

1-14-2010

# Studying Research Collaboration: A Literature Review

Helena Bukvova

*Technische Universität Dresden*, [helena.bukvova@tu-dresden.de](mailto:helena.bukvova@tu-dresden.de)

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## Recommended Citation

Bukvova, Helena, "Studying Research Collaboration: A Literature Review" (2010). *All Sprouts Content*. 326.  
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## Studying Research Collaboration: A Literature Review

Helena Bukvova  
Technische Universität Dresden, Germany

### Abstract

This working paper offers an annotated bibliography on studies in research collaboration. It identifies different research areas and presents existing research results. The aim of the paper is to provide orientation for researchers interested in approaching this diverse and important research topic.

**Keywords:** research collaboration, scientific collaboration, collaboration, review

**Permanent URL:** <http://sprouts.aisnet.org/10-3>

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**Reference:** Bukvova, H. (2010). "Studying Research Collaboration: A Literature Review," . *Sprouts: Working Papers on Information Systems*, 10(3). <http://sprouts.aisnet.org/10-3>

Collaborative research appears to be growing in popularity. It is also being actively supported by governments and organisation. The decision to perform research with partners instead of individually influences the research process as well as its outcomes. For this reason, research collaborations have been explored and discussed by many authors. In this paper, I attempt to systematize the different research areas related to research collaborations. I do not mean to pursue the different research issues, but rather offer an annotated bibliography. Through this working paper, I wish to provide orientation help for researchers interested in approaching this diverse and important research topic.

I begin with reviewing the literature for a definition of the term ‘research collaboration’ (see Section 1). In this section, I also present literature about the development of research collaborations. In Section 2, I show the problems with measuring research collaborations. Section 3, offers an overview of potentials of research collaborations, attempting to answer the question “Why do researchers collaborate?”. In Section 4, I present explanatory approaches to research collaborations. Finally, Section 5 is a brief introduction to the issues of supporting research collaborations with Information and Communication Technologies (ICT).

## 1 What is it?

Research collaboration has been a subject to a considerable research effort. The existing research has not only focused on different facets of research collaboration, but also considered research collaboration in a variety of contexts. As a result, a common definition of the term does not exist (Hu & Racherla, 2008). The definition of the term is often based on the understanding of ‘collaboration’. Amabile et al. (2001, p. 419) describe collaboration as “individuals who differ in notable ways sharing information and working toward a particular purpose”, citing in particular the definition by Jassawalla and Sashittal (1998, p. 239): “the coming together of diverse interests and people to achieve a common purpose via interactions, information sharing, and coordination of activities”. Melin and Persson (1996, p. 363) have a similar understanding of collaboration. They further point out the importance of communication as well as “sharing of competences and resources”. Sonnenwald (2007, p. 645-646) stresses the social context of research collaborations and its place within the scientific community. She argues, that besides the superordinate goal of the collaboration, the partners can also bring their individual goals.

‘Research collaboration’ is seen as special form of collaboration, undertaken for the purpose of research, where ‘research’ is implicitly seen as scientific research (Amabile

et al., 2001, pp. 419, Katz & Martin, 1997, p. 7). Amabile et al. (2001, p. 419) suggest three dimensions, that can be used to describe research collaboration: (1) the profession of the participants, (2) the institutional affiliation, and (3) the organisational level of the collaboration. Sonnenwald (2007, pp. 645-649) further adds (4) the disciplinary focus and (5) the geographical focus. Viewing these dimensions, a research collaboration has to include some academic researchers, although non-scientists can also be included (cross-profession collaborations, e.g. Amabile et al., 2001; Mathiassen, 2002; Manjarrés-Henríquez, Gutiérrez-Gracia, Carrión-García, & Vega-Jurado, 2009; Baba, Shichijo, & Sedita, 2009). A research collaboration can take place between individuals from the same institutions as well as among individuals from different institutions, even from a different country. It can also connect different disciplines. There has been some debate, about the organisational level of collaboration. Some authors see collaboration as purely individual matter, others discuss research collaborations on departmental or institutional level (compare Hu & Racherla, 2008, p. 304; Stokols, Misra, Moser, Hall, & Taylor, 2008, pp. 97-99).

Although the term ‘research collaboration’ is not clearly defined, there is a consensus about the growing importance of collaborative research (compare Wray, 2006). There has been a number of studies exploring the development of research collaborations (e.g. Grossman, 2002; Leydesdorff & Wagner, 2008; Luukkonen, Persson, & Sivertsen, 1992). Here, the research collaboration is mainly operationlised using co-authorship and sometimes also acknowledgements (see Section 2). According to these studies, the number of co-authored papers has been rising steadily, although there are considerable differences among disciplines (Cronin, Shaw, & La Barre, 2004, 2003; Newman, 2004). Furthermore, the number of international co-authorships is also growing (Georghiou, 1998; C. S. Wagner & Leydesdorff, 2005), though the level of collaboration is not the same in all countries (Leydesdorff & Wagner, 2008). Due to the this development, collaborative research has been of interest to a number of authors, who try to explain the mechanisms behind it (see Section 4).

Many studies in the area of ‘research collaboration’ have been concerned with the measurement of the development (see Section 2) as well as with the explanation of the growth. In Section 3, I review the advantages as well as disadvantages of research collaboration for the individual scientists. Besides considering the micro level, several authors have tried to explain the growth on the macro level. C. Wagner and Leydesdorff (2005, p. 1609) summarize literature on this topic and distinguish between factors relating to the diffusion of scientific capacity and factors relating to the interconnect-edness of scientists. C. Wagner and Leydesdorff themselves suggest, that the scientific community is a self-organising system, where selection of partners and research location depend on the individual choices of the researchers.

## 2 How can it be measured?

There has been a debate concerning correct operationalisation of research collaboration (Melin & Persson, 1996; Katz & Martin, 1997; Laudel, 2002). The most common measures are based on co-authorship (Savanur & Srikanth, 2009). As publication of research results is seen as a necessary part of the research process (Bukvova, 2009; Kraut, Galegher, & Egidio, 1987), articles published by multiple authors are seen as a measurable output of research collaboration. However, not every research collaboration will necessarily lead to a publication and not all co-authored papers are results of a collaborative research process. Furthermore, not all collaborators have to appear as co-authors. There are different levels of collaboration and not all levels are believed to merit a co-authorship of the resulting publication (for a detailed discussion of the different collaboration levels and their mention in publications see Laudel, 2002). In addition to co-authorship, sub-authorship (i.e. a mention in the acknowledgements) has been also suggested as a measure (Cronin et al., 2003, 2004). Besides the analysis of metrics, research collaborations have also been explored as networks. These analyses use data about co-authorship to create graphs depicting the network formed by the researchers (e.g. Grossman, 2002; Hou, Kretschmer, & Liu, 2008; C. Wagner & Leydesdorff, 2005; Newman, 2004).

## 3 What are the potentials and risks?

The quick growth of research collaboration necessarily leads to inquiries about the reasons for collaboration. Table 3 offers an overview of the potentials, that collaboration has for individual researchers.

Table 1: Potentials of research collaboration

Potentials	Source
Access to expertise	Katz & Martin, 1997; Melin, 2000
Access to resources	Melin, 2000; Beaver, 2001; Heinze & Kuhlmann, 2008; Vanrijnsoever, Hessels, & Vandeberg, 2008; Sonnenwald, 2007
Exchange of ideas, esp. across disciplines	Beaver & Rosen, 1978, 1979b, 1979a; Katz & Martin, 1997; Melin, 2000; Heinze & Kuhlmann, 2008; Birnholtz, 2007
Pooling expertise for complex problems	Beaver, 2001; Birnholtz, 2007; Sonnenwald, 2007

Keeping own activities focused	Heinze & Kuhlmann, 2008
Learning new skills	Heinze & Kuhlmann, 2008; C. S. Wagner, Brahmakulam, Jackson, Wong, & Yoda, 2001
Higher productivity	Beaver, 2001 (compare results of S. Lee & Bozeman, 2005; Sooryamoorthy & Shrum, 2007)
Higher quality of results	Rigby & Edler, 2005
Access to funding	Beaver, 2001; Heinze & Kuhlmann, 2008
Prestige	Beaver & Rosen, 1978, 1979b, 1979a; Katz & Martin, 1997; Vanrijnsoever et al., 2008
Political factors	Sonnenwald, 2007
Personal factors	Sonnenwald, 2007
Fun and pleasure	Katz & Martin, 1997; Melin, 2000; Beaver, 2001

There are, however, not only positive effects of collaboration. Wray (2006) argues, that research collaboration can lead to problems with assigning credit to the participants, particularly for scientific publications. Scientific credit is the main currency in the careers of academic researchers (Heinze & Kuhlmann, 2008). Tension caused by uncertainties about credit can have adverse effect on the researchers' motivation. Furthermore, it is often unclear, who has responsibility for the results of a collaboration. The resulting limitation of accountability for mistakes can lead to lower quality of research finding (Wray, 2006). Cummings and Kiesler (2007) further point to the high costs of coordination, particularly in large inter-institutional or even international collaborations (see also Stokols et al., 2008).

## 4 What are the mechanisms behind it?

A number of studies have aimed to achieve better understanding of the mechanisms behind research collaborations. In the following, I distinguish three efforts with regard to this aim: (1) the search for influence factors in research collaborations, (2) the development of models and frameworks, and (3) the development of collaborator typologies.

## Influence factors

Many authors have discussed factors that influence research collaboration. In this section, I present an overview of such factors. I divide them into internal influence factors, which can be utilised by researchers participating in a collaborative project (see Table 4), and external influence factors, which are of interest to decision makers attempting to support collaboration (see Table 4). Whereas the tables in this section simply list the factors that can influence collaboration success, in the following section I present complex models attempting to explain the interaction of such factors.

Table 2: Internal influence factors

Influence factors	Source
Issues of quality	Birnholtz (2007) finds a positive influence of agreement on quality and collaboration propensity.
Issues of credit	Stokols et al. Birnholtz (2008, pp. 101-102) discuss the importance of reward, particularly group-reward for collaboration. In research, scientific credit in publications is among most important rewards. However, Birnholtz (2007) did not find evidence, that previous agreement on assignment of credit influences the collaboration propensity.
Coordination	Cummings and Kiesler (2007) show that engagement in coordination activities predict the project outcomes. Coordination is particularly important for geographically dispersed projects (Stokols et al., 2008, pp. 102-103). Coordination problems intensify depending on the size of the team, distance, interdependence and scientific competition (Walsh & Maloney, 2007).
Preparation	Preparation of the collaborative project particularly the goal-alignment are important for the success of the collaboration (Stokols et al., 2008).
Communication	Communication plays a crucial role for the team success (for a review see Stokols et al., 2008, p. 101)
Awareness	Carroll, Rosson, Farooq, and Xiao (2009) point to the importance of awareness.
Dealing with differences	Jeffrey (2003) explores conflicts caused by different backgrounds and perspectives and suggests steps for dealing with differences. Bammer (2008, pp. 876-880) supports this argument and presents strategies to harness differences.

Familiarity of team members	Increased familiarity of team members apparently leads to higher productivity. However familiarity seems to have a negative effect on the long-term team performance. (see Stokols et al., 2008, pp. 99-100 for a review).
Leadership	A number of studies have tried to identify characteristics and patterns of successful leaders (for a review see Stokols et al., 2008, pp. 100-101)
Personal characteristics	Stokols et al. (2008, pp. 106-107) stress the importance of personal characteristics for successful collaboration. They describe personalities particularly suited for collaborative work.
Setting boundaries	Bammer (2008, pp. 876, 881-883) points out that in case of complex problems researchers have to set boundaries to their aims. This is important for the project success, but it can be also limiting.
Legitimate authorisation	Large and complex project require support from a range of stakeholders. Bammer (2008, pp. 876, 883-886) present steps to identify and address relevant stakeholders.

The influence factors of research collaborations are of interest not only to the involved researchers, but also to institutions. With view to the advantages collected in Table 3, many institutions and organisations try to encourage collaboration, for example by founding research centres or offering funding for collaborative research (Sonnenwald, 2007). These are therefore interested in external success factors, that can positively influence research collaborations (compare C. Wagner & Leydesdorff, 2005, who believe that scientific community is a self-organising system, not influenced by external factors). The existing research on this topic identifies and describes a number of such factors. Table 4 offers a summary of the findings.

Table 3: External influence factors

Influence factors	Source
Academic culture	Sorensen (2003) describes the influence of national and institutional culture on collaboration (also compare Ponomariov, 2008). Birnholtz (2007) finds a lesser influence of this factor.
Funding	Defazio, Lockett, and Wright (2009) find that funding influences more the research productivity than research collaboration.



Group size	There are different results as to the effect of team size on the team performance. Furthermore, optimal group size will depend on the teams goals and context. (Rigby, 2009; Stokols et al., 2008)
Resources	According to Birnholtz (2007), the perceived level of resource concentration has a positive influence on collaboration.
Institutional support	The availability of help positively influences research propensity (Birnholtz, 2007; Amabile et al., 2001; Sargent & Waters, 2004).
Level of institutionalisation	Corley, Boardman, and Bozeman (2006) see the need for the institutionalisation of large-scale, multinter-discipline, inter-institutional collaborations.
Existence of research centres	Boardman and Corley (2008) find that the affiliation to research centre has positive influence on the individuals' readiness to collaborate.
National vs. international collaborations	Apparently, national and international collaborations produce results of comparable quality, although international collaborations have positive influence on future output of the collaborators (He, Geng, & Hunt, 2009, compare also Walsh & Maloney, 2007).

To systematise the external factors, Heinze and Kuhlmann (2008) use a framework, called governance cube, for structuring institutional influence dimensions. The governance cube has three dimensions, (1) organisational dimension, (2) resource endowment and (3) thematic interdependence, that are further subdivided. The factors from Table 4 can be arranged according to the governance cube.

## Models and frameworks

Whereas some authors focus on the study of particular influence factors, others develop complex models and frameworks. Amabile et al. (2001) explore the success factors in academic-practitioner collaboration. They consider three determinants of research collaboration: collaborative team characteristics, collaboration environment characteristics, and collaboration processes. Collaborative team characteristics of particular importance appear to be (1) project-relevant skill and knowledge, (2) collaboration skill, (3) attitudes and motivation, and (4) compatibility of problem-solving styles. Collaboration environment characteristics are particularly influenced by the support

of the organisation to the individual team-members. Finally, the effective use of member capabilities and frequent, well planned meetings are essential for the collaboration process. Based on the findings by Amabile et al. (2001), Sargent and Waters (2004) develop a framework for academic research collaboration. Their framework considers dimensions: the collaboration process, the interpersonal processes within the team, and the contextual factors. The collaboration process is iterative and has four phases: (1) initiation, (2) clarification, (3) implementation, and (4) completion. Additionally, there are interpersonal processes in every team, concerned with management and social issues. The team and the collaboration are influenced by the context including national and institutional climate, the institutional support and available resources. Another model is presented by Stokols, Harvey, Gress, Fuqua, and Phillips (2005). They develop a conceptual framework to enable better analysis of research collaborations. The framework considers three areas: (1) antecedent conditions (intrapersonal, social, physical environmental, organizational, and institutional), that influence the researchers' readiness to collaborate; (2) intervening processes (behavioural, affective, interpersonal, and intellectual), that are active throughout the collaboration and that contribute to (3) research products and outcomes (novel ideas, integrative models, new training programs, institutional changes, and innovative policies).

Some focus on the process character of research collaborations. Kraut et al. (1987) identify and describe three stages of research collaboration: (1) the initiation stage, in which the collaboration partners get acquainted and establish a work agenda, (2) the execution phase, in which the actual research work is carried out, and (3) the public presentation, which serves the documentation and publication of research results. Based on Kraut et al., Sonnenwald (2007) introduces four collaboration phases: (1) the foundation phase, a "prehistory" in which the researchers decide their views on collaboration, (2) the formulation phase, in which the researchers come together to prepare and plan the research work, (3) sustainment phase, in which the collaboration has to be maintained to reach the set goals, and (4) the conclusion stage, in which the results can be realised and disseminated. Unlike Kraut et al. and Sonnenwald, Söldner, Haller, Bullinger, and Möslin (2009) do not develop a new model for a collaborative research process, but discuss collaboration based on the general individual research process by Graziano and Raulin (2009). However, throughout their analysis, they found this process model insufficient to explain the functions of collaborative research. The main problem is the missing consideration of coordination functions (see Cummings & Kiesler, 2007, about the importance of coordination activities).

## Collaborator typologies

The roles of the collaboration partners influence the process and the results of research collaboration. Bozeman and Corley (2004) suggest a typology grounded on how researchers select their collaboration partners. Their study reveals five collaborator types: (1) the taskmasters, who select their partners based on their reliability and work ethics, (2) the nationalists, who choose collaborators fluent in their own language and of the same nationality, (3) the mentors, who collaborate to support junior colleagues or students, (4) the followers, who choose collaborators with strong reputation, (5) the buddies, who prefer partners that they have worked with before and that are fun to work with, and (6) tacticians, who select partners with skills compatible to their own.

Price and Gürsey (1975) have developed a typology of collaborative authors based on their publication patterns. They distinguish four collaborator types: (1) newcomers, who just started publishing collaborative papers, (2) transients, who publish only a few collaborative papers and then move out, (3) continuants, who publish co-authored papers over long periods of time, and (4) terminants, who just stopped publishing collaboratively. Braun, Glänzel, and Schubert (2001) used this typology to analyse publications in neuroscience. According to their findings, the continuant co-authors are responsible for the majority of co-authored publications. Furthermore, continuants appear to prefer co-authored publishing over single publications. Braun et al. also found evidence, that continuants mediate research collaboration among the other three categories.

Laudel (2002, 2001) develops a typology with six collaboration categories. These categories also mirror the different roles of research partners: (1) collaborations involving a division of labour, in which the collaborators share a common goal and divide the creative labour among them, (2) service collaboration, in which one partner sets the goal and performs the creative labour, whereas the other partners perform routine work, (3) transmission of know-how, typically when a researcher requires help of a colleague, (4) provision of access to research equipment, (5) mutual simulation, involving a free exchange of ideas without focus on a particular goal, and (6) trusted assessorship, when colleagues act as accepted and friendly critics in the publication process.

## 5 Supporting research collaboration with ICT

Scientific research projects are often costly and complex. Researchers have therefore been interested in harnessing the potentials of ICT to support them (Jankowski, 2007).

Many authors have studied the possibilities of supporting the research collaborations with ICT (Sonnenwald, 2007). For geographically dispersed collaborations, the use of ICT can act as an enabler (Stokols et al., 2008, p. 102). E. Lee, McDonald, Anderson, and Tarczyhornoch (2009) review the development of laboratories, which they define as “laboratories without walls’ where researchers can perform their research independent of time and location” (compare Stokols et al., 2008, p. 102). (E. Lee et al., 2009) identify a set of relevant laboratory concepts. These include communication, common workplace, data sharing and management. They also name concepts particularly relevant for biomedicine, environmental factors, and continuous collaboration support. Bos et al. (2008) also review the literature on laboratories and develop a taxonomy of laboratory types.

Carroll et al. (2009) discuss the issues of awareness and its role in collaboration. They show, that ICT offers new potential in this area. This is especially true for research, because the research community is often connected by weak and latent ties (Genoni, Merrick, & Willson, 2005; Farooq, Ganoë, Carroll, & Giles, 2007). Similar issues are raised by Walsh and Maloney (2002), who study the influence of e-mail on the scientific community. They also note the potentially greater awareness, particularly in geographically dispersed teams.

Recently, the potentials of Web 2.0 technologies and Social Software for research, particularly research collaborations have been discussed. Kalb, Bukvova, and Schoop (2009) discuss potentials of such applications based on the research process by Söldner et al. (2009). Rinaldi (2009) paints briefly the potential of Wikinomics for science. Sauer et al. (2005) view the potentials of Blogs and Wikis in research groups (see also Ebner & Maurer, 2009).

Despite the dynamic development of ICT, there are still considerable barriers regarding the use of ICT in research collaborations. Firstly, the coordination of the research groups as well as the research itself place high demand on the technology (Stokols et al., 2008, p. 102). Research project relying heavily on ICT also require a high level of technology readiness from the participating researchers (Olson & Olson, 2000). Furthermore, although the use of ICT enables collaborations, which would not have been possible otherwise, it also changes the collaborative environment of the partners. Particularly with regard to communication the participating researchers will have to adapt to new settings (Stokols et al., 2008, pp. 102-104). The environmental settings are also likely to influence other factors like the building of trust and common ground (Stokols et al., 2008; Carroll et al., 2009; Olson & Olson, 2000; Birnholtz & Horn, 2007).

## 6 Conclusions

My aim in this working paper was to present and outline different research areas concerned with collaboration in (academic) research. Based on my literature review I have identified following areas:

**Terminology.** The terminology of this area has been discussed by several authors. There are however still misunderstandings. Connected to this topic is also the question of classification of research collaborations.

**Research.** The exploration, particularly the operationalisation of research collaborations has been much discussed. Some researchers use different measures of co-authorship as an indicator for collaboration. Others call for the use of qualitative methods.

**Development.** Based on their operationalisation of research collaborations, many authors try to describe and understand the development of collaborative research.

**Incentives.** Researchers exploring the development of research collaborations noted a general rise in collaborative research. This necessarily poses a question as to the reasons for collaboration.

**Explanation.** A number of authors present models, processes and typologies to provide a better understanding of mechanisms behind research collaborations.

**Potentials of ICT.** The execution and coordination of collaborative research requires a great effort. Many papers discuss the possibilities of supporting research collaborations with ICT.

All of these fields have been addressed in different manner by a number of authors. However, they all still offer challenges and open questions. Further studies in the area of research collaboration are necessary in order to fully understand and utilise the advantages of research collaborations, but also to avoid its risks.

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