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What are institutional boundaries and how can they be overcome? Germany's collaborative research centres as boundary-spanning networks

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**What are Institutional Boundaries and how can
They be Overcome? Germany's Collaborative
Research Centres as Boundary-Spanning Networks**

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Abstract

Social entities create institutional frameworks, i.e. internal systems of rules which govern (but do not control) the actions of their members. Both scientific communities and scientific organisations are social entities whose institutional frameworks include rules promoting internal collaboration. Based upon a diffuse reciprocity, members of the social entities are stimulated to collaborate with other members. The tendency to prefer other members as collaborators is accompanied by a relative exclusion of non-members from collaborations. Thus, in this way institutional frameworks create institutional boundaries hindering collaboration.

In order to overcome institutional boundaries both within universities and between scientific communities, in Germany collaborative research centres (CRCs) were established. These are networks of research groups from different departments of one or more universities, i.e. from different organisations and different scientific communities. They contain their own institutional framework, which overlaps with the institutional frameworks of both organisations and scientific communities. Because the network's institutional framework includes rules promoting collaborations, these necessarily span the original institutional boundaries. A detailed discussion of these rules shows the functional equivalence of the different social entities' (communities, organisations and networks) institutional frameworks.

Zusammenfassung

Scientific communities und formale Organisationen wie Forschungsinsitute oder Universitäten bilden jeweils eigene Institutionensysteme aus. Diese Institutionensysteme fördern direkt oder vermittelt Kooperationen zwischen den Mitgliedern der communities bzw. Organisationen. Indem sie Kooperationen zwischen ihren Mitgliedern fördern, errichten sie aber zugleich institutionelle Schranken für die Kooperation mit Außenstehenden. Solche Kooperationen werden durch die Institutionensysteme meist nicht unterstützt und damit relativ erschwert. Die Mitglieder einer scientific community oder Organisation wählen deshalb tendenziell Kooperationspartner aus derselben community bzw. Organisation.

Um solche institutionellen Schranken zu überwinden, hat die Deutsche Forschungsgemeinschaft das Förderprogramm 'Sonderforschungsbereiche' (SFB) etabliert. Dabei handelt es sich um Netzwerke von Forschungsgruppen, die aus verschiedenen Fachbereichen einer oder mehrerer Universitäten stammen. Die Sonderforschungsbereiche bilden ein eigenes Institutionensystem aus, das die der scientific communities und der Organisationen überlagert. Weil auch dieses Institutionensystem kooperationsfördernde Regeln enthält, werden innerhalb eines SFB solche Kooperationen gefördert, die die klassischen institutionellen Grenzen überschreiten. Eine Analyse der kooperationsfördernden Regeln von SFB zeigt, daß sie den in scientific communities und Organisationen entstehenden Regeln funktional äquivalent sind.

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1. Introduction

It is commonly known that collaborative research is often hindered or even prevented by institutional boundaries. Prominent examples are disciplinary boundaries hindering interdisciplinary research and organisational boundaries, the latter being discussed primarily with regard to industrial R&D. Since the institutional boundaries are seen as an eminent obstacle to scientific progress, science policy tries to create instruments to promote boundary-crossing collaborations, for example, government funded programmes promoting research collaboration between firms (Quintas and Guy 1995; Häusler, Hohn and Lütz 1994) as well as programmes to promote interdisciplinary academic research. As a result of such funding, collaboration networks emerge that link scientists from different scientific communities or different organisations.

It is, however, by no means clear whether institutional boundaries can be overcome and how this can be achieved. The classic paper by Aldrich and Herker excludes the problem of boundary-crossing collaborations by reducing boundary-spanning roles to either information processing or external representation (Aldrich and Herker 1976: 218-221). With regard to disciplinary boundaries it is often stated that they exist and hinder collaborations, but neither their causes nor the opportunities to overcome them are discussed (e.g. Becher 1989).

In our paper we want to discuss what institutional boundaries are and what collaboration networks do to them. Our first question is how institutional boundaries emerge. Since science is by its very nature a collective enterprise, the nature of institutional boundaries between scientists must be explained. Subsequently, we will show how a specific collaboration network - the Collaborative Research Centres (CRCs) funded by the Deutsche Forschungsgemeinschaft - can weaken institutional boundaries. Our discussion is based upon an empirical investigation of two CRCs with nearly 500 collaborations between scientists at universities and non-university research institutes (Laudel 1998). The research groups belong to biological, chemical and physical fields, most of them conducting experimental research. To investigate the scientists' collaborations and conditions of action, qualitative interviews were conducted with about 100 scientists.

2. The Nature of Institutional Boundaries in Science

Our discussion of institutional boundaries is based upon a comparatively narrow understanding of institutions, which restricts this concept to systems of social rules (North 1990; Mayntz and Scharpf 1995; Scharpf 1997). This approach is used relatively seldom, though it has several advantages. Firstly, it allows us to conceptualise institutions not only as being subject to evolutionary change, but also as formed by purposeful actions. Thus, institutions can be independent as well as dependent variables in institutional investigations. Secondly, the restriction to systems of rules makes it clear that institutions are only one of the factors influencing actions. A concept of institutions which comprises all social patterns including cognitive and symbolic elements tends to be quasi-deterministic because it embraces all determinants of action and leaves no room for an intentional actor. Thirdly, this narrow concept supports an empirical search for institutions because it may be operationalized to a certain extent.

The understanding of institutions as systems of social rules implies that they are characterised by the following features:

- institutions govern the actions of individual, collective and corporate actors,
- they link attributes of an actor's situation with forms of prescribed or at least expected behaviour,
- deviant behaviour may be sanctioned.

All social systems (communities, groups, organisations, etc.) develop institutions which merge into a framework. A social system's institutional framework is usually restricted to the system's members and governs their interactions as well as interactions with the system's environment. Thus, institutions have a certain scope which is determined by the number of situations they apply to and by the number of actors whose behaviour is to be governed. The institutional framework's scope exists in organisations where the membership is institutionally fixed as well as in scientific communities where membership is a perceived rather than an ascribed status. A social system's institutional boundaries can be understood as the limits of its institutional framework's scope.

Scientific research is governed simultaneously by the institutions of two different social systems. Scientists belong to at least one scientific community, i.e. a community of scientists who jointly define research problems, provide each other with knowledge, sometimes collaborate, and evaluate the results. The second social system scientists usually belong to is a formal organisation (university, research institute, etc.) which provides the resources for the research and links the research to that of other scientists working in the organisation.

The institutions of both social systems promote collaboration between the systems' members in two different ways. Firstly, there are institutions governing actors who produce the conditions which are necessary for collaboration. Secondly, some of the institutions directly touch the collaborative behaviour by governing the emergence, the accomplishment or the rewarding of collaboration. Thus, institutionally caused collaboration as well as institutional prerequisites for collaboration exist. According to our empirical investigation, the following prerequisites for collaboration must be given (Table 1):

Research Organisation	Scientific Community
provision / allocation of resources	
Coherence of the research processes	
institutionalisation of communication: conferences, etc.	
<ul style="list-style-type: none"> • perception of cognitive links • development of a shared language • development of trust in the potential collaborator's skills 	
Rules of collaboration: Joint usage of research equipment, supply of service	Rules of collaboration: diffuse reciprocity
	Rules for the distribution of the outcome of collaboration
	Rules for rewarding the collaborators' contributions

Table 1 Promotion of collaboration through research organisations and scientific communities

Research projects and, thus, collaborative research projects as well, need resources. These resources are provided through the research organisation. This fact should be mentioned because it is not as trivial as it may seem. Collaborations often require additional resources which must be somehow acquired.

An important cognitive prerequisite for collaboration is the coherence of the research processes: Two scientists can only collaborate if their research actions are inter-linked with respect to the research problem, the research method or the research object. Both the research organisation and the scientific community combine scientists whose work is likely to be linked this way. The scientific community is formed by scientists dealing with similar problems and sharing a certain amount of scientific knowledge. An organisation's research is usually restricted to few fields and the coherence of these fields is maintained by the recruitment process.

For a collaboration to come about it is not sufficient that these cognitive links exist. It is necessary that scientists perceive them and wish to apply them in collaboration. The perception

usually takes place within the process of scientific communication. Since the latter is promoted by personal interactions, opportunities for personal communication enlarge the scientists' opportunities to perceive cognitive links. Thus, institutionalised communication (conferences, workshops, seminars, etc.) promotes the emergence of collaborations by bringing together potential partners.

A second effect of institutionalised communication is the support it provides for the scientists' mutual understanding. All collaborations require communication, which is possible only if the collaborators share a common scientific language. Since all scientific communities produce their own scientific language, the latter can be learned only in the communication process itself. The support of this learning is one unintended, but nevertheless very important function of institutionalised communication which takes place in scientific communities as well as in research organisations.

With regard to the outcomes of collaborations two different effects of a scientific community's institutions are of importance. The evaluation of a scientist's results by his or her colleagues includes an appraisal of the results' relevance to the community. This relevance is perceived to be greater if a problem was chosen which has a high priority in the community. Thus, the evaluation of results by a scientist's peers forces him or her to choose problems within their community's consented field.

When the results of collaborative research are to be evaluated, the scientific community provides rules for rewarding the different contributions to a collaboration. In symmetric collaborations involving a division of labour, all partners of a collaboration become co-authors of the ensuing publication. The supply of service is usually rewarded by acknowledgements in publications.

The institutions of both scientific communities and research organisations embrace norms which directly aim to promote collaboration. In scientific communities an informal rule exists that a scientist should provide his or her know-how to other scientists without direct return (the principle of diffuse reciprocity). It is common to answer detailed questions from other scientists during conference breaks, via e-mail, etc. Another example is the support of scientists who visit a lab:

.. now someone comes from the States .. and wants to do measurement here, that means, that somebody - usually the one who mainly uses the equipment - is assigned to show them first of all how it works ... You are happy to do this of course, because you may happen to want to measure somewhere else yourself sometime and then you'll get an introduction there as well.

In a similar manner, some research organisations develop specific rules of collaboration, for instance about the joint usage of special research equipment or rules concerning the supply of service.

Although in the literature trust is regarded as one of the most important prerequisites for collaboration, it played a minor role in our two cases. Scientific communities seem to be one of the cases in which a climate of trust emerges in the process of collaborative work:

Rice growing, fishing, lumbering, and other kinds of agricultural endeavors require collaborative behavior, and over the centuries a climate of trust has developed in the areas where these occupations predominated. (Alter and Hage 1993: 265)

It is likely that in a scientific community a climate of trust develops in a similar manner if and insofar its research requires collaboration. This climate seems to be the cultural expression of the norm of diffuse reciprocity.

Trust may refer to the collaborator's correct behaviour as well as to his or her skills. The latter form of trust proved to be more important for the collaborations investigated by us. It is built up in personal communications which take place at the meetings organised within both scientific communities and organisations. To build trust in potential collaborators is a third effect of institutionalised communication both within scientific communities and research organisations.

Since the prerequisites we described are direct or mediated impacts of institutions, they are given only for collaborations between the social system's members; it is more difficult or even impossible to collaborate with outsiders. Thus, by promoting collaboration within their scope, the institutions make it much easier to collaborate with members of one's own community or institute than with non-members. Taking into account the overlap of the institutions of both social systems, a hierarchy of collaboration difficulty can be assumed (Figure 1). This hierarchy is confirmed to a certain extent by the findings of Blume and Sinclair, who discerned the following "Ranking of Collaborator Localities:

1. Same department
2. Outside United Kingdom
3. Different UK university
4. Industry
5. Different departments of same university or college
6. Government institution
7. Elsewhere." (Blume and Sinclair 1973: 43)

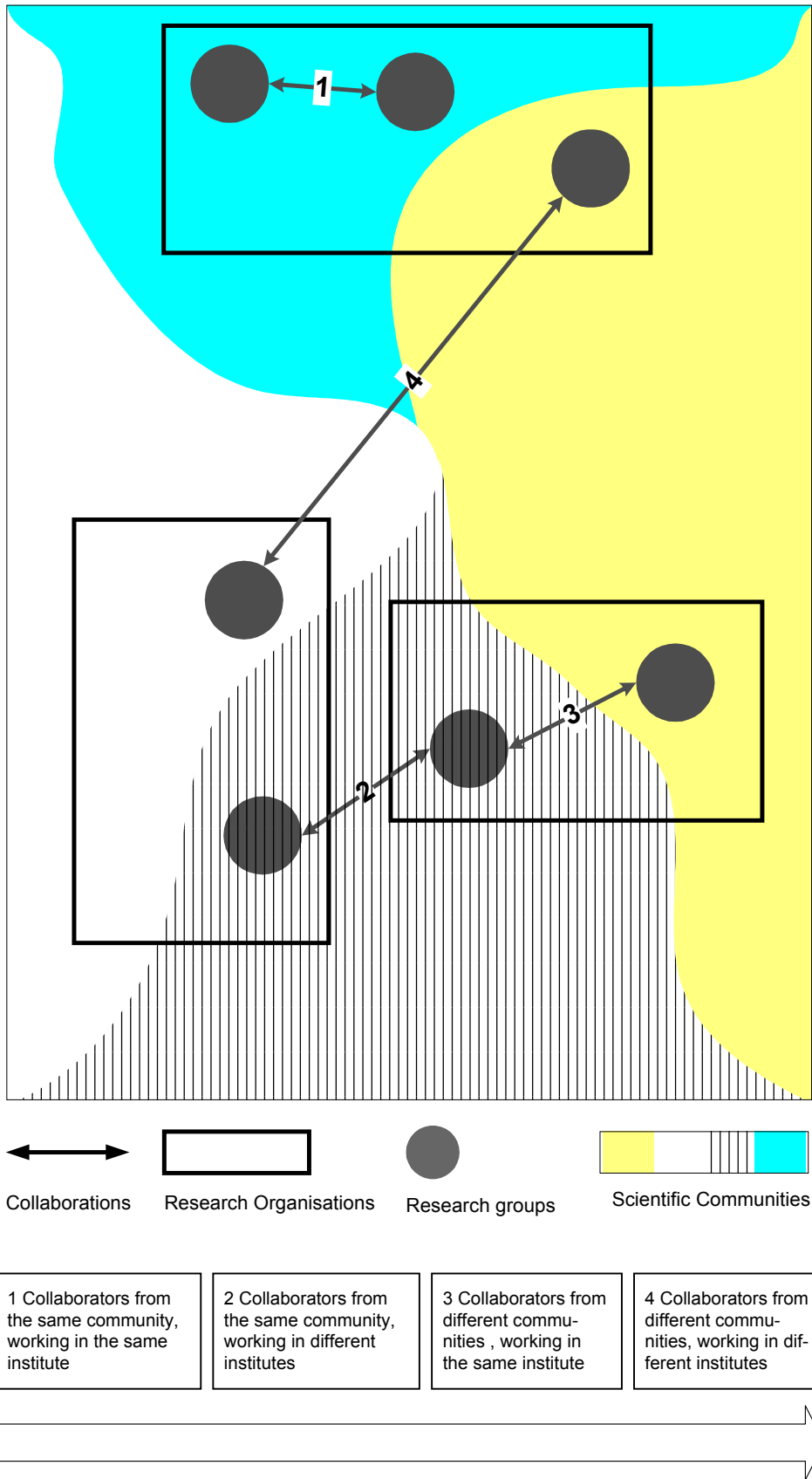


Figure1: Hierarchy of Difficulty for Boundary-Spanning Collaborations

Although it is important, the influence of institutional boundaries is only one of the factors affecting collaborations and its influence may be changed or even overridden by others. This is why boundary-crossing collaborations take place in spite of the hindering effects of institutional boundaries. Since many contemporary research problems can be solved only by means of collaboration with scientists from other communities or organisations, scientists who want to deal with a problem of this type are forced to seek boundary-spanning collaborations and to realise them. Once established, boundary-crossing collaborations tend to be continued because the hindering conditions mentioned above tend to hinder mostly the emergence of collaborations.

Another condition which modifies the effects of institutional boundaries may be rules which are directly designed to govern collaborations with outsiders. The effect of institutional boundaries may be weakened if collaborations with non-members are directly required, as it is the case in a research organisation which offers research facilities for external groups (CERN may serve as an example). In contrast, in the case of industrial R&D, collaborations with outsiders may be directly forbidden.

Summing up our results, we may conclude that institutional boundaries emerge because a social system's institutions promote collaboration only within their scope - which is restricted to the social systems' members. Although collaborations with outsiders are only directly forbidden in special cases, they are usually hindered or even made impossible because the researcher would have to invest far more time and resources in a boundary-spanning collaboration. The nature of institutional boundaries lies in the difference between the institutionally driven support for collaborations between a social system's members, on the one hand, and the lack of any support for collaborations with outsiders, on the other hand.

3. Germany's Collaborative Research Centres (CRCs)

In the beginning of the 1960s German science policymakers perceived that university research had fallen behind the international level in fields requiring interdisciplinary collaboration. The cause for this deficiency was seen in the institutional boundaries existing between research groups, especially between groups belonging to different disciplines.

To overcome the university structures' hindering effects on collaborations, the Deutsche Forschungsgemeinschaft, Germany's most important funding agency for university research projects, established a new funding programme for so-called 'Collaborative Research Centres' (CRCs). A CRC is a network of research groups characterised by a shared research programme

and shared additional resources. It consists of about 10-20 projects. The research groups must be located in the same city (principle of locality - [Ortsprinzip]). They are customarily affiliated to universities. In addition, a few groups from non-university research institutes may take part in the CRC. The CRC receive considerable funding - about 1.5-3.5 million DM per year for 12-15 years. Every three years the quality of the research and collaboration within the CRC are evaluated by referees from the Deutsche Forschungsgemeinschaft.

Because of the large amount of funding and the CRC's long duration, the scientists who want to apply for CRC funding must go through a lengthy elaborate procedure. The initiators of a CRC must design an interdisciplinary scientific programme and find enough research groups prepared to participate in the CRC. The most important difference between CRCs and other forms of programme-oriented funding lies in the fact that the participating scientists must develop the research programme themselves, an activity which is already collaborative in itself and requires interdisciplinary communication. Because of the potential funding, a research group is usually highly interested in joining a CRC. The candidates must, however, prove that there is a common subject matter of research and that collaborations with other CRC groups are possible and will be conducted. In this initial phase, informal negotiations take place with the Deutsche Forschungsgemeinschaft regarding the content of the programme, the quality of the groups applying and the planned collaborations. Advice is given on the formulation of the official application. In some cases, the Deutsche Forschungsgemeinschaft recommends withdrawal from the application procedure.

If the Forschungsgemeinschaft's requirements are met, the initiators submit an official application. This is evaluated by a group of referees covering all fields of the participating research groups. Two additional referees from more remote fields are appointed to the evaluation committee in order to guarantee an equal standard for all CRCs. The evaluation process takes place at the potential new CRC's university and lasts two days. The referees discuss the prior results, the scientific programme, the experimental designs and the planned collaborations with all research groups. Thereafter, the referees decide in a closed group discussion whether the CRC should be funded and whether all research groups should be included. This evaluation is repeated after every three-year funding period. Due to the detailed evaluation procedure, it is impossible for research groups to 'free ride' (receive funds without actually collaborating).

The CRC forms an institutional framework which governs both the collaborations between the research groups and the interactions regarding resource distribution, the evaluations, etc. The

CRC is lead by an assembly of the project heads, which elects a speaker. Procedures must be established for

- the selection of new research groups as CRC members,
- the utilisation of common resources, and for
- the scientific communication in the CRC.

This short description of a CRC shows that a CRC has some of an organisation's features, such as membership, resource allocation and institutions. It is, however, an additional structure which allows the scientists to stay in their traditional social systems and to preserve their autonomy. However, as the CRC becomes the most important link to additional funding, scientists from different organisations and scientific communities volunteer in designing a joint research programme, planning collaborations and institutionalising communication. Thus, the CRC and the links to other scientists it produces become an important additional environment for the research groups.

4. How Does a CRC Change the Conditions of Collaborations ?

Until the CRC programme was established, the research groups we studied collaborated primarily within their research departments and scientific communities and had only few collaborations crossing these boundaries. The development of both CRCs was accompanied by a rapid growth in the number of collaborations and, among them, of boundary-crossing collaborations. The boundary-crossing collaborations increased rapidly after 3 and after 6 years of the existence of the CRC, i.e. with every new funding period (Figure 2 and 3).

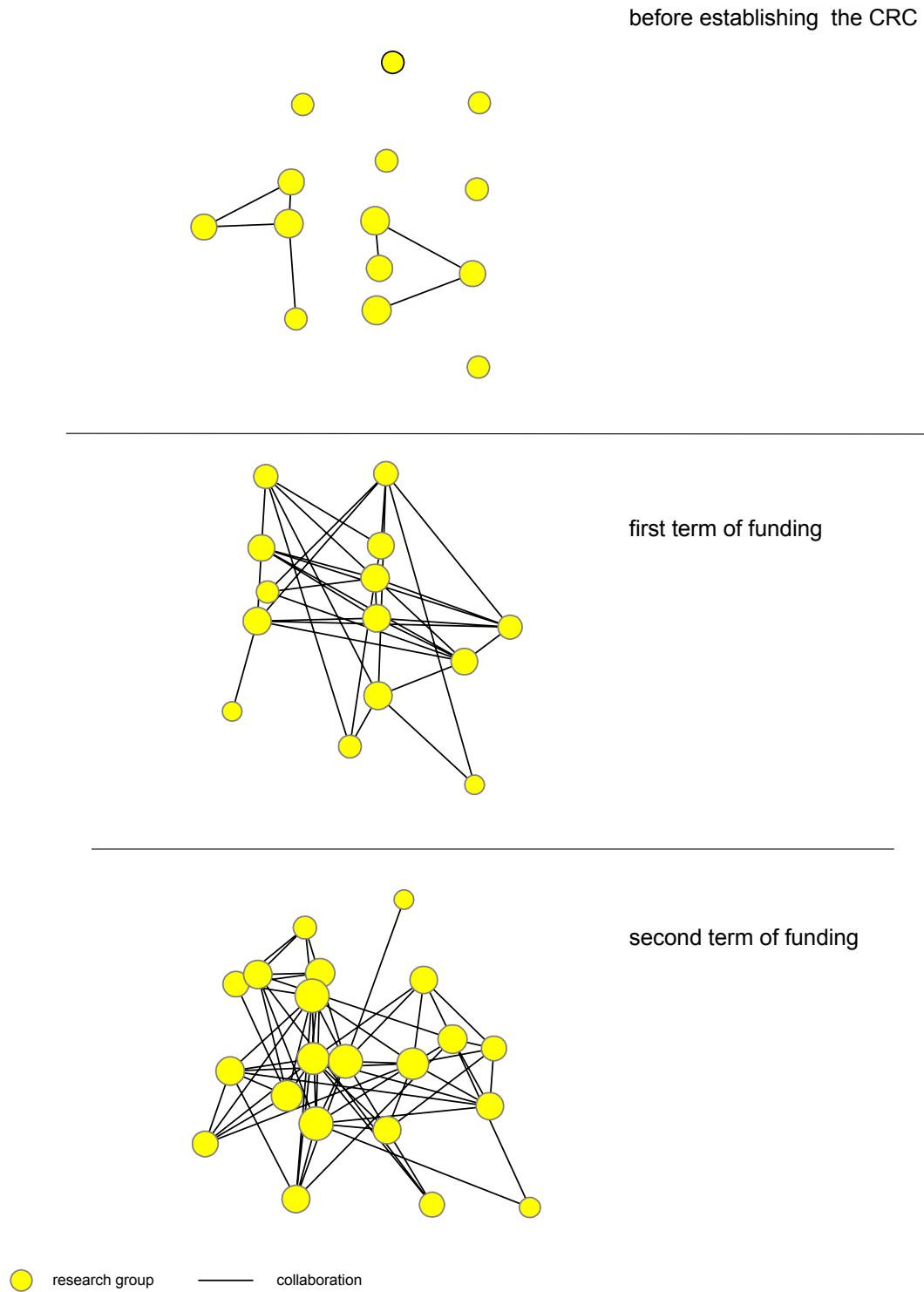


Figure 2 Development of Collaborations in CRC II (Source: Laudel 1998: 184)

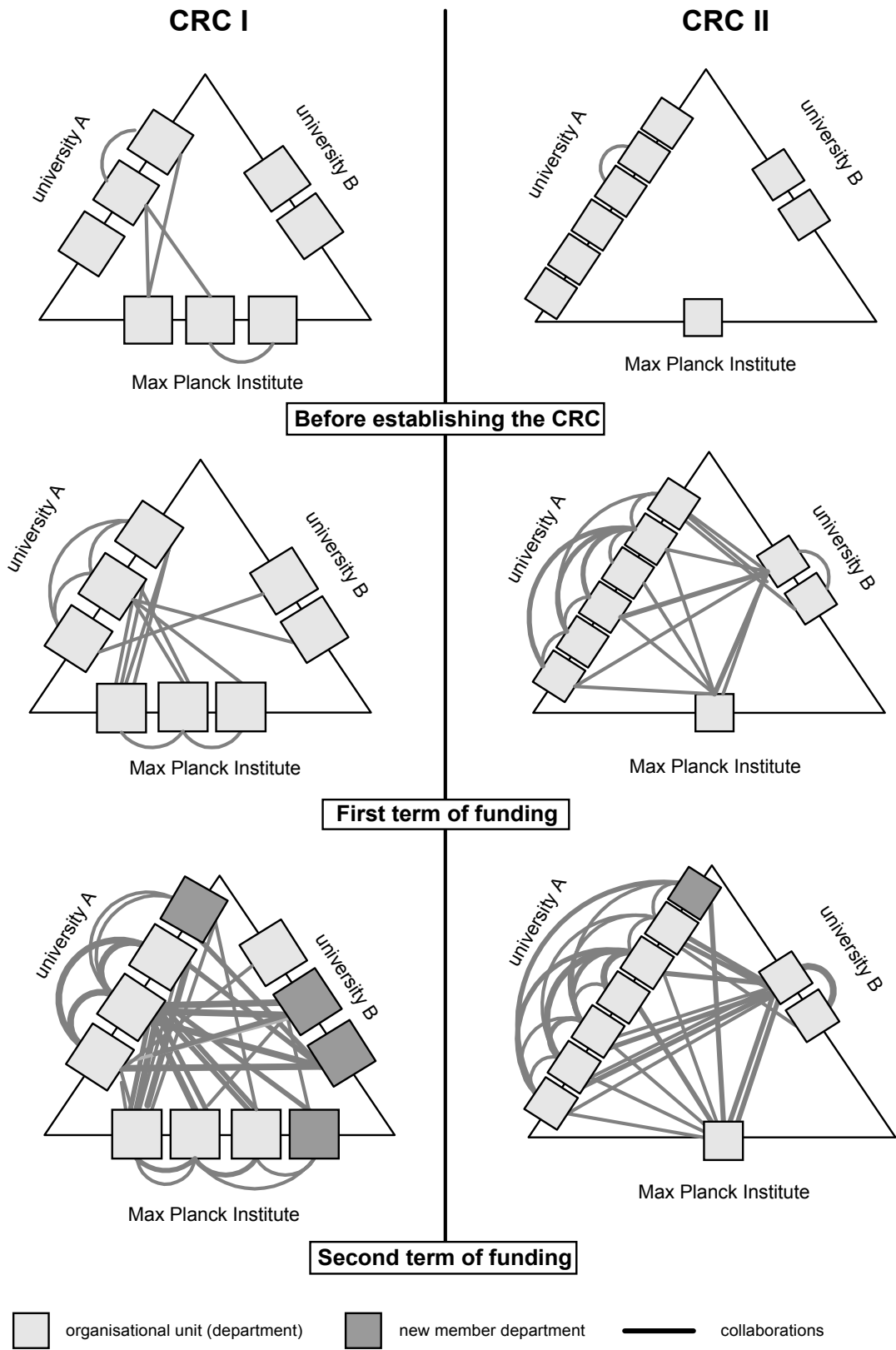


Figure 3 Development of Boundary-Spanning Collaborations in both CRCs (Source: Laudel 1998: 188)

We will now demonstrate how the collaboration networks promote boundary-crossing collaboration.

The CRCs create their own institutional framework, which overlaps the institutions of both the scientific communities and the research organisations. With regard to the necessary conditions for collaboration, the following components of the institutional framework are of special importance (Table 2):

CRC
additional resources: * research personnel * jointly used large equipment
principle of coherence
institutionalisation of communication
norms of collaboration

Table 2: Collaboration Promoting Conditions of a CRC

Resources: The CRC's research groups receive additional resources. Most important are resources for additional research personnel. With these additional scientists, the groups are able to establish new collaborative relationships to the other CRC members without reducing their existing system of collaborations within the scientific community and the research organisation.

It is always the case that you can only work on a project or subject in a collaborative manner if you have somebody in the working group who actually does the work. It is very easy to think out a research task that could be undertaken, it is awfully difficult to then do it if there is no head and no hands to actually realise it ... I have an assistant who does not himself realise the research topics but who is very competent in the method that Mr P.'s assistant needs. This way they can do it together at the bench ... Then it works, but only then, if there are people there, who actually realise such a collaboration.

A second important aspect of the additional funding is the opportunity to receive money for large equipment if it is necessary for various CRC members and to be used jointly. Analogously, special service staff are funded if some CRC projects need time-consuming service.

Unlike the resources provided by a research organisation, the additional resources provided by a CRC not only enable the collaborations to occur, but result in a certain pressure to collaborate. Since the funding depends heavily on a minimum level of collaboration in the CRC, the

opportunity to receive a large amount of resources provides a strong stimulus for all CRC members to seek out possible collaborations with one another.

Coherence: The existence of cognitive links between research processes is guaranteed by the principle of coherence, which plays an important role in the evaluation process. Since it is possible that the funding of the whole CRC or of single projects is refused because of a lack of coherence, the CRC's (future) members themselves select potential partners very carefully. Each member of the CRC must have cognitive links with at least some other members.

Especially in the case of people who primarily contribute a method, it only makes sense to include them in the CRC if they are actually willing to apply their method to a subject dealt with by the CRC. It makes no sense to include a NMR group if it doesn't work with proteins which interact with membranes or phase-interfaces.

Since only groups which have cognitive links to others are included in a CRC, there are good grounds for the emergence of shared goals and interests between the scientists.

Communication: The CRC institutionalises communication in a similar manner to an organisation. Usually, at least one regular colloquium is established which all CRC members are expected to attend. Thus, interdisciplinary communication becomes institutionalised for a time span of 12-15 years. All effects of institutionalised communication in research organisations and scientific communities described above were also observed in CRCs.

It was a direct collaboration ... which would certainly not have been accomplished without the CRC. I had known nothing about him, about his existence and his interest in the problem. I learned this in the talks during such a meeting.

Due to the long existence of a CRC, its members learn to understand the languages of the scientists belonging to other disciplines and thus develop the joint knowledge which is necessary for communication:

At first I was of course shocked to a certain extent ... at the beginning I naturally didn't understand very much of what was going on, I simply didn't understand the vocabulary ... At the start I found it very exhausting, tiring .., difficult, of course, but you get used to it. ... So that it somehow gradually becomes a bit easier. Of course, I've never understood ... the details, but I could at least comprehend what the general objective is and the research questions, approximately, that are being dealt with there.

The institutionalised communication as well as the collaboration in the CRC produce trust in the research skills of the potential collaboration partner.

Norms of Collaboration: The CRC develops a norm of collaboration. According to this norm each research group has to plan collaborations regularly.

When I phone somebody in Basel who is not interested at all then he will not help. Whereas in the CRC, it is expected that you give colleagues the possibility to at least use the equipment there and perhaps also the know-how. Maybe also in the hope that you could somehow use such connections for the next research proposal.

The shared use of research equipment is a very important part of the norm of collaboration, especially in the experimental sciences. The CRC consequently acts as a large laboratory, in which each member is allowed to use each piece of research equipment:

Thus, it means that it's also no problem if you want to do measures, then you basically always have the opportunity within the CRC. X or Y has the equipment needed, then you just call him and ask if you can measure. We did such partial things with many projects.

In addition, a CRC obliges members to help other CRC members by offering services. For example, CRC members produce substances or do measures according to the wishes of other members.

When you approach somebody so to say as stranger it is relatively difficult to get a substance to fiddle around with. But within the CRC it is very simple. ... You got the substance even if it was valuable ...

These services are provided without a guaranteed reward. They take place due to the general expectation that every CRC member receives service if he or she needs it. Thus, a norm of diffuse reciprocity emerges in the CRCs.

The communication between CRC members as well as the norms of collaboration are supported by the 'principle of locality' which is implicit in the funding programme. Since all research groups must be located in the same city, favourable conditions are given for personal communication, joint usage of equipment, supply of service, etc. In other words, spatial barriers for collaborations are excluded by the selection of local research groups.

5. Conclusions

In both social systems important for scientific research - the scientific community and the research organisation - institutions emerge which directly or indirectly promote collaborations between scientists. Since they do this only within the social system, institutional boundaries emerge which are defined by the institutions' scope. These boundaries make it very difficult to collaborate with scientists from other scientific communities or research institutes.

The CRCs overcome the institutional boundaries by producing new institutions whose scope spans the traditional boundaries. The CRC has features of both a scientific community and a research organisation (Table 3). Like a research organisation, it provides the researchers with

resources. The funding's effects on collaborations are even stronger than that of a research organisation because the funding is bound to the purpose of promoting collaborations. Being created on the basis of a shared research interest, a CRC connects scientists whose research is very likely to show cognitive links to that of other members. Moreover, these links are to be purposefully sought in order to receive the funding. The institutionalised communication, as well as the necessity to communicate in the application process, stimulates the development of a shared language. And the long-lasting sequences of collaborative work produce both a norm of diffuse reciprocity and a climate of trust in the other members' skills. The institutional framework, the joint decision-making and the repeated application and evaluation procedure create additional links between the CRC members.

Research organisation	Collaborative Research Centres	Scientific community
provision / allocation of resources		
Coherence of the research processes		
institutionalisation of communication: conferences, etc. <ul style="list-style-type: none"> • perception of cognitive links • development of a shared language • development of trust in the potential collaborator's skills 		
Rules of collaboration: Joint usage of research equipment, supply of service		
	Rules of collaboration: diffuse reciprocity	
		Rules for the distribution of a collaboration's outcome Rules for the reward of collaborative contributions

Table 3 Promotion of Collaboration: Comparison of Research Organisations, Scientific Communities and CRCs

These structures overlap the institutions of both the different scientific communities and research organisations. Their influence is strong because the CRC becomes an important means to receive resources. The CRC produces for its members the conditions which promote collaborations. Since these members belong to different communities and organisations, the institutional boundaries between them become permeable for CRC members.

If the CRC actually overcomes institutional boundaries by producing the collaboration-promoting conditions for all members of the network, the reverse effect - the emergence of a CRC's institutional boundaries - must be observable. This effect was also identified in the empirical investigation: If scientists left the CRC due to appointments in other cities, the collaborations with them declined.

Taking into account all the observed effects, the question of how collaboration networks influence institutional boundaries can be answered as follows: Collaboration networks seem to be one institutional solution for crossing institutional boundaries. They allow the scientists to retain the links to their traditional social systems - the research institute and the scientific community - and simultaneously to establish new links to members of other social systems. The means by which a collaboration network promotes collaborations are the same as the means working in the traditional social systems - scientific communities and research organisations. Due to the collaboration network they were applied to a community of scientists which spans the traditional boundaries.

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