps with acting on these ideas. The relevance of this connectivity-plus-closure approach to innovation was demonstrated in several contexts, ranging from business project teams (Burt 2005) to Hollywood musicals (Uzzi and Spiro 2005). Yet this approach has some important shortcomings. The connectivity-plus-closure perspective is based on two tenuous assumptions: that the sources of innovation are new ideas that freely circulate in social space, and that social groups relevant to innovation are exclusive.

In my view, true innovation is about *generating* new ideas, rather than *adapting* them. Let us turn to examples of innovation to highlight this point. In their study of new product development in cellular telephones, blue jeans, and medical devices, Lester and Piore (2004) demonstrate that each of their cases of radical innovation involves combinations across disparate fields, or communities: Fashion jeans are the marriage of traditional workmen's clothing and laundry technology borrowed from hospitals and hotels. Medical devices draw on both basic life sciences and clinical practice. And cellular phones recombine in novel form radio and telephone technologies. They conclude that "without integration across the borders separating these different fields, there would have been no new products at all" (Lester and Piore 2004: 14-15).

If innovation is beyond importing and adapting ideas developed elsewhere, the key question is: How are new ideas generated? The telling phrase in the preceding paragraph is "integration across the borders…" First, Lester and Piore do not refer to "contacts" across borders, for it is not enough for different communities to be *in contact*. Innovation takes closer integration. Second, integration was *across the borders* of communities, not merely tight integration within a community. Thus, translated to the language of network structures, new ideas are generated when cohesive communities interpenetrate – when cohesive groups give up their exclusivity.

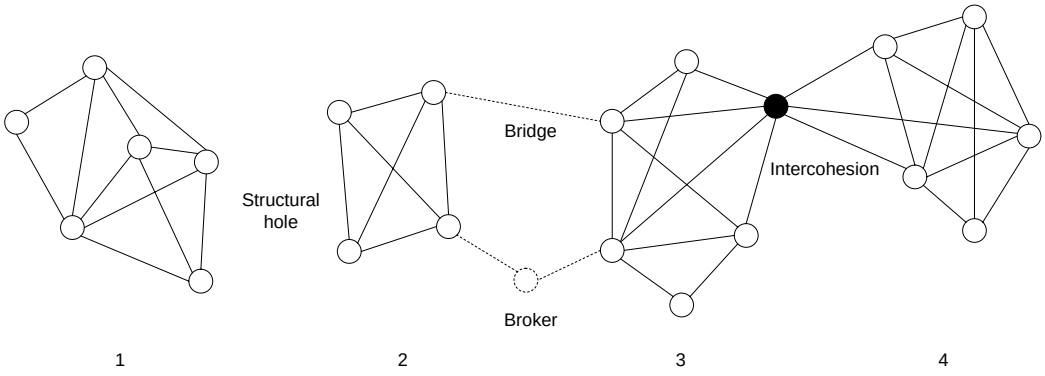
By the alternative framework proposed by this project, innovation happens by *generating* new ideas *while* acting on new combinations: the *idea problem* is itself an *action problem*. That is, the most innovative ideas are not "out there" in the environment of the group. Instead of waiting to be found, they must be found out (Kogut and Zander 1992). It is one thing to recognize an already-identified

pattern; but quite another to make a new association. In this sense, the process of innovation is paradoxical for it involves a curious cognitive function of re-cognizing what is not yet formulated as a category. As John Dewey ([1938] 1998) and the pragmatists argued, it is only in the process of attempting to make a transformation in the world that new problems can even be formulated. Generating novel recombinations is itself a kind of production requiring coordination and cooperation across different communities. In the next section I operationalize this hypothesis in network terms.

The intercohesion hypothesis

To understand the theoretical importance of the various kinds of links between social groups for innovation, let us consider four possibilities, presented on Figure 1. The first possibility is that there is no link between two groups. On the figure, groups 1 and 2 are not connected. Such lack of connections might seem trivial and unimportant at first, but such structural holes are locations of unrealized potential (Burt 1992). A structural hole can be spanned by bridging ties or brokering nodes. There are two kinds of connections between groups 2 and 3: a bridging tie and a brokerage connection. When groups become bridged by a connection between members in each group, information can start flowing. Alternatively, groups might become in contact by a third party, a broker that mediates the flow between the two groups, while turning a profit. But a structural hole can be also spanned by a group member that becomes a member of both groups. Intercohesion, the form of contact between group 3 and 4, is distinct from either brokerage or bridging: groups not only become in contact, they interpenetrate by a mutual member. The processes enabled by intercohesion are qualitatively different from as mere flow of information.

Figure1. Possible connections between groups.



The hypothesis of intercohesion states that the overlapping of social groups ignite processes of generative tension, where group members recognize the potential of recombining diverse group-based resources, and are also able to realize this new idea by their discretion over those group-based resources. In contrast to the connectivity-plus-closure perspective, intercohesion rests on different assumptions: social groups are not necessarily exclusive, and new ideas need to be generated, rather than imported. The overlapping of social groups is generative, because intimate access to group-based resources in multiple groups lends itself to *recognizing* new combinations. These group memberships are also conductive to *realizing* these new combinations – members that are insiders in both groups can mobilize group assets towards acting on the new idea. Deep access for generating new problems, new knowledge, and new capabilities (as opposed to transferring already accepted ideas) requires considerable trust, hence familiarity. Such access can only be achieved by being an insider, an accepted member of a group. I argue therefore that productive recombination requires familiar access to resources by being multiple insiders. Such access is not provided by the narrow bandwidth of the slender ties of bridging and brokerage.

Taking an example from business, a firm, producing windows and embedded in a construction industry group, can benefit by an additional membership in a chemical industry group. By recognizing the potential of a certain plastic, it can initiate a project on plastic window frames within the construction group, securing a steady supply of raw material within the chemical industry group. By the virtues of commitment and trusted embedding in both groups, production can start, and profits from the new product would flow to both groups. This new project on plastic windows is not likely to happen in another scenario where groups are exclusive. If the window-producing firm is a member of the construction group only, even if it had connections to a member of the chemical group, it would not be able to initiate the plastic windows project. First, the firm would not have a comprehensive overview of the capabilities and resources available in the chemical group. Second, even if the firm would be fully informed about the chemical group, it would not be able to make the chemical group commit resources to the plastic windows project: members of the chemical group would also need to see the capabilities of the construction group, and moreover, members of both groups would need the trust to jointly recombine their resources.

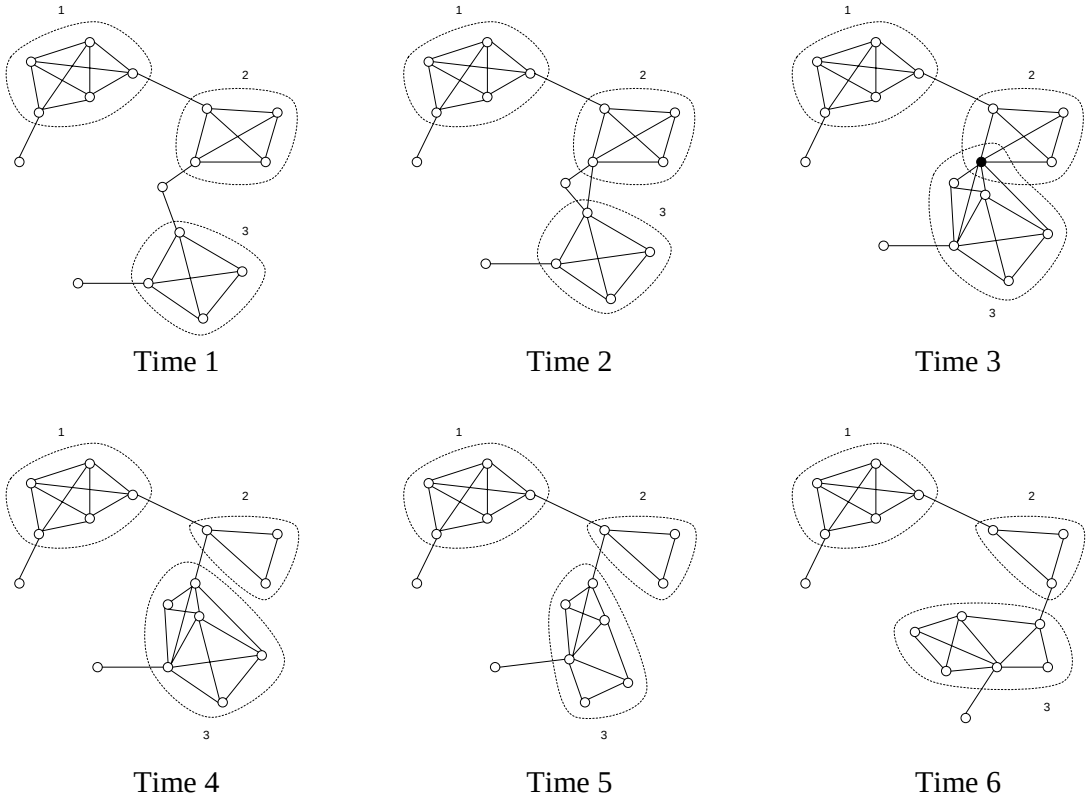
We could also think of examples from academic life. A sociology department that decides on a joint appointment with the history department might initiate a new working group, a graduate program, or publications on historical sociology. Just by knowing colleagues in the history department, such new initiatives might never happen. Or, to bring an example from social movements, from the overlap of an environmentalist group and group on regional development, a project to build bicycle routes might be formulated – promoting tourism and environmental protection at the same time. Such a multi-purposed project might be much more efficient in achieving developmental and environmental goals for the same amount of support.

While intercohesion is expected to contribute to innovation, it is also expected to create tensions and instabilities. A non-exclusive group is prone to coordination problems. Members in one group have little insight into the strategies of those engaged in multiple groups. Loyalties might be questioned. Maintaining multiple memberships might strain the resources of members that they can devote to networking. A business group might dissolve when firms question each others commitments. An academic department might be paralyzed by simple scheduling difficulties with too many joint appointees. A social movement might disintegrate by a lack of loyalty and commitment from activists. In sum, it is reasonable to expect that non-exclusive groups are less stable than exclusive ones.

The idea that intercohesion is both generative and disruptive is in line with a long tradition of thinking about innovation and entrepreneurship, stating from Joseph Schumpeter's conception of entrepreneurship as creative destruction (Schumpeter 2003). The flipside of the idea is also of intuitive interest: exclusive groups can be more stable, but less innovative. Through the unintended consequence of group disruption, intercohesion serves a larger social function of constantly re-mixing group members, to enable new group formations, and ultimately new innovations. Taking the perspective of a social field, as opposed to just a social group, intercohesion is a candidate for a structural feature that enable change from within. In a seminal article on social structure and agency, William Sewell points to the intersection of structures as one structural feature enabling agency (Sewell 1992). Intercohesion is an operationalization of this idea.

Figure 2 illustrates a short hypothetical example for a history of group evolution in a field. This example follows the evolution of three groups. Group 1, in the upper left corner is exclusive throughout, and there is no change in its membership, or internal structure. While this group is connected to group 2 by a bridging tie, this connection does not lead to sharing members. I expect that such group histories are not rich in innovation. Exclusive groups are expected to be stable, but not particularly entrepreneurial.

Figure 2. Illustration of intercohesion in a historical perspective.



The evolution of group 2 and 3 is different. These two groups start building stronger ties to one another – first there is a brokered tie between them, then there is also a bridging tie. Eventually, by Time 3, the two groups share a member. This is a period of time, when I expect groups to become innovative, as members of either groups, and especially the dark node with multiple membership, can recombine practices from the two groups. But this intercohesive structure is not expected to last long. By the fourth step in time these groups start disintegrating – first group 2, then group 3 is losing ties. While the original point of attachment disappears by Time 6, there is already a new bridging tie at another location between the same two groups. It is reasonable to expect that groups that are more open to intercohesive recombination, will tolerate instability. Learning that openness generates innovation, there might be a population of groups that experience change in structure while experimenting with combinations.

Beyond following this example from a birds-eye view to highlight structural processes, we should also think of processes from the perspectives of individual members. The most interesting group member of course is in group 2, the lower left member of the four. This is the actor that becomes member of two groups by time 3. Does it take a certain personality, networking skill, or habitus to jointly participate in multiple groups? This actor is also the one that spends the most resources on networking: it has seven ties at time 3. This highlights that intercohesion requires high investment into network ties from those in multiple groups. Following the example, this actor finds itself in group 3 by the last point in time. Was this member expelled from group 2, or did it just simply move on to operate in another group? What is dynamics of structures at the birds-eye level, is network search, persuasion and disillusion, attachment and conflict at the level of actors. In the case of an academic research groups, social movements, or business groups I will draw similar maps, spanning more periods in time, and considerably more participants and groups, and I will also look closely at processes on the level of individual agency, search, recognition, and conflict.

ii. Methodology

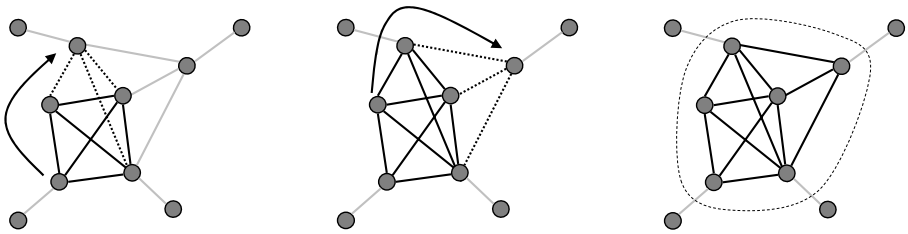
I analyze innovation in three domains – academic, civic and business – to understand the network foundations of innovation, and specifically, to test the idea of intercohesion. For each of the three domains I will specify cases, and collect fine-grained historical network data for large datasets. I will also collect qualitative data (in targeted case studies and interviews) in each of the three domains. I specify the particular cases, and the particular sources of data in the next section (Cases and Data). For each of the three substantive domains, my research proceeds in three steps. The first step is to map cohesive groups. This step will be based on assembling large scale historical network datasets, and identify cohesive groups at each step in time (a unit of time in which meaningful changes to group memberships are possible). The second step is analyzing the historical evolution of group cohesion, based on group memberships identified at the previous step. This involves using sequencing methods borrowed from biology to identify typical group evolutions – such as stable exclusive groups, dissolving groups, and sets of groups in repeated member exchange. The third step is based on qualitative methods, and aims to identify mechanisms of agency, and the content and operation of membership ties towards innovation.

Identifying groups and intercohesion

Social network analysis of group cohesion has so far neglected the importance of group overlaps. For methodological ease, techniques of group identification parse network data into disjunct, exclusive communities (Freeman 1992). To step outside this methodological tradition of group exclusivity, I borrow methods recently developed in physics. To identify cohesive groups I will use a method that starts from cohesive localities, recognizes groups independent of the global network environment, and identifies intercohesive positions. Most methods within social network analysis parse cohesive groups into exclusive sets, so I turn to a method developed by physicists: the clique percolation method (Palla et al 2005). In a recent publication, the potential for this method as a suitable tool to analyze the evolution of cohesive groups was fully demonstrated (Palla, Barabasi, and Vicsek 2007).

In a nutshell, the clique percolation method finds contiguous regions of cohesion by "rolling along" a small cohesive pattern. The algorithm starts from a clique of *k* nodes, a *k*-clique, and operates on clique adjacency. *K*-cliques are adjacent if they share *k*-1 vertices. A clique of four is adjacent to another clique of four if they share three members. From adjacencies one can assemble a clique chain, traversing along clique adjacencies. The union of all *k*-cliques in such a chain form a *k*-clique percolation cluster if no more *k*-cliques can be added. This contiguous and highly cohesive region of the network is a cohesive group, within which a *k*-clique can percolate, or roll along, by always replacing only one of the *k* nodes. Using a *k* value of four, as we do in this study, yields cohesive groups where all members have ties to at least three other members in the group.

Figure 3. Illustrating the process of the clique percolation method with k=4.



Step 1 Step 2 Step 3

Figure 3 illustrates the logic of the CPM method (with k=4) in identifying a small cohesive group (by step 3). The method starts by start by identifying a 4-clique, and in step 1 this 4-clique is rolled

along by replacing one node (replacing the node at the base of the curved arrow for the node at the point of the arrow). In step 2 the 4-clique is rolled further along in a similar fashion, and in the final step, step 3 the group is identified, as there is no further possibility to roll the 4-click along (replacing one node with another to add another 4-clique). The 4-clique can percolate in the final group (circled by a dashed outline).

The *k* parameter of the CPM method is adjustable. Choosing a lower k results in a more uneven distribution of group sizes. A *k*-value of one is of little utility, since considering the percolation of complete subgraphs of a single node means that the whole network is one group. At this extreme value the size distribution of groups is the most extreme – there is just one group that encompasses the whole network. A *k* of two means that we consider the percolation of complete subgraphs of two nodes, which is equivalent to considering the percolation of edges. In this case cohesive groups are the disconnected components of the graph. The size distribution of components is very skewed, as a giant component containing an overwhelming proportion of nodes is a common feature of most networks. Increasing the value of *k* to three is equal to considering triangles (complete triads) as the percolating subgraph. Groups in this case are made of triangles sharing at least two nodes. The distribution of group sizes is more even, although in denser networks the largest triangle-percolation cluster can still be much larger than the second in size. Moving to a *k* of four is even more restrictive, since groups need to be dense enough to allow the percolation of complete subgraphs of four. In this case the distribution of group sizes is more even, and there might not be a clearly largest group.

Although developed by physicists, the clique percolation method improves on standard approaches in social network analysis and resonates with new departures from the conventional models. Most importantly for the purposes of this project, a group identified by the CPM method can overlap with another group. CPM is thus in line with Everett and Borgatti (1998) who recognized the limitations of forced partitioning in various algorithms and pointed to the utility of clique adjacency as a theoretical solution. By relaxing clique membership in favor of clique adjacency, hence capturing group overlaps, CPM achieves greater sociological realism allowing for closer approximation to the notion of community than does the concept of a sociometric clique. In a social community – unlike in a network clique – everyone is not necessarily connected to everyone else.

Historical analysis of group dynamics

To analyze the causal relationship between intercohesion, innovation, and instability, I will use methods, and more general methodological strategies from historical sociology, and sequencing techniques borrowed from genome sequence matching, adopted to historical purposes (Abbott 2001, Sankoff and Kruskal 1999). From historical sociology, I adopt the concepts of path dependency, conjuncture, and turning point (Mahoney 2000). Social network analysis is susceptible of adopting a structuralist mode of argumentation – assuming that patterns of ties determine behavior. A historical network approach helps avoiding structuralism, by identifying the durability of structures, and determining the temporal ordering of innovative action and network patterns. The evolution of groups are especially vulnerable to path dependencies: a system of reciprocated assistance, investment in resource commitments and shared understandings are not abandoned easily. Overlapping membership between two groups might mark a conjuncture point in their development: a point where two lines of group evolution meet (and potentially clash). Intercohesion is thus expected to mark turning points in the evolution of groups.

I will translate these general methodological ideas to practical historical mapping techniques by adopting and refining sequence methods already developed for network purposes in preceding publications. For identifying typical evolutionary paths of group development, I will adopt an optimal matching sequencing technique, tuned to network application (Stark and Vedres 2006). This analysis provides a typology of group evolution sequences, and helps answering questions on

the impacts of intercohesion: Do groups with more intercohesion live shorter? Do these groups experience more member turnover? Are there thresholds in the amount of intercohesion that predict a complete dissolution of a group? How quickly does innovation follow intercohesion? Does innovation success lead to increased intercohesion (that is further exploration), or does it lead to group closure (and a focus on exploitation)? These methods will also enable recognizing alternative mechanisms at work: Do groups with more bridging and brokering connections show more innovation subsequently? Are there successful group evolutionary paths with innovation, no intercohesion, and high external links?

Mechanisms of intercohesion

Qualitative methods will be used to understand network mechanisms of innovation. Case studies of groups and stories of innovations will be collected to answer questions about the practices of deploying social contacts in the process of innovation. Quantitative methods can help in identifying patterns of connections, and correlating these structures with innovation. The key type of question that the qualitative component can answer is about the *content* of social ties: How are ties built? How does one activate a network tie in the case of a specific need? How do actors in the field fill ties with content? What ties are considered inactive? How is breaking a tie negotiated?

This part of the project will be crucial in addressing several questions about multiple group memberships specifically. The first set of questions concern the emergence of non-exclusive groups, and the practical organizational challenges of intercohesion: How does one decide about taking up multiple memberships? What features of individual members contribute to taking up multiple memberships (resources, habitus, previous experiences)? What are elements in the immediate environment (physical space, buildings, group norms, meeting routines, communication tools) that are conducive or prohibitive of multiple memberships? What are practical ways to manage multiple memberships (time and resource sharing, identity switching)? Also, what makes groups exclusive: a rational consensus of members, the absence of cognitive categories for multiple memberships, or norms of loyalty?

The second set of questions concern the connection between group structures and intercohesion – the practical workings of intercohesion and bridging ties towards innovation: What are typical stories of the emergence of new ideas? How are such stories told, learned from? Are new ideas coming from those that have multiple memberships, or any member in intercohesive groups? How do groups select what to implement from multiple ideas? I will also collect histories from the emergence of an idea to a highly cited article, successful mobilization, or profitable product.

The third set of questions concern the tensions that multiple memberships create: How does multiple group membership strain group cohesion? What are typical stories of conflict? How are such stories told, learned from? What are the mechanisms of group breakup? Who initiates breakup? Is breakup limited to expelling multiply committed members, or does it run deeper to disintegrate the whole group? What are typical narratives of dissolved groups? How is group memory stored?

Cases and Data

I consider three diverse social contexts to test the idea that intercohesion contributes to innovation: academic production, social movement mobilization, and business groups. These are three key fields where innovation contributes greatly to societal development. Academic innovation defines new directions for science, and ultimately leads to new applications. Innovation in the civic field improves the efficiency of political representation of what counts and who counts, and ultimately leads to improved decisions. Innovation in the business field leads to profitability and economic

growth. Understanding innovation in each of these three domains independently is an important task, but I argue for the importance of incorporating cases from all three domains into one research project.

A strong test of theory is when multiple independent cases are used from different contexts to test the same argument. In this sense this research project constitutes a strong test to network theories of innovation. With my case selection I would also like to maximize the possibilities for testing, revising, or rejecting the intercohesion argument, and also the connectivity-plus-closure argument. Stepping back, I would also consider the possibility that none of the network structures help predicting innovation with considerable precision. After all, no research project attempted to test these theories with a wide range of cases.

Academic networks and productivity

Academic knowledge production is increasingly networked: teamwork became widespread in natural sciences, and the social sciences are catching up recently: Publications in the leading journals of sociology have become overwhelmingly co-authored over the last decade (Moody 2004). I argue that academic productivity depends on the network structures of collaboration. I expect that research teams with overlaps to other teams will have higher success in terms of the number of citations to their publications.

It also makes intuitive sense to argue that intercohesion benefits academic innovation. After all, calls to interdisciplinary research are based on beliefs, that combining diversity in science is beneficial to frontier research. We probably all have experiences when academic teamwork benefited from intercohesion, either by attachments to interdisciplinary seminars, institutes, or by joint appointments between departments.

Within the field of academic production, I will select two fields as cases: complex systems and the sociology of immigration. Both fields featured rich examples of interdisciplinary collaborations. Complex systems research spans information science and archaeology, physics and biology. Migration research features political science and anthropology, economic sociology and criminal justice. Both fields became very active over the last two decades, featuring research institutes, journals, and applications in governance and business consulting.

Quantitative datasets will be compiled from bibliographical datasets, by a combination of keyword search and snowball sampling along citation networks. This dataset will provide a historical record of co-authorship links and citation activity. I will reconstruct overlapping groups of authors, and analyze the relationship between group overlaps and publication impact. I will also collect data on collegial ties by co-presence at departments and institutions, and co-organized conference panels. This data collection strategy builds from collaboration that becomes public, and does not contain collaboration that remains informal. I expect that intercohesive groups will have higher impact publications, but will be more likely to disintegrate.

Qualitative case studies of research teams from complex systems will include research groups such as the Northwestern Institute on Complex Systems, Evanston, USA, or the Department of Biological Physics at Eötvös University, Budapest. Case studies in migration research will include groups like the Center for Migration and Development, Princeton, USA, or the European Research Centre on Migration and Ethnic Relations, Utrecht, Germany. I will use these case studies to understand the mechanisms behind intercohesion: How do team members decide on taking on multiple affiliations? How do they manage such multiple commitments? How does intercohesion lead to the discovery of a new scientific idea? How can scientists mobilize resources in multiple groups to realize that idea in publications? What is the nature of organizational friction that arises due to intercohesion?

Social movement networks and mobilization

Social movement organizations are key agents of innovation in political representation. By making novel associations between ideas, goals, and agents, social movements contribute to extending and refining the definitions of who and what counts, in political sense. Now we take for granted that the reduction of ecological diversity counts as a threat to public good, but this would not be part of the public agenda without decades of work from environmental movements. We also take for granted that women count in the sphere of political representation, but again, this would not be so without decades of work by women's movements.

Central Europe is an active ground of civic experimentation, as nonprofit organizations are creating project networks involving businesses and local governments, to compete for grants from the EU structural and regional development funds (Bruszt and Vedres 2007). This experimentation has a longer history dating back to the time of the postsocialist transition. An example of a civic innovation of high impact was the combination of environmental activism and demanding free elections in Hungary in 1988. The Duna Kör movement was formed in 1984 to protest damming the Danube river. In the following years they established strong contacts with political dissidents and invented a framing that portrayed the dam project as the "Danube-saurus" – suggesting that the heavy handed treatment of fragile ecologies was part of a larger behavioral pattern of the communist party akin to a collection of dinosaurs. This framing contributed to mass protests demanding free elections to topple the old regime.

I consider the history of social movements from Hungary and Poland, between 1988 and 2008. I will collect data on news releases that concern an action from a social movement, from both the Hungarian and Polish new agencies, with the help of native speaker graduate students, and relying on local data collection firms affiliated with the news agencies. Based on a small pilot study at the Hungarian News Agency, I estimate that about ten thousand items will be available in each country. Networks between civic organizations will be drawn up by their co-participation in events (such as a demonstration, petition, conference, or other project). This sampling strategy builds from ties that enter the public sphere as new items, and will not see ties that do not become public. I expect that movement groups that are intercohesive will be more successful in generating issues that will become part of the political agenda.

Qualitative case study research will target social movements that especially successful in generating new forms of representation. These will include environmental and human rights groups, corruption watchdog organizations and regional developmental movements. One example from Hungary is the Urban and Suburban Transit Association, that links environmental groups, engineers, enthusiasts of old railway cars, and urban sociologists. They lobbied successfully to make municipalities recognize riders of public transport as stakeholders with a voice, backed by engineering expertise. Such case studies will enable answering questions on how movements form, how they attempt to create new forms of representations, and how the network structure of the movement matters in that.

Business networks and entrepreneurship

There is a considerable literature addressing the connection between business performance and network structures – both at the inter-organizational level between firms, and both at the intra-organizational level, at the level of work teams, and projects. If such research focused on innovation, it predominantly considered the spread of innovations, rather than the generation of new ideas.

This research project will focus on network patterns at the inter-organizational level, in business groups spanning the global-domestic boundary. Specifically, I will consider business groups

around the Fortune Global 500 firms, with local data collection in Hungary. Data about personnel and ownership connections among global corporations will be collected from the Fortune 500 database service, and connections among Hungarian firms will be collected from registry courts. I will consider the top 500 Hungarian firms in each of the years between 2005 and 2008.

By using historical network analysis I will map group processes at both the level of global business networks and local processes. My previous research with David Stark (NSF SES 0616802) included data collection on the largest 2000 firms between 1987 and 2006. In this research project I will extend that dataset by adding corporate network developments in Hungary between 2006 and 2010, and I will collect new data on ownership and personnel networks between the Fortune Global 500 corporations, available from 2005. Many of these global firms have ownership interests in Hungary. My previous research showed that intercohesive business groups are more successful in terms of economic performance. I would like to extend that analysis to consider transnational business groups. Hungarian firms can be part of global business groups, where there might be further intercohesive group overlaps. Is there an impact from transnational group processes locally? There is a possibility that innovation, sparked by local group intercohesion is adopted into a transnational business group.

I will conduct qualitative research to understand the operation of business groups. I will locate groups with interesting new products, and also groups with failed new products. To consider an example from Germany, Bionade is a combination between traditional alcoholic brewery technology, carbonated soft drink, and organic food marketing. These case studies will explore membership dynamics and innovation in global-local business groups, and managerial teams.

Dissemination

The primary publication planned of this project is a monograph that introduces a network theory of innovation, illustrated by three case studies from academia, movements, and business. This book will be targeted to a broader audience of general social scientists, business managers, and governmental agencies involved in the promotion of innovation. The book will feature both network models of group evolution, visualizations of network processes, and stories of innovation and group dynamics from the qualitative aspects of the project.

Beyond the book, the most important ongoing publication outlet of the project will be a website that features working papers, presentations, and information on group meetings. A working paper series will be established, where doctoral and postdoctoral fellows can publish manuscripts in preparation, and invite comments on forum posts from the general public. The website will also feature as an outlet for visual material that is not publishable in print, i.e. dynamic visualizations of network processes and interactive network graphs with zoomable or clickable content. Beyond publications in the working paper format, the website will also serve as an interactive platform to publish blog entries related to network science, innovation research, and interesting cases and related research.

The project will promote independent publications from doctoral and postdoctoral fellows in international journals, and international conference presentations. An important goal is to target major journals in the sciences – Science or Nature – with a publication on network mechanisms of innovation with data from multiple fields. Only very recently did these major journals accept manuscripts for publication from social scientists researching networks.

iii. Resources (incl. project costs)

Team members

The research team will consist of the principal investigator, postdoctoral fellows, and doctoral fellows. Two postdoctoral fellows will be key members of the team in analyzing data, conducting case study research, and supervising doctoral students employed in qualitative modules of the project. Postdoctoral fellows will also be involved in various tasks of the quantitative analysis, and publications of various components in the project. These postdoctoral fellows will be recruited from outstanding academic schools of network science in Europe (for example universities such as Oxford, Groningen, Ljubljana, Barcelona, Parma). Postdoctoral fellows will be selected in a competitive basis. The composition of the team will always represent scholars from across disciplines, e.g. post docs from both natural and social sciences.

Doctoral fellows will be involved in preparing a website for the project, and assisting with organizing a working paper series. Doctoral fellows will be recruited from PhD students already admitted at CEU. A part-time administrator will be hired to help with practical arrangements.

Budget justification

Personnel costs include salaries of the principal investigator, postdoctoral, and doctoral fellows, and the part time administrator. Tuition fees and stipends of doctoral fellows will be provided by CEU. Personnel cost rates are based on CEU institutional averages.

Equipment costs cover two high-speed and one budget personal computer. The high-speed computers will be used to analyze data, run network community detection methods, and historical sequencing methods. CEU will provide office space, computer network access, and one additional personal computer.

Consumables include a one-year subscription to the ScoPus bibliographical dataset, in order to collect co-authorship data in the academic networks module; and costs of purchasing CD-roms of Hungarian corporate personnel data.

Travel costs intended to cover trips of the principal investigator to targeted case study sites, and to academic conferences, presenting findings of the project. Travel costs also intended to cover expenses of postdoctoral and doctoral fellows travelling to conduct case study research.

Publication costs include an initial cost of setting up a project website, that features interim results, concept papers, presentations, findings. Publication costs are also intended to cover a working paper series that showcases publications from members of the team.

Subcontracting covers collection of quantitative data about academic collaboration networks, civic action networks, and business groups. The procedures to collect such data in all cases can be well formulated. These data collection tasks are highly repetitive and labor intensive, thus a subcontracting arrangement is the most efficient. One subcontractor will be the MTI Hungarian News Agency, that maintains archives of press releases by civic organizations, to be used towards data collection on social movements.

Budget

	Cost Category	Year 1	Year 2	Year 3	Year 4	Year 5	Total (Y1-5)
Direct Costs:	*Personnel:*						
	PI	79,200	79,200	79,200	79,200	79,200	396,000
	Senior Staff						
	Post docs	33,000	66,000	66,000	33,000	33,000	231,000
	Students	6,600	13,200	13,200	6,600	6,600	46,200
	Other	10,000	10,000	10,000	10,000	10,000	50,000
	Total Personnel:	128,800	168,400	168,400	128,800	128,800	723,200
	Other Direct Costs:						
	Equipment	3,300	3,300	3,300			9,900
	Consumables		24,450	3,500			27,950
	Travel	1,500	3,500	3,500	1,500	3,000	13,000
	Publications, etc	2,000	500			2,000	4,500
	Other						
	Total Other Direct Costs:	6,800	31,750	10,300	1,500	5,000	55,350
	Total Direct Costs:	150,600	225,150	193,700	140,300	133,800	843,550
Indirect Costs (overheads):	Max 20% of Direct Costs	27,120	40,030	35,040	26,060	26,760	155,710
Subcontracting Costs:	(No overheads)	15,000	25,000	15,000	10,000		65,000
Total Costs of project:	(by year and total)	177,720	265,180	229,440	166,360	160,560	999,260
Requested Grant:	(by year and total)	177,720	265,180	229,440	166,360	160,560	999,260

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iv. Ethical issues

	Research on Human Embryo/ Foetus	YES	Page
*	Does the proposed research involve human Embryos?		
*	Does the proposed research involve human Foetal Tissues/ Cells?		
*	Does the proposed research involve human Embryonic Stem Cells (hESCs)?		
*	Does the proposed research on human Embryonic Stem Cells involve cells in culture?		
*	Does the proposed research on Human Embryonic Stem Cells involve the derivation of cells from Embryos?		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	X	

	Research on Humans	YES	Page
*	Does the proposed research involve children?		
*	Does the proposed research involve patients?		
*	Does the proposed research involve persons not able to give consent?		
*	Does the proposed research involve adult healthy volunteers?		
	Does the proposed research involve Human genetic material?		
	Does the proposed research involve Human biological samples?		
	Does the proposed research involve Human data collection?		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	X	

	Privacy	YES	Page
	Does the proposed research involve processing of genetic information or personal data (e.g. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?		
	Does the proposed research involve tracking the location or observation of people?		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	X	

	Research on Animals	YES	Page
	Does the proposed research involve research on animals?		
	Are those animals transgenic small laboratory animals?		
	Are those animals transgenic farm animals?		
*	Are those animals non-human primates?		
	Are those animals cloned farm animals?		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	X	

	Research Involving Developing Countries	YES	Page
	Does the proposed research involve the use of local resources (genetic, animal, plant, etc)?		
	Is the proposed research of benefit to local communities (e.g. capacity building, access to healthcare, education, etc)?		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	X	

	Dual Use	YES	Page
	Research having direct military use		
	Research having the potential for terrorist abuse		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	X	

Section 3: *Research Environment* (max 2 pages)

i. PI's Host institution

Central European University is a graduate university concentrating on the social sciences and the humanities. The university pursues a mission to achieve excellence in teaching, research and policy in order to become a change maker in the region and beyond, with a special focus on contemporary challenges of open society, and democratization.

CEU is also research university with more than 400 doctoral students in its student body of 1,400. Educational and research activities at CEU are based on the promotion of innovative and creative ideas, particularly those of an interdisciplinary scope. Accredited both in the United States and in Hungary, CEU embraces the Bologna Process, actively partaking in the modernization of higher education across Europe, while also cultivating its ties to leading universities in the US.

CEU offers its students a wide range of academic and extracurricular resources in an attractive urban setting in the Hungarian capital city of Budapest, a meeting place of people, ideas and cultures from all over the world.

The university's commitment to academic excellence and the social dimension of its mission are mutually reinforcing: being a regional thought-leader enables CEU to support and advise policy initiatives for social and economic reform. CEU has been working hand-in-hand with the Open Society Institute, providing academic and professional backing for OSI's global agenda of democratic governance, human rights, and economic, legal and social reform. The university has also been an active academic partner of local initiatives to strengthen the rule of law, public health, education and independent media. CEU's knowledge-based social engagement not only offers students a greater academic choice, but also helps to prepare them for a future of service and leadership.

Since its founding in 1991, Central European University has sought to contribute to innovative academic research, progressive higher education and the development of dynamic, sustainable open society. In its first decade, the university had turned primarily towards the population of Central and Eastern Europe and the former Soviet Union countries. More recently, its interest has become global, with special attention paid to emerging democracies throughout the world.

The CEU Center for Network Science is an emerging interdisciplinary group, gathering faculty and students from sociology, anthropology, environmental science, political science, history, economics. The goal of this emerging group is to discuss the potential of non-linear thinking in terms of complex emergent dynamics, the impact of connectedness in network structures especially along the following lines: global civic networks, ecological webs, business-political interconnections and corruption, blog networks and online communities, multinational business networks, migration, academic flows, terrorist networks, semantic webs.

The group plans to start up bi-weekly meetings to facilitate learning new techniques of analysis, and understanding commonalities in network dynamics across a wide variety of fields. The group is open to all students and faculty with any level of familiarity regarding methods. The research theme of the center this year concerns the connections between ecological and social networks, and the center is hosting a postdoctoral fellow from Italy, Marco Scotti, an ecologist researching robustness and flows in food webs.