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University Research Management: An Exploratory Literature Review[1]

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Abstract: Professional management is increasingly important for successful research at universities as well as other organizations. This exploratory review draws on different bodies of literature in order to reformulate the complex challenges of research management by applying newer organizational theory. Research management can be described as boundary work that produces couplings between science and the wider society. Because of the complexity of organized science, management is increasingly indispensable to ensure the social, cognitive, and material preconditions of research. This paper discusses different means of research management on the research group level and within university departments. Research organizations are characterized by their relative diffuse distribution of management functions over organizational levels as well as by little direct determination between organizational elements. Charismatic scientific leaders can enhance the efficiency of research organizations and projects. More recently, universities have started to create new management positions within projects and centers. Scientifically trained people are hired as specialists in research management, constituting a new professional role. In contrast to pure administration, the new research managers make decisions with reference to scientific knowledge and the societal environment of research.

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1 Introduction

Professional management is increasingly important for successful research at the university. Far-reaching institutional changes within German universities that have been amplified by the Initiative of Excellence (Exzellenzinitiative) are only one case in point (Hornbostel et al. 2008; Sondermann et al. 2008). This government funded program supports the establishment of large, internationally competitive research clusters, called Centers of Excellence, within leading universities. Similar tendencies towards research centers can be observed in many countries (Hackett 1990: 252; Katz and Martin 1995; Corley 2005). In fields relying on expansive technology and interdisciplinary cooperation, organized collaborations have advantages over independent university groups led by single professors. Some authors observed growing similarities or isomorphism among non-university institutes, industry laboratories, and the university. While the autonomy of scientists within industrial and large-scale research organizations has been growing—e.g. to attract outstanding scientists and to create an optimal context for creativity—the availability of organizational resources has become an important factor in university research (Hurley 1997; Powell and Owen-Smith 1998; Mirowski and van Horn 2005; Furukawa and Goto 2005). Large collaborative projects and the commercialization of research in many disciplines reveal this tendency (Gulbrandsen and Smeby 2005). It is not surprising then, that many authors choose resource-centered approaches towards organizations when studying research management (Slaughter and Leslie 1997; for an overview over the concept see Barney 2001).

The accumulation of financial, cognitive, and instrumental resources in research collaboration allows a higher degree of labor division. This is true and well-studied for interdisciplinary collaborations (Klein 1996; Shrum and Genuth 2001; Röbbecke et al. 2004); much less studied is the emergence of new professional roles within research organizations. It was shown that the employment of technicians (Barley and Bechky 1994), engineers, and research managers can improve the performance of research collaborations (Walton et al. 1986). In bigger cooperation projects crossing organizational boundaries, disciplinary and functional division of labor seems to be inevitable. Hence, systematic planning (Glueck und Deich 1972), a higher degree of formalization (Shrum et al. 2001; Chompalov et al. 2002), and the definition of interfaces for data and technology sharing (Kwa 2006), theory connection, and stakeholder participation all need to be negotiated. The goal of this paper is a structured but far from complete review of literature on research management.

I prefer the term management to "governance." However, the governance approach captures important dimensions of the same topic. Research management is not carried out by a single power or principal at the top of the research system and by its agents within a clearly structured hierarchy. It is instead distributed to a large number of more or less independent actors dispersed over different levels of hierarchy, the political system, and within research organizations (Mayntz and Scharpf 1995: 16; Jansen 2007; Benz 2007). The governance approach, originating in political theory, focuses on the emergence of binding rules through formal organization, institutionalization, and shared norms and values. In contrast, I will focus on management as a process of *decision-making* vested in specific organizational and cognitive contexts. Research management refers to the day-to-day activity in which the complex and permanently changing institutional environment of scientific work has to be taken into account in order to make research possible. It is characterized by competition and collaboration of actors who have different, sometimes conflicting goals and varying access to organizational resources, power, and assets.

Sometimes "research management" seems to be just a new label for positions within the university administration. In many other cases, new roles are emerging in which heterogeneous skills

converge that are essential for successful research (Hockey and Allen-Collinson 2009). The necessity to manage research stems from at least three interconnected developments. *First*, an increasing number of research organizations compete for scarce resources provided by governments or by the private sector (Shrum et al. 2001: 683; Slaughter and Leslie 1997). *Second*, the complexity of many scientific problems require inter- or transdisciplinary collaborations within or between research institutes and often non-scientific organizations (NAS et al. 2005; Kwa 2006). *Third*, many fields depend on expensive infrastructures, facilities, and instrumentation such as particle accelerators, genome sequencers, airplanes, super computers, or even satellites that require government support as well as interorganizational collaboration.

The increasing demand for societal support of research has had created new opportunities for politicians to pursue non-scientific social agendas through science policy (Simpson 2004: 253). Funding decisions are increasingly coupled with external, non-scientific goals such as international competitiveness, usability, or the solution of urgent social problems (Remington 1988; Hellström and Jacob 2005). A large amount of research money is even distributed outside the scientific peer-review processes (Powell and Owen-Smith 1998: 267) or through procedures of extended review involving stakeholders from industry, policy makers, or lay people from civil society (Nowotny et al. 2001). Scientists need to take these new external influences on research goals and evaluation into consideration and design projects accordingly. Lobbying science policy and convincing political actors about the importance of certain research lines has been a challenge for scientists since extensive government funding began (Mulkay 1976; Hart and Victor 1993). In a common analytic framework, authors differentiated three levels of the research system: a policy level, a strategic level, and a performing or operational level (OECD 1991; Rip and Van der Meulen 1998; Morris 2002).

Along these lines, many authors described various phenomena when using the term ‘research management.’ The majority focused on the management of national R&D systems. Despite setbacks of the planning approach toward scientific development in the 1970s, politicians and university leaders developed new managerial approaches to higher education (Slaughter and Leslie 1997; Simpson 2004). In contrast to older large-scale research strategies working toward the development of specific technologies, newer programs often require scientists themselves to justify the usefulness of their endeavors. In addition, politicians frequently assume that useful research could find support outside government programs. Without doubt, basic research programs are still in place, though they may have shrunk relatively compared to applied and problem-oriented research. Nevertheless increasing collaboration with firms and external stakeholders is not just an empirical observation (Nowotny et al. 2001) but a political objective. Discursive concepts such as ‘transdisciplinarity,’ ‘relevance,’ or ‘competitiveness’ refer to new research goals. The management of strategic collaborations provides a way to achieve them (Hellström and Jacob 2005).

A *second* form of research management can be found on the level of funding agencies. Program mangers do not only translate societal problems in research opportunities, but they are also mediators who observe scientific development closely and try to relate new research areas to political agendas. In fields that are highly dependent on one or a few agencies, program managers can influence scientific dynamics by promoting and facilitating scientific choices sometimes even on an international level (Kwa 2006). Examples are NASA managers in climate research and geophysics (Lambright 2005) or the influence of the National Institute of Health (NIH) on medical research. In Europe, similar roles are emerging; however, European program managers are rarely as influential as are those in the US (for the increasing role of funding agencies in the cognitive development of science, see Braun 1998).

A *third* level of management is the administration of research organizations, e.g. the university or higher education consortia (Beerkens and Derwende 2007). Due to changing policies, university administrations have tended to promote managerial control similar to business organizations (Buchbinder and Newson 1988; Slaughter and Leslie 1997), sometimes called New Public Management (Ylijoki 2003:330) or New Managerialism (Deem 2006). They are characterized by formalized routines of controlling and evaluating to improve productivity and increase the accountability of researchers for the use of resources and the outcome of research activities. In academic capitalism (Slaughter and Leslie 1997), funding is considered an investment that should produce returns and generate income for the university. The attention of university leaders shifted from the orchestration of autonomous research toward measurable outputs (Simpson 2004; Jacob 2001). Many universities prioritize more productive areas and distribute internal funding accordingly (Taylor 2006). In many cases, allegedly marginal departments were closed down entirely.

I will focus primary on a *fourth* level, on project management in research groups, research clusters, centers, and the department where research work is actually done and where decisions are made with reference to the societal environment of research as well as to the cognitive dynamics of a scientific field. How do university researchers cope with the changing societal environment and institutional reforms? While answering this question, the three management levels introduced above cannot be neglected. They are an integral part of the environment of university research and they shape the work conditions, the opportunity structure, and constraints—sometimes in the intended direction, sometimes with surprising outcomes.

The review has the following structure. In the next, *second* section; I explore the external reasons for the emergence of new forms of management at the university. In the *third* section, I outline internal organizational problems that need to be managed. In the *fourth* section, I sketch some approaches of modern organizational theory that influenced the thinking about organized research, especially in relation to the production of knowledge. In the *fifth* section, I discuss goals and means of research management within research groups, in collaborations between groups and organizations, and at departments and centers. In the *sixth* section, I ask how different management functions are distributed to new roles and positions within research organizations and whether a professionalization of research management can be observed. In the *seventh*, concluding section, I present some questions for further research.

2 Research management at the boundaries of science and society

Research management can be described as work at organizational boundaries as well as at the boundaries of science and society which are increasingly complex and blurry (Whitchurch 2006). The term ‘boundary work’ was originally introduced to replace the logical criterion of demarcation of scientific and non-scientific propositions (Popper 1994, first published in 1935). In the social studies of science, it was suggested that scientists actively draw the boundaries between science and other parts of society and maintain them strategically through their actions and highly specialized discourses (Gieryn 1983; Guston 1999). An important part of boundary work ensures the societal support and resources necessary for the continuation of the increasingly costly scientific endeavor. Boundary work does not mean segregation; it is rather a constant attempt to maintain control over the complex relationships of research with its societal environment. Because of the enormous need for resources and the growing complexity of the institutional environment, the orchestration of research projects is very labor-intensive. One effect is the emergence of specialized boundary organizations that bridge science and the application of scientific knowledge (Jasanoff 1990; Guston 2001; Hellström and Jacob 2003). Notable examples are technology

transfer or industry relationship offices at universities (Fisher and Atkinson-Grosjean 2002), user boards, or organizations that transform scientific knowledge in expertise for policy-makers (e.g. the Intergovernmental Panel for Climate Change, Miller 2001).

By shifting the attention from the level of explicitly stated organizational goals to the day-to-day operations, I suggest a more general meaning of 'boundary organization.' All research organizations can be considered boundary organizations in the sense that they regulate the relationship between science and society. Within organizations, it is much easier to mobilize resources for research. In fact, advanced research is virtually impossible outside formal organizations. They provide legal frameworks and legitimization; scientists are hired and paid by organizations and they benefit from organizational prestige. In short, organizations reduce the complexity with which researchers have to cope. This is also true for science; members of an organization surrender some of their freedom (e.g. control over time) to gain very specific advantages resulting from a complex division of labor (Fujimura 1987).

Of course, scientists have been, consciously or not, always engaged in boundary work. In the laboratory, they need to translate raw data, experimental, or field notes, and new ideas in a theory-guided form that would fulfill the norms of scientific communication (Latour and Woolgar 1986; Knorr-Cetina 1981; Bazerman 1984). However, boundary work at the laboratory level is rarely sufficient in modern science. Scientists are usually members of committees within and outside their organizations; they negotiate with funding agencies, lobby research policy, and they influence the distribution of funding by reviewing proposals of others.

With the high complexity of the boundaries and new forms of (structural) coupling of science and the wider society (Weingart 2001), research management is not limited to the work at the outer margins of organizations. The meandering boundaries between science and other parts of society proceed within and through research organizations. No organization would be able to focus all day-to-day operations entirely on scientific matters. Human resources, public relations, accounting, planning, and legal departments show that the functional differentiation of society is reflected in the structures of every research organization. By producing new connections between science and its environment, research organizations are able to control the boundaries between different functional systems of society regarding their specific goals and missions.

The university exemplifies the fact that competing visions about the role of an organization can coexist. Following a new Managerialism, university administrations attempted to gain more control over research work. At the same time, individual scientists developed external connections with funding agencies, cooperation partners, or the industry. The resulting centrifugal tendencies can decrease the influence of university administrations. The potential or actual conflicts within universities reflect the tensions between different sectors and the necessity to mitigate and manage them. The integration of research and teaching has been a central objective in the university. The resulting conflicts are well-known: professors complain about their teaching load eating up necessary time for research; successful researchers neglect their teaching obligations, etc. (Schimank and Stucke 1994; Slaughter and Leslie 1997). New couplings, e.g. between research and its application or policy consulting, generate similar tensions.

Research management—as defined here—refers to decision-making processes with a double reference: scientific dynamics (knowledge production and certification) and society. One outcome is that the boundaries between the administrative and scientific domains of the university are not as clear cut as they used to be (Whitchurch 2006). In addition, an entrepreneurial attitude toward problem-solving and career-planning has replaced a status quo in which scientists considered each others as equals. The goal of research management is the production of selective couplings

between organizational elements, disciplines, and across organizational boundaries. By tightening loose couplings up within temporary projects the adaptive capacity of research organizations can be increased. This functionalist definition does not reveal who actually manages a specific task within a given context. I consider it a research question that cannot be solved using an elegant definition alone. As a high variety of management arrangements can be observed, research contexts become more diverse (Nowotny et al. 2001). I assume that the concentration of some of the distributed management tasks within specialized management positions could foster the development of new professional roles.

The definition I suggest is not compatible with all literature. In addition to the many phenomena called management discussed above, there is a fondness for new terms in organizational theory. Hansson and Mønsted (2008) call the formalized routines of administration 'management' and see entrepreneurialism in science as a newer development; governance (Jansen 2007) is another example (focusing more on rules than decisions); nonetheless, they describe similar developments. Of course, rationalist management theories based on the distinction between the (genius) entrepreneur and managers as her or his agents within necessary but less creative bureaucracies cannot be applied to today's network organizations where innovative initiatives can originate from various positions within and outside the organization. One might argue that management itself is changing (Lakomski 2005); professionalization and entrepreneurship can now be considered two sides of the same coin. Professions provide employees of organizations authority that is not necessary vested in the hierarchy of an organization (Ben-David 1984: 154) and hence room for entrepreneurship. But in order to understand research management and its distribution among different actors, research management has to be distinguished from (scientific) leadership (Hansson and Mønsted 2008: 655).

Research management was often thought of as a task for scientific elites whose leadership resulted exclusively from reputation gained by above-average contributions to a discipline (Mulkay 1975; Crane 1972). However, productivity and excellence alone do not qualify scientists to be good managers. Research management requires a general view of a subject matter, the ability to coordinate interdisciplinary efforts, and individuals who are highly interested in the societal implications of their fields. Some of these complex demands even contradict the traditional role of scientists. The high managerial workload often reduces scientific productivity (as measured by the number of publications). This explains also the actual seniority of many scientific leaders. The second connected reason lays in the reward system of science. After a long publishing career, alternative sources of acknowledgement and status become more attractive since much cannot be gained by the publication of yet another paper. Diamond (2001) showed that at advanced career stages, teaching and administrative experience influence the salary of scientists more than the number of publications.

It is a newer development that younger and middle-aged PhDs pursue research administration and management careers. Motivation for this can be understood in relation to the reward system of science. Because of the competition that makes a scientific career more difficult and the demand for qualified personnel that understands the scientific as well as the social implications of research, research management has become a career option for scientifically trained students. The mere administration of money and personnel within the university is characterized by prescribed procedures and provides only little freedom for innovative initiatives. But modern research management has changed. New functions like the organization of information exchange, strategic planning, public and user relations provide room for creativity and leadership (Morris 2002: 823). But such management positions are still a second choice for many. To improve this situation, two scenarios might be implemented either separately or in conjunction with one another. *First*,

managerial work could be integrated within the reputational market of science. It is common for leading scientists to be mentioned as co-authors on papers (Owen-Smith 2001); it is less common for non-leading managers to be mentioned. *Second*, it seems more likely that a new profession will emerge (Kirkland 2005) with separate standards of performance and success. Within such a profession, management work would be evaluated not only by its beneficiaries but also by manager colleagues. The development of a new field of expertise, with its own journals, university courses, and conferences, would be an indicator for such a development.

However, the variety of research managers' responsibilities and the differences in their influence and responsibilities among organizations show not-yet stabilized role expectations. At universities, scientists often do not know what services new research managers provide or should provide. The task uncertainty typical for research (Whitley 1984, Omta and de Leeuw 1997) propagates into the research manager's role. Even if some research managers are quite influential, most of them cannot refer to a role model to demand autonomy or more responsibilities. Conflicts with scientists and their specific ideas of self-governance are common. Problems usually occur if scientists delegate work without giving up tight control over finances and organizational routines (Jacob 2001: 91–93). Proficiency in research management stems mostly from tacit knowledge, personal qualities, and experience (Hockey and Allen-Collinson 2009: 145). Talented and well-connected manager-scientists are treasures for research organizations and often almost irreplaceable. Whether in the long run these research managers of the new type will be able to pursue high-profile careers, or whether they will stay confined to sometimes precarious lower or middle level positions, is an open question (on the role of new marginal positions at the university, see Hackett 1990: 252–254).

In contrast to firms, the emergence of professional management in research organizations has rarely been the result of a widespread conviction that formal organization would be a better way to achieve scientific goals. Quite the opposite seems to be true. Scientists have always been defending their autonomy against the growing demands of university or government bureaucracies. Formal organization has been seen as a constraint to individual's creativity (Hemlin 2006a: 85). New management roles in the university emerged primarily from an overload of self-governance capacities resulting from the internal and external constraints of changing R&D systems and the coordination efforts of collaborative research.

3 Problems of Organized Research

3.1 Organized Research and the "Organization of Science"

Organized research became prevalent in the mid-20th century and has been a challenge for the science studies ever since. Bernal (1967, first published in 1939) reasoned that effective organization would be essential for bringing research into the service of broader society and the production of wealth. Merton and Polanyi considered tendencies toward national R&D policies as threats to the autonomy of science. The freedom that is essential for the productivity of creative individuals as well as the inherently communal structure of science seemed to be at stake (Merton 1968; Polanyi 2000, first published in 1962). Nevertheless, the "occupation of science" (Ellis 1972) for societal purposes grew rapidly. Following Merton, many sociologists assumed that the orientation toward profitable products and the resulting management demands in business firms and the professional ethos of university-trained scientists would clash permanently (Marcson 1961; Kornhauser 1962; La Porte 1965). The resulting role-strains (Evan 1962) – it was assumed – would cause less satisfaction among scientists working in industry. Surprisingly, the opposite

turned out to be true. In a series of surveys, researchers in for-profit organizations were more satisfied with their work than university employees were (Cotgrove and Box 1970; Barnes 1971). A variety of reasons for this satisfaction were provided: *First*, even corporate scientists are somewhat removed from hierarchical structures due to the task uncertainty of researcher's work. Industrial scientists also enjoy a relatively high degree of autonomy. *Second*, organizational structures and the availability of resources can reduce the burden of coping with complex institutional environments if R&D departments are organized in supportive ways. Hence, the literature on effective knowledge and innovation management in firms is overwhelming (Brown and Duguid 2001). The independence of industrial researchers from the scientific reward system might be a *third* reason. Industrial researchers can draw satisfaction from functioning products and they are often rewarded by their employers, e.g. by a high salary (Dasgupta and David 1994; Powell and Owen-Smith 1998: 254).

Another strand of literature deals with "Big Science" (De Solla Price 1963). The goals of large-scale research organizations have always been heterogeneous. Especially in physics, many bigger institutes have been dedicated to pure basic research (Galison and Hevly 1992). Nevertheless, after World War II, national governments attempted to steer the scientific development in order to pursue strategic goals (Jang 2000). Leading scientists defined policies within government bureaucracies (Hart and Victor 1993). However, the history of large-scale research took unexpected turns and revealed the limits of control and command approaches to research. Many of the far-reaching visions formulated in the early days (e.g. Weinberg 1968) never became reality. In contrast to Polanyi's assumption about the low capacity of problem generation in planned research, the invested resources generated an abundance of new scientific problems. Nevertheless, many scientists were more interested in new problems than in the original political goals. The assimilation of large external inputs (money, machinery, womanpower, Weinberg 1968) often led to the diversification of research goals (e.g. Galison and Stump 1996; Lambright 2005). Modern government research organizations usually have several disciplinary and interdisciplinary departments and they are committed to a vast number of heterogeneous missions (Sutton 1984).

The conclusion that can be drawn from the literature on large-scale research organization and industrial research is twofold. *First*, it seems difficult (if not impossible) to steer and control scientific development through research policy and organization. *Second*, formal organizations are able to facilitate and support research. The availability of resources and certain forms of work organizations increase the likelihood of research success and productivity (Hurley 1997). Even if the connection between organizational goals and the work of scientific employees is usually loose, research outside formal organizations is remarkably rare. These findings seem to be contradictory at first glance; and indeed, this alleged contradiction has been a conundrum for an organizational theory of scientific research for a long time. It is also reflected in ambiguous attitudes of many scientists toward organization and management (Jacob 2001).

In the sociology of science, the term 'organization' has been used in different ways, which have not been always precisely distinguished. The singular—"the organization of science"—was used in the sense of social order or structure and denominated different phenomena as disciplines, the communal and the professional organization of scientists (Ben-David 1984), the reward system (Hagstrom 1965), and—neglecting categorical differences—formal organizations as universities or government laboratories (Weingart 1976). The second (often plural) use—"research organizations"—refers solely to formal organizations (universities, national labs, or industrial research departments) in the sense of modern organizational theory. In order to avoid this confusion, I refer to the (non-organized) social structure of science using a different terminology: it can be considered an institution or a functional system (e.g. Storer 1966; Luhmann 1990). Some authors de-

scribed the reward system of science as reputational markets (Bourdieu 1975; Latour and Woolgar 1986). The term research organizations as I use it here refers to more or less formal organizations. Thus it differs also from the "professional organization" of scientists (as used by Ben-David 1984) as well as from self-organization (Krohn and Küppers 1989).

3.2 Universities as Organizations

The identification of universities with autonomous and disciplinary science is an example for the imprecision discussed above. A certain type of indeed formal organization was widely identified with informal or even unorganized science (e.g. Nowotny et al. 2001). Of course, the dominance of university research shaped the institutionalization of science for a long time. However, maintaining the faculty's autonomy and the relative detachment of tenured professors from hierarchy has been an organizational decision in itself (Ben-David 1984). Once in place, universities could only gradually depart from this model. Otherwise, they would have lost their attraction to excellent scientists. Nevertheless, the idealistic description of academic freedom has mostly focused on leading universities. In many second or third tier institutions, the teaching function dominates over research. In addition, the expansion of higher education that was not accompanied by a proportional growth of funding generated a shortage of faculty positions which gave universities a bigger leverage to impose new organizational demands on scientists. In so-called new Higher Education Institutes (HEI), such as German Universities for Applied Research (Fachhochschulen) or schools focused on engineering, research is institutionalized in a very different way than at research universities usually in corporation with non-scientific partners (Hazelkorn 2005).

The communal structure of science easily crossing organizational boundaries proved to be very effective in terms of scrutinizing knowledge claims and distributing acknowledgement among productive and excellent scientists. However, the community model is less effective in resources acquisition. Modern academic research is an organized activity that requires the mediation between the quite different arenas of science, economy, public, and policy (Hackett 1990). The autonomy of scientists has rarely been discussed as a function of available resources. However, the concept of entrepreneurship entails that a scientist's freedom to make research decisions is determined not only by the organizational autonomy but also by available money, instrumentation, and collaborative networks.

Universities are textbook examples for structural couplings of several societal functional systems within or through formal organization (Baecker 1199:57; Tacke 2001; Luhmann 2002:18; Lieckweg 2003: 62). The traditional coupling between education and science has been extended (or even replaced); universities are also the place of couplings between economy and science or policy and science. At the same time, universities lost the quasi-monopoly of integrating science into society. Until recently, the societal support of universities was not primarily based on their research function. The support varied depending on the country and the university type. The educational function and, especially in elite universities, the reproduction of social status have been more important. The forms of coupling (formal or informal, long-term or episodically) and the channels of knowledge- and problem-transfer between the university and wider society are much more heterogeneous than the older linear model of innovation or even the theory about new forms of institutionalized university-industry-relationships (Etzkowitz and Leydesdorff 1997) suggest. Knowledge transfer takes place through alumni working in different professions (Mangematin et al. 2003), political campus organizations, or the individual initiatives of scientists to connect with actors in civil society (Krücken et al. 2009). Research is only one among many other activities at the university (Blau 1973). As early as in the 1960s, this observation was captured with catch-

phrases like “multiversity” (Kerr 1995, first published in 1963) or “university-bundle” (Parsons and Platt 1973).

Despite their particularities, universities are indeed formal organizations. In the literature, universities have been viewed as fairly inflexible structures, struck by institutional inertia, and dedicated to traditional values instead of rapid organizational change (Alpert 1985; Hellström and Jacob 2005). Regardless of this widespread image, universities have proven to be quite adaptive (Lehrer et al. 2009). Of course, these adaptive capabilities did not stem from effective planning in the administration but instead from the relatively low levels of control over organizational elements. The high autonomy of departments, research centers, and graduate schools provides enough flexibility to realize new forms of couplings within other domains of society, often as a result of individual initiatives and bottom-up pressures (Krücken et al. 2009). Examples are the commercialization and the marketing of proprietary knowledge (Slaughter and Leslie 1997), professors engaging in policy advisory roles, or social advocacy. The integration of research in society varies between disciplines and even within disciplines as e.g. the contrast between the trend to patenting and the open source movement in the life sciences shows (e.g. Maurer et al. 2004). Despite successful adaptation to a changing environment, universities have experienced an ongoing identity crisis. It seems difficult, if not impossible, to formulate an overall mission that would wrap up all the different types of knowledge production, education, and the vast number of other activities. In the past few decades, universities were confronted with an endless reform process that constantly failed to capture their complex societal functions (Scott 2006; Rochford 2006).

In the beginning, the growing importance of external funding within the university did not stem so much from organizational pressures or the scarcity of resources. A few scientists with an entrepreneurial attitude towards science tried to extend their freedoms once promised by the university. Due to the inability of the university to finance many modern large-scale projects, they created alliances with industrial or governmental organizations that ensured access to additional resources and expanded opportunities (Powell and Owen-Smith 1998: 264). It is somewhat ironic, but the possibility of signing external contracts that generated higher external dependencies is a result of the freedom university scientists enjoyed. Many universities promoted this development and made the amount of external funding a benchmark for faculty evaluation. Nevertheless, a shift in power distribution within the university organization occurred with increasing resources governed at the department or institute level.

In the US, the role of centralized university administrations has been shrinking since the 1970s. The participation of scientists in faculty governance is declining and some leading scientists earn more money than the presidents of their own universities (Alpert 1985). Germany has a similar tendency: government funding of universities has been shifting away from a general institutional support to project funding (German: *Drittmittel)* and amplified the trend to powerful departments. The increase of funding and power at the department level or for temporary projects led to a new demand for management functions closely connected to the research process itself. In the entrepreneurial university (Clark 1998; Etzkowitz 1998; Lehrer et al. 2009), scientists can be seen as leaders of relatively autonomous quasi-firms within the university (Etzkowitz 2003). That is especially true for research groups working closely with firms, but it is also true for basic research. Scientists have to generate income either from government funding or other sources (Hansson and Mønsted 2007).

The ideal university was thought of as an organization governed solely by scientists. Nevertheless, universities are characterized by a double structure: they are collegial organizations and bureaucracies at the same time. University administrations have implemented (usually more than

just a few) formal rules and everyone was supposed to comply with them regardless of their status and scientific reputation. These rules rarely interfered with faculty governance and they limited the power of the administration. For research, the university's administrations played an indifferent, in some cases a supportive role seen as management *for* research (Woodrow 1978). In contrast, the new more complex "social contract" for university research (Leydesdorff and Etzkowitz 1997) requires management *of* research, because the prerequisites for every single project have to be negotiated with funding agencies, project partners, hosting organizations, and with external stakeholders. Both forms of management, of and for research, can be observed at the level of university administration and increasingly at the level of departments or projects; for the most part they are inseparably intertwined. Because of the traditional independence of these levels, this double structure generates specific problems and sometimes tensions about control and power.

4 Vantage Points in Organizational Theory

4.1 Isomorphism and coupling—system vs. network perspective

In the recent organizational turn in science studies (Hellström und Merle 2003, Röbbecke et al. 2004, Hemlin 2006a), newer approaches of organizational theory were applied to research organizations. While older organizational studies focused primarily on firms characterized by bureaucracy, hierarchies, the motivation and control of work as well as clear-cut membership and client roles, organizing is increasingly analyzed as a dynamic process (Hernes 2008) in which formal structures provide orientation and sense but reflect only a small part of the daily processes and operations within an organization (Meyer and Rowan 1977). Approaches like management without leadership (Lakomski 2005), distributed management, governance (Jansen 2007), or network organizations (Powell 1990) describe decision-making processes within flat hierarchies that often cross permeable organizational boundaries. The tension between formalization and informal dynamics that change or marginalize existing structures and practices is widely seen as an innovative force in organizational life. Furthermore, to understand research organizations, the specific role of professionals in organizations must be addressed. Professionals draw on authority and resources that are rooted in interorganizational networks, not in their position within the hierarchy of formal organizations. This is especially true for research where the motivation of scientists stems from individual career strategies dependent upon networks and the reward system of science.

Two theories were especially influential in the analysis of research organizations: the neo-institutionalist school and the hypothesis of loose coupling (Weick 1976). Both marked a departure from the fixation on formalization and hierarchy towards an interpretation of organizations within their wider social context. While Max Weber attributed the high similarities between organizations within a field to rationalization and bureaucratization, the neo-institutionalist theory explains the form of a given organization as a function of its institutional environment characterized by markets, regulatory regimes, and an organizational field consisting of other organizations with similar objectives that observe and respond to each other (Meyer and Rowan 1977). DiMaggio and Powell (1983: 150) described three different types of isomorphism; "[…] 1) *coercive isomorphism* that stems from political influences and the problem of legitimacy; 2) *mimetic isomorphism* resulting from standard responses to uncertainty; and 3) *normative* isomorphism, associated with professionalization […]." The pressures leading to isomorphism increase with the frequency of competition and cooperation between organizations within a given organizational field.

At universities, all three forms of isomorphic pressure can be observed. *Normative isomorphism*: The institutionalist paradigm in science studies named professional norms, especially the ethos of science (according to Merton) and the disciplinary structures of the professional labor market as the strongest factors forming university organizations. The departure from the disciplinary matrix would reduce the employment chances of students dramatically at least within the professions, and universities need to comply with the disciplinary structure to hire well-trained scientists (Abbot 2001: 126; Ben-David 1984: 158f.). By creating departments, they reproduce the disciplinary institutionalization of science. Shifts in the disciplinary structure are usually slow and depend on big funding inputs or other forms of outside societal support (Bensaude-Vincent 2001; Good 2000), in short, on an external reduction of institutional pressures. Without doubt, the growing importance of external problems accelerated the disciplinary dynamics, a vast number of new interdisciplinary fields emerged (Klein et al. 2003; Schützenmeister 2008). But only a few, big and influential organizations can dominate the institutional environment (Freeman 1982: 14; DiMaggio and Powell 1983: 149); some are even able to create new disciplines by providing continuous project funding and creating a labor market (e.g. NASA, Lambright 2005).

Coercive Isomorphism: This is when universities within a national research or education system share a common legal environment that usually more or less limits the room for experimentation. In addition, science policies that promote institutional change toward commercialization and managerial control have a strong impact on the organizational structures of the universities (Atkinson 2002). *Mimetic isomorphism*: Even if university managers still have room or even gained opportunities for the development of new initiatives and policies, mimetic isomorphism occurs when the institutional changes that shake the organizational field of research generate uncertainties. Mimesis is often the answer of overburdened university administrations. Role models, e.g. the US research system or a few elite universities like Harvard, Stanford, or Berkeley, influence university and research policies all over the world (for Germany see Hartmann 2006).

The second influential approach is the concept of loose coupling (Weick 1976; Perrow 1984; Orton and Weick 1990). Coupling refers to the mutual responsiveness of elements (events, positions, means, and goals) within an organization that preserve their own identity, physical and logical separateness. Common mechanisms of coupling in work organizations are the technical core and authority (hierarchy); neither dominates the structure of modern educational organizations (Weick 1976: 4). At the university, events and structural units are loosely coupled. They are somehow attached but respond usually slowly to each other and they have limited possibilities to force a certain behavior or action. Loose couplings are often rather impermanent, dissolvable, and tacit. The advantage of loose coupling is that it provides building blocks that can be rearranged for the solution of very specific problems without disturbing the organization as a whole (ibid: 3). Loose coupling connects organizational elements horizontally rather than vertically; it requires a certain degree of autonomy on all organizational levels. In organizations with decentralized authority backed by professions instead of hierarchy, important management questions can be derived from this approach. According to Weick (ibid: 5): “The question of what is available for coupling and decoupling within an organization is an eminently practical question for anyone wishing to have some leverage on the system”.

Loose coupling and temporary cooperation are not only be observed within organizations but also across organizational borders. In so-called network organizations, elements of different organizations are rearranged to pursue strategic goals through the complimentary exchange of resources and capacities (Powell 1990; Podolny and Page 1998). One of the main findings is that the duality between free market exchange and power relationships (hierarchy) is not appropriate to capture all forms of exchange in and between organizations; the social embeddedness of exchange

relationships was neglected for a long time and was one reason that organizational theory could not capture the reality of scientific research (and other professions). Scientific collaboration is certainly an exchange relationship mostly with strategic goals (e.g. to get access to instrumentation and tacit knowledge, to benefit from publishing assets of others, or to gain other advantages); however it strongly depends on the structures of a discipline, pre-existing personal relationships, and informal networks. In contrast to markets, where interaction is thought as strictly episodic and only driven by prices, collaborations in networks are more persistent even if they are only temporarily formalized; for instance in projects which usually dissolve after the goals are accomplished (or the resources used up). Such forms of collaboration stabilize informal networks and personal relationships and make further collaboration more likely.

4.2 Research and organization as decision-making processes

The theory of loose coupling describes organizational resources as a highly flexible medium for problem-solving while institutional isomorphism can explain why members from different research organizations can relatively easily cooperate, especially if they share common values, speak the language of the same discipline, and are interconnected in a complex web of interpersonal relationships. Furthermore, laboratories within a given discipline are characterized by a high degree of isomorphism often centered on certain experimental technologies and instrumentation that provide a vast number of vantage points for communication but also by the specific pressures resulting from the institutionalization of a discipline within the wider society (Gieryn 2008).

Nevertheless, it seems necessary to include an actor-centered perspective to analyze research management as a decision-making process. Ethnographic studies of the laboratory (Latour and Woolgar 1986; Knorr-Cetina 1981) provide a starting point. The goal of this approach was to bring action (Gooding 1992) and a social world perspective back into science (and into organizational) studies. Research itself can be described as a decision-making process that is not only guided by scientific knowledge but also situated in the social world of laboratories that are embedded in the wider society. In every organization, many decisions have already been made in the past; research contexts are structured by artifacts, instrumentation, and resources that limit further action. Laboratories and other organizational resources provide opportunities, but they also constrain what employees are able to pursue. Scientists have to choose problems that can be solved within a given organizational context. They usually select “do-able problems” with a chance of successful solution (Fujimura 1987). Scientific experiments can be described as assembling artifacts and knowledge intended to “make things work” (Knorr-Cetina 1981; see also Hackett 2005). I suggest an extension of this version; the same way as artifacts and instruments have to be arranged, bigger collaborations require the reorganization of widely distributed resources and experts.

Research can be seen as a dynamic process of organizing contexts which is flexible enough for the emergence of new knowledge (learning) but also rigid enough that knowledge can be tested against hypothetical expectations (probation). Research is highly decision-laden. However, scientific knowledge alone is not a sufficient guideline to direct such decisions; they are oriented toward social and organizational contexts. For a long time, such contexts were usually called “laboratory” or “experiment.” In modern research organizations (or networks), decisions that influence the outcome of research have a much wider range and have to take a larger environment into account. The society itself serves increasingly as a laboratory: with the use of scientific knowledge for the solution of societal problems and the monitoring of the outcomes, knowledge claims are

constantly tested (Krohn and Weyer 1990). Still, science is still a highly specialized communication system (Luhmann 1990: 536); the results of experiments or "real-world experiments" in society (Groß et al. 2005) have to be systematized within theories and by methodical standards (see Knorr-Cetina 1981; Bazerman 1984; Gooding 1992). Because of the complexity of the relationship between science and society, the fabrication of knowledge (Knorr-Cetina 1981) has to be managed.

Organizing is a process of recursive decision-making (Baecker 1999; Luhmann 2002). Projects are the smallest unit in organized research (Luhmann 1992); they are the place were knowledge is produced and tested. Projects are rarely formal subdivisions of existing organizations. They rather couple different resources available inside and outside of organizations temporarily tightly together to "make things work" (operational coupling). This version explains why the flexibility of networks is essential in organized science. Formal organizations embedded in heterogeneous networks surrounding science contain bits and pieces that can be used to create new contexts and recombinations of knowledge that exceed the cognitive capacities of single researchers. A striking example is particle accelerators that are so complex that they require the cooperation of hundreds of scientists and engineers. Once in place, they can be used by research groups to perform certain experiments. In this sense, the role of organizational elements is similar to the role of instrumentation and technical devices (Halfmann 2002).

4.3 Knowledge management

It is somewhat surprising that knowledge management has been rarely discussed in the literature about university research management. It is difficult to apply literature to knowledge within firms to scientific research that results from different conceptualizations of knowledge. In classical organizational theory, knowledge was seen as a state of mind or capability of employees, rarely as a collective good. Consequently, knowledge management was often considered a special form of human resource management. From this perspective, a firm can acquire knowledge by hiring skilled people and motivating them to exemplify personal (implicit or tacit) knowledge. Knowledge creation processes in firms occur when people collaborate who combine and rephrase personal and explicit knowledge to produce assets for the company. In addition, processes of internalization and externalization of organizational knowledge were studied (for an overview see Nonaka 1994). Knowledge is usually exemplified as proprietary objects (e.g. data bases), processes, or organizational routines (Alavi and Leidner, 2001). In contrast to science, knowledge is usually considered a resource on short supply. These statements are of course oversimplified; the findings of the sociology and philosophy of knowledge and the cognitive paradigm of science studies among others have had an big impact and motivated elaborated cognitive theories of the firm and knowledge creation (Mir and Watson 2000; Brown and Duguid 2001; Grandori and Kogut 2002; Jashapara 2007).

In science studies, Kuhn's (1967) notion of communities sharing a world view (paradigm) nurtured a long-standing view that the social and the cognitive structure of science would be almost identical and only temporarily resolved during scientific revolutions. Nevertheless, this version is not sufficient to describe the complex social world of research where scientists are usually members of different formal organizations and several overlapping communities (Gläser 2007: Schützenmeister 2008). These communities are not very coherent; most scientists belong to several communities that emerge around subject matters, theories as well as around methodologies, funding programs, and non-scientific advisory roles (e.g. political). Epistemic communities include often non-scientific actors and external stakeholders (Haas 1992; Epstein 1996). In addi-

tion, scientific collaboration is based on complementary exchange and not shared knowledge and abilities. In building valuable relationships, distinctive insights are more useful than shared knowledge and abilities. Nevertheless, scientific knowledge is reflected in the communal structure of science (disciplines and specialties) but it is not identical within the organization of research. The connection between the cognitive and the organizational structure has to be constantly reproduced within decision-making processes. Scientists (and research organizations) often try to produce new knowledge by gradually departing from the existing cognitive structure of science. Also in science, organizational realignment can lead to innovations. Interdisciplinary projects are a case in point, and the use of new instrumental technologies another. Formalization can sustain collaboration where the cognitive and informal integration of a community does not provide strong enough connections to guarantee continuity in collaboration (Corley 2006).

The goal of knowledge management in firms is to generate competitive advantages. In contrast, scientific knowledge was generally thought of as a public good or commons (Nelson 2003). Contributions to the shared knowledge pool are rewarded with acknowledgement by the scientific community. Ryle (1949) and Polanyi (1967) pointed out that knowledge has a personal component that cannot be fully exemplified, and that the difference between tacit and explicit knowledge was very influential in the writing about knowledge in organizations and in science (Jashapara 2007). Tacit knowledge is deeply embedded in the practices of professional and scientific communities. Collins (1985) showed that published papers are not sufficient to reproduce scientific findings; successful replication is dependant upon the implicit and tacit knowledge about the use of instruments and experimental technologies as well as of their interpretation. These abilities cannot be learned through studying alone; they are primarily acquired through a long training process in laboratory practice.

Despite this view of scientific knowledge as a common good, it is still common for scientists to conduct some sort of knowledge management which is legitimate prior to publication. They publish (or postpone publications) strategically in order to maximize the scientific reputation gained by certain findings, data, and experiments. In an ideal world, scientist would be interested in publishing new results as soon as possible to prevent other researchers from publishing similar results first. If scientists within a field work with the same shared knowledge, the discovery of a phenomenon at the same time by more then one researcher is very likely; literature about simultaneous discovery and priority conflicts shows this (Merton 1957). This situation might be different when new findings are not likely to be accepted by other scientists because they conflict with expectations within the field. In this situation, both the production of further evidence as well as the creation of alliances of collaborators might be a more successful way to establish new knowledge (this was shown by Edge and Mulkay 1978 for the case of radio astronomy; also Hackett 2005: 804).

In classical science, the tacit dimension referred to the personal knowledge of a researcher while explicit knowledge was seen as a common good. In addition to publication, the main channel of knowledge transfer within and outside academia was the teacher-student relationship. Collective research led to a dramatic departure from these principles; research teams share and exchange knowledge that is not part of the scientific commons. This is especially true for commercialized research, but knowledge assets are also a big advantage in basic research. A research organization without assets has a smaller chance of competing and makes a less interesting partner in collaborations. Strategic knowledge management has become very important at the university (Shoham and Perry 2009). One reason is that the marketability of research findings can be turned into revenue. Another is that simultaneous discoveries can be dramatically reduced by the creation of research contexts that are partly sealed off from the scientific community. The creation of exclu-

sive research contexts within a university such as centers or clusters generates environments characterized by a unique set of experts and resources that reduce the risk that other groups would do exactly the same thing (Atkinson et al. 1998). In addition, such structures allow the mutual observation of specialization within organizations. Other organizations can distinguish themselves strategically, define their own fields of expertise, and buy equipment accordingly. The challenge for research management is balancing competitive advantages and the connection to the scientific commons that are still an important resource.

If tacit knowledge or explicit knowledge is kept in secret for awhile to gain competitive advantage, classic problems of proprietary knowledge and knowledge transfer become prevalent in scientific research. How can projects and organizations prevent other teams from learning about their new practices and skills too early? This question is especially important since open science does not have a codified protection mechanism for the use of knowledge by others. Sharing and maximizing the advantages of situated tacit knowledge requires a large amount of trust among collaborators and sometimes formal contracts.

In organized research, there is another dimension of tacit knowledge. Since many research fields are dependant upon external funding, personal networks, and connections with stakeholders and potential collaborators, knowledge about the social world of research is important. Furthermore, since science is increasingly dependant upon the external evaluation of its products, effective knowledge transfer is an important requirement used to promote the usefulness of a research field. It was shown that *scientific* knowledge is often inefficient in the political process — not data or proof, but conceptual ideas backed by a scientific community influence policy most efficiently (Lavis et al. 2003). Scientific knowledge has to be tailored to different audiences and reframed to be efficient and useful for non-scientific actors. In addition, the presence of scientific findings in the media has a legitimizing function. The professionalization of research management also means that a good part of the knowledge about the function of science in society and its prerequisites is made explicit within a new field of expertise.

5 Goals and means of research management

5.1 The University Research Group

The smallest organizational unit in university research is the group usually lead by a professor. The original notion of autonomous scientists focused mainly on group leaders and did not take into account students, post-docs, and technicians. Collective research cannot be fully understood by focusing on group leaders; all group members and the supportive management structures outside the group must be taken into account. Scientific research is indeed hierarchically organized and leading scientists have a strong influence on the overall success of a group (Hemlin 2006a). Nevertheless, direct control can only provide a limiting framework; unobtrusive forms of leadership that focus on the information flow are more decisive (Owen-Smith 2001). Especially in bigger groups, leaders usually work more in an office than at a laboratory bench (Hackett 2005). Much of their time is dedicated to management tasks, e.g. the observation of competing groups, the development of ideas, writing grant proposals, staffing, or negotiating with funding agencies and collaboration partners. When defining research as a decision-making process embedded in a social context, management work has to be considered an integral part of research.

An important management goal of group leaders should be the promotion of creativity and innovation as well as the reduction of organizational and extra-organizational impediments. There is a vast set of literature dedicated to the relationship between leadership and creativity in firms (Ford

1996; Mumford et al. 2002; Woodman et al. 1993; Heinze et al. 2009). In this literature, factors such as encouragement of creativity, relative autonomy and freedom of group members, sufficient resources, challenging work tasks, and mutual acknowledgement all play a role in fostering innovative outcomes of individual work (Amabile et a. 1996). Nevertheless, creativity is hard to measure: most studies use productivity or the number of citations as proxies (Heinze et al. 2009).

The benchmarks for success are increasingly set by research organizations, e.g. the university. Evaluation systems are based not only on the number of publications or citations but also on generated income, interdisciplinary activities, and external collaborations. The effects of a "managerialist attitude" of politicians and administrators seem to be mixed, but the recent reforms produced new opportunities as well as additional bureaucratic demands. However, excessive evaluation, scarcity of resources, lack of time, and missing freedom to develop ideas that might not bear success and limited means to attract and hire excellent scientists are counterproductive at the group level (Amabile et al. 1996; Hemlin et al. 2004; Wang et al. 2006). Organizational requirements that differ from the reward system of science that is important for the individual advancement of a scientific career can produce a productive tension but they can also be counterproductive.

The performance of a research group does not entirely depend on the scientific qualification of its members; the organizational environment and effective leadership are also decisive factors (Hemlin 2006b; Van der Weijden et al. 2008). Omta and de Leeuw (1997) pointed out that just bringing brilliant people together often ends up in an argument. In addition, the forms of leadership vary widely between disciplines and organizations.

In general, the control of leaders over the work of group members is usually relatively weak. One reason for this is that scientists are often hired to bring in expertise or tacit knowledge that is not readily available. The work of group members of other disciplines is often difficult to evaluate before the overall project goals are met. Occasionally, single group members are more productive than the group leaders. In contrast, tight control and command approaches generate resistance and are usually seen as exploitation. Owen-Smith (2001) showed that efficient leadership and coordination are usually achieved by frequent, often causal meetings and other forms of "shop talk." During such occasions, group leaders usually do not instruct group members directly what to do. The communication is oriented toward the skeptical evaluation of outcomes and characterized by—depending on the position of group members—more or less binding suggestions about variations of experiments (see also several works of laboratory studies Knorr-Cetina 1984; Latour and Woolgar 1986). Still, some group leaders autocratically intervene in the work of members (Hackett 2005: 801).

The status of group members varies depending on their role, financial dependency, and academic achievements. This is especially true at the university where graduate students are trained within research groups. The influence of professors on the work of students or Ph.D. candidates might be stronger than their influence on the work of members with an independent scientific standing. The rather indirect management of research groups depends on norms and values shared among members. Students are trained in an enculturation process into collegial forms of coordination replacing the direct control found during earlier career stages (Campbell 2003). The power differential between students and professors is usually big; exploitation in one form or another is not as rare as one might think (Rupert and Holmes 1997). Nevertheless, the ideal relationship can be described as mentorship (Green and Bauer 1995). The time the group leader invests helping students is meant to be paid off by the student's contributions to the group work.

The literature on efficiency provides heterogeneous results about the optimal size of research groups. Some authors claimed that the productivity of groups increases with size (Wang et al. 2006). Others showed that the per capita productivity as well as the quality is declining above a certain threshold (Andrews 1979; Von Tunzelmann et al. 2003). For groups in natural science a size of five to six members seems to be optimal (Heinze et al. 2009: 612). The higher variability of efficiency among bigger groups results from a higher degree of labor division, the diversity of membership roles, and the resulting management challenges. The success of bigger groups depends on highly professional management and efficient leadership (Hemlin 2006b).

5.2 Collaborative Research Projects

Modern research is usually organized in projects. Projects are planned work phases that can be evaluated against an original objective after a limited span of time. In reference to the approach I suggested in section 4.1, projects can be understood as temporary tighter couplings within the medium of loosely coupled organizational and network resources. The work of most research groups is structured accordingly; they are dependant on rather limited grants and have to report to funding agencies. The opportunity for continued funding generally depends on the positive evaluation of the outcome of completed projects. However, a narrow goal definition conflicts with the common assumption about the unpredictability of research results. This is especially true if funding agencies prefer risk-averse decisions (Laudel 2006). Scientists developed several strategies to deal with the ensuing problems. Often, projects are close to completion before they receive funding because the preparation phase itself is very labor intensive and many proposals contain fully fledged scientific work. In many cases, scientists propose little more than varying or scaling up already successful experiments. In the meantime, many researchers use the money and time provided by approved grants to develop new projects. This structure of projects amplifies the difference between the managing group leaders who have to come up with new ideas and to develop proposals and the group members who work at the laboratory bench to produce data and finalize projects.

However, projects are not limited to single research groups; they often span the boundaries of several organizations, sectors, and countries. Through multi-organizational collaborations, scientists are able to combine parts and pieces from different organizational contexts to pursue advanced research goals (Genuth et al. 2000). Many funding agencies support the trend towards interdisciplinary and interorganizational collaborations (NAS et al. 2005: 114–137; Defazio et al. 2009). While research groups show a high degree of isomorphism which is caused by the formal requirements of universities and funding programs as well as by the limits of informal organization, the reasons and the initiatives for the formation of inter-organizational research projects are heterogeneous and result from the available resources, individual career strategies, and organizational cultures. Many authors isolated determinants of successful collaboration. The well-balanced relationship among input factors such as personnel, money, and infrastructure are necessary requirements for success (Carayol and Matt 2004). But the appropriate balance widely varies among research fields and countries (Woods 1990); different disciplines call for distinct forms of organization. Some studies have shown that a formal division of labor within the university—measured by the number of non-faculty members and technical personnel—can increase the productivity of researchers (Walton et al. 1986). Most studies show that high organizational complexity in research requires some sort of leadership or management (Röbbecke et al. 2004), but research collaboration is still a black box (Rigby and Edler 2005; Melin 2000: 32). Only a few

studies tried to open it and took a closer look (e.g. Melin 2000; Jeffrey 2003), often with rather specific results than a general approach to research management.

A few decades ago, university researchers were not very well equipped to participate in big collaborations that are led by large-scale research institutes. Of course, university scientists worked together with colleagues all the time but the informal communication-style is sufficient only in smaller collaborations (Melin 2000). It seems difficult to capture all forms of informal research collaboration. Sometimes a brilliant suggestion during a coffee break at a conference can move someone's research further. Such forms of mutual influence are not captured by organizational or co-citation analyses as the most common method to measure collaboration (Katz and Martin 1995: 2). Informal networks and formalized collaborations seem to be equally important for successful research. The relation between these two dimensions is not well understood yet (for an attempt see Schützenmeister 2008). Shove (2000) showed that contacts and networks are a jealously guarded currency where funding and acknowledgement are distributed to well-organized and scientifically comprehensive collaborations.

The creation of bigger collaborations requires a strategic approach towards research (Bozeman and Corley 2004). In the context of this review, one might say a managerial attitude is needed. Project goals have to be negotiated, compromises found, and the terms of collaboration codified in contracts or conceptual papers. One aspect of such a managerial approach is to accommodate personal research goals into a given context and opportunity structure. Scientists are still members of a highly individualist culture where only one thing is more important than their research interests: individual careers. Even if they are principally autonomous in the selection of research questions, they tend to choose such topics that can be done within a given institutional structures (do-able problems, Fujimura 1987). For this reason, the actual autonomy to choose the most intriguing problem from a wide range of possibilities is highly dependant on the resources available with an organization and, increasingly more important, a network of scientific and interorganizational relations upon which a researcher can draw. Most of these network relations are still informal and communal with a rather latent character. The art of research management is to transform these latencies into working projects.

The necessity of bureaucratic control and formalization grows with the size of projects and the disciplinary and professional heterogeneity of the participants, and the diversity of the individual goals (Chompalov et al. 2002; Corley et al. 2006). Landry and Amara (1998) proved in a Canadian study that there tend to be more formalities if the collaboration receives additional funding. Collaborations where the primary goal is increased publication have rather informal structures. The reason for this is that formal coordination can be indeed more effective; but it also has higher transaction costs (Landry and Amara 1998: 911). Even if the benefits usually outweigh these costs (Narin et al. 1991; Rigby and Edler 2005), the extra investment can only be compensated if additional resources are available.

However, bureaucratization and professional management alone do not guarantee success even for bigger research projects. They can instead be seen as measures to avoid conflicts between scientists from different disciplines and organizational cultures. However, codified rules implement an important distinction between the basics that are not questioned during the common work, the space for innovation, and the scopes of expertise (Bammer 2008). Furthermore, the terms of negotiation that form collaborations are not of purely administrative nature; they also produce a shared view of research objects. In contrast to the theory of the scientific community, such consensuses are not overarching and they do not necessary create a shared *world* view among the collaborators. The definition of so-called boundary objects (Star and Griesemer 1989) as refer-

ences for mutual interaction is usually based on rather pragmatic in the everyday language nested (and often minimal) agreements about interfaces.

Research collaborations occur for many reasons (Katz and Martin 1997: 4).[2] Two main patterns can be identified: the first is more of an economic, the second more of a political nature. In the *first* pattern—as already stated above—differences among the collaborators can be utilized by at least one of the partners. Collaboration is more likely in situations that provide advantages for all participants. The benefits collaborators gain can be quite heterogeneous within the same project; they dependant on the career stages of the participants and on the organizational setting. A senior researcher might provide tacit knowledge or ideas to a younger more inexperienced post-doc who invests time to test these ideas in labor-intensive experiments (Bozeman and Corley 2004; Mangematin and Robin 2003). External collaborators can gain from the prestige of a university, or university researchers can profit from resources available in a bigger business corporation. In general, collaborations provide access to expertise, skills, or instrumentation and equipment that one might not have (Katz and Martin 1997; Melin 2000; Bozeman and Corley 2004), but also the human resources, work capacities, and prestige (e.g. publication assets of famous authors that guarantee higher attention toward the work of the co-authors). Most research collaborations can be described as an exchange of complementary assets (Landry and Amara 1998: 903; Rigby and Edler 2005).

A *second* rather political pattern is common interests among scientists. Collaborative projects may have better access to funding. Often, groups of scientists promote the creation of new programs and facilities and push such issues to higher levels of science policy (Bammer 2008). Government programs that explicitly require interdisciplinary, intersectorial, or international cooperation give not only interdisciplinary teams a source of funding while most funding programs are still disciplinary, but they also encourage opportunistic creation of research collaborations that are not primarily driven by the research problems of the participants.

Collaborative research projects are usually relatively independent temporary organizations; the ties to the hosting organizations are often weak and limited to a few rules about money transfers and reporting requirements stipulated in formal contracts. Classified military research projects at US universities are an extreme (Chubin 1985). Nevertheless, the switch from block grants provided by the university to external funding, either from the government or the industry, shifted

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[2] Katz and Martin (1997) list the following reasons: "1. changing patterns or levels of funding (Clarke 1967, Heffner 1981, Smith 1958); 2. the desire of researchers to increase their scientific popularity (O'Connor 1970), visibility and recognition (Beaver and Rosen 1978; Beaver and Rosen 1979a, Beaver and Rosen 1979b, Crane 1972); 3. escalating demands for the rationalisation of scientific manpower (Beaver and Rosen 1978; Beaver and Rosen 1979a, Beaver and Rosen 1979b, De Solla Price 1963); 4. the requirements of ever more complex (and often large-scale) instrumentation (Meadows and O'Connor 1971; Meadows 1974); 5. increasing specialisation in science (Bush and Hattery 1956; Jewkers et al. 1959; Smith 1958); 6. the advancement of scientific disciplines which means that a researcher requires more and more knowledge in order to make significant advances, a demand which often can only be met by pooling one's knowledge with others (Goffman and Warren 1980; Maanten 1970) ; 7. the growing professionalisation of science, a factor which was probably more important in earlier years than now (Beaver and Rosen 1978; Beaver and Rosen 1979a, Beaver and Rosen 1979b); 8. the need to gain experience or to train apprentice researchers in the most effective way possible (Beaver and Rosen 1978; Beaver and Rosen 1979a, Beaver and Rosen 1979b); 9. the increasing desire to obtain cross-fertilisation across disciplines (Beaver and Rosen 1978; Beaver and Rosen 1979a, Beaver and Rosen 1979b); 10. the need to work in close physical proximity with others in order to benefit from their skills and tacit knowledge (Beaver and Rosen 1978; Beaver and Rosen 1979a, Beaver and Rosen 1979b)." (citation style changed by F.S.)

the power balance in the university in favor of successful researchers and departments (while the administrative pressures on scientists who are less successful in grant acquisition have increased).

5.3 Balancing competition and cooperation

The last two sections demonstrated the necessity of research management on the level of the (university) research group and on the level of interorganizational collaborative projects. At the level of the university, another tendency can be observed which has been decisive for the emergence of new management roles. Traditionally, (informal) collaboration followed disciplinary lines rather than organizational boundaries. Only at the bigger universities and in a few disciplines were professors able to find cooperation partners of their specialty within the same organization. This changed with the growing importance of interdisciplinary research as well as with university administration's attempts to strengthen successful research areas. With the encouragement of intraorganizational collaboration and additional funding, departments and university centers developed a new role.

The department (or the institute) is the place where many of the new demands on science and resulting conflicts are mitigated (Morris 2002); at the department, the strategic and the operational level of the research system are closely interwoven. In the traditional dual structure of the university, the department used to be part of the self- or faculty governance system, even if departments had had also administrative functions. Very heterogeneous decisions about research and administration mingle on the department level. It is a recent tendency that departments develop research plans and mutual strategies or provide funding for preferred research lines in order to build and strengthen a unique profile (Morris 2000: 823). The dedication to certain focus topics provides higher chances for collaboration among department members, advantages of an economy of scale—especially if expensive equipment is needed—and a higher visibility within a field. Such strategies play out particularly when new scientific appointments are made. Besides scientific excellence, staffing decisions are guided by the field of expertise that is required to fulfill the strategic choices within the department. Hiring decisions are especially influential at the university where the autonomy of a professor is still very high (Bryman 2007).

The tendency to encourage scientific collaboration within organizations rather than across the scientific community emerged first in large-scale research. It became prevalent at the university when university researchers accommodated to the new chances resulting from big government programs and inter-organizational collaboration. The emergence of specialized centers, the founding of Clusters of Excellence, and strategic decisions about the promotion of certain research fields are evidence for this development. As a result, the competition between research organizations increasingly shapes the contexts of research. In addition to the personal tacit knowledge and the knowledge shared in a scientific community, there is knowledge (and resources) that is available only to members of an organization but not for outsiders. Early results are often discussed among colleagues of a research cluster rather than within the wider scientific community.

Since collaboration is usually based on the exchange of assets, highly visible centers that have certain technologies, specific know-how, or skills have better chances for collaborating with other highly resourceful institutions. Research management is not very important where people agree and share but where people compete and corporate for competitive advantages it is quite important (Corley et al. 2007).

6 Professionalization of research management

6.1 Management typologies

The last section treated management as a necessity for modern research and sketched the problems that need professional attention. In this section, I discuss the distribution of management functions to different roles—e.g. administration, academics, and new management roles—within the university.

Much of the literature on research management states a growing need for management as result of the social and economic pressures that have to be mitigated and negotiated within research organizations (Ziman 1994, Morris 2001: 819). The effects are a redistribution of management functions that come with power shifts within universities (Taylor 2006). Some authors observed a reduced role of central university administrations (Alpert 1985) and a higher influence of entrepreneurial scientists at the department level. However, the gain of autonomy, influence, and power through university scientists or departments is not evenly distributed. It varies between disciplines, departments, and it depends on the external resources scientists can mobilize. With the redistribution of power and influence to the department level due to new sources of funding, new management roles are emerging (Hockey and Allen-Collinson 2009). Since distributed management can only be understood as a whole, these managers' roles need to be studied in terms of their relationship with leading scientists, the university administration, competing institutes, and the wider society. Also the emergence of cross-departmental structures—e.g. interdisciplinary research centers or projects—required new administrative positions while the participating scientists stayed attached to their departments and had to comply with their obligations (Morris 2002). The often temporary and sometimes limited funding of centers means that new faculty members are rarely hired. A differentiation between the strategic decision-making of leading scientists and the facilitation of the day-to-day business by non-faculty research managers became a feasible but not always simple solution.

The observation of this process of professional differentiation led to attempts to describe the new division of labor as different levels of research management. Some authors distinguished three tiers of management within national research systems, the policy level of government agencies, the intermediary or strategic level in research organizations, and the operational level, where research work is done by scientists (Rip and Van Der Meulen 1996; Morris 2002; Ernø-Kjølhede 2001: 59). Based on the assumption that group leaders still have much of the autonomy for setting research goals, Ernø-Kjølhede (2001: 101) suggested an additional typology of research management. Management and self-governance at the group level is classified as *first order management* since it is immediately related to the research process and—according to Ernø-Kjølhede—mostly governed by the values and norms of science. *Second order* management has a supportive function for the self-governance and autonomous decision-making at the group level. It refers to different forms of university management and administration. *Third order management* refers to the science policy environment and to the societal support of research organizations. Whitchurch (2006) suggests a Four-Domain model of research management according to the concept of structure and agency (Archer 2000; Giddens 1992). What she calls the "Inside Outside University" is characterized by new fields of agency crossing functional boundaries in the knowledge domain, in the institutional (or organizational) domain, in the sector domain, and the domain of scientific and administrative projects at the university.

The rest of the review will focus less on the governmental level and the organizational resistance or opportunistic adaption to imposed research policies (Hellström and Jacob 2005). It will focus instead on the interface between the strategic and the operational level, where management deci-

sions are influenced by scientific problems *and* by the institutional and societal environment at the same time (*second order management* according to Ernø-Kjølhede; project domain according to Whitchurch). It remains an open question to what extend both references of decision-making are intertwined. The interconnections vary certainly between different organizational contexts. The high variety reveals a process in progress; nevertheless some tendencies toward isomorphism in new organizational structures within the university can be identified. An important reason is that the professionalization of research management is accompanied by more interaction between research managers and science administrators and the emergence of professional organization, e.g. RAGnet (Research Administrators' Group Network) and ARMA (Association of Research Managers and Administrators) in Britain (Hockey and Allen-Collinson 2009: 143). As mentioned above, I prefer the term research managers for this professional group to differentiate them from administrators who follow mainly prescribed rules (see also Whitchurch 2004).

6.2 New research managers

Despite its growing significance at the university, the profession of non-faculty research managers has been under-researched for a long time (Hockey and Allen-Collinson 2009). Of course, leading scientists still decide about the direction of research and make a large share of the strategic goal setting in research collaborations at the university as well as at university centers. However, new research managers play a crucial role in implementing these strategies, in facilitating research projects, and in decision-making processes. Research managers can be considered specialists who deal with the social, organizational, and political context of research and work on complex projects in a given societal and organizational environment. Even if research management and university administration have rarely been distinguished in literature, research managers constitute a new profession that is characterized by a synthesis of (changing) academic, managerial, and public service values.

One striking difference between traditional university administration and new research management is the research manager's direct involvement in planning and execution of research projects. Research managers are typically trained as PhDs in the fields in which they work. Two main tendencies have shaped the hybrid role of professional research managers at the university (or Multi-Professionals s. Whitchurch 2006). The *first* is the growing interest of university administrations in research planning and specialization. The goal to sharpen the research profile of universities and to focus on promising fields that could generate income, prestige, and competitive advantages requires scientific insights on the level of administration (Collinsen 2006) as well as expertise about science policy and the research sector as a whole.

The *second* tendency results from external funding sources, collaborations, and resources that need to be managed on the group, department, or center level. Many research managers developed indispensible expertise about the vast number of potential funding sources and the manifold requirements of many of them. These requirements include the need for partners, an interdisciplinary research design, the inclusion of stakeholders, and the integration of international partners. In addition, many programs require the promotion of more general social goals, e.g. family friendly work places and gender equality. By working at the boundaries of research organizations and projects, research managers disburden the work load of scientists connected to self-governance.

The two tendencies described above seem to be somewhat in conflict with each other. Higher demands of control by the university are confronted with centrifugal forces at the research level

that is an effect of external funding sources and interorganizational collaboration. The role of new research managers is to mediate between these two levels. In many universities, new research management positions are created both at the level of the departments, centers, or research clusters and at the level of the central administration. The place of research managers within the power structure of a university can be quite different. Are they agents of the administration evaluating scientist's performance or advocates of the scientists that do everything so that certain research goals can be met? As specialists of mediating the conflicts in complex organizational structures, research managers have gained a higher degree of professional autonomy from both the administration and from scientists (compared to a secretary). Nevertheless, the job description of newly hired research managers is rarely very specific. The professional autonomy of research managers depends still on their ability to create their own profile of tasks by rendering specific services.

Much of the literature on research managers deals with the problems of professional identity (Collinsen 2006). The existence of papers reflecting the work of research managers is evidence for the professionalization of this occupation. Some of these practitioner authors contest the strict difference between academic and administrative work at the university and try to interpret both as 'university work' seen as an emerging but integral profession (McInnis 1998; Conway 2000). This version roots in the British and Australian reforms of higher education that reduced faculty's independence and imposed new managerialist routines mostly top-down and conditional funding. Nevertheless, it seems not a very promising strategy for research managers to be part of the same scientific or university profession. Scientists are very protective of their specific status and many conflicts in research organizations are indeed status conflicts. Even if such a strategy were successful, research managers would always be mediocre since publications is the currency of the scientific profession. Professional identity could be gained more likely in distinction to the scientist's role and in an established professional exchange with scientists (Collinson 2007). Such a exchange would replace a relationship between university administrations and scientists that is often characterized by the formal demands of the administration on the one hand and by scientists ignoring non-binding initiatives of the university administration on the other (unless money is involved). To work together with good research managers could prove a competitive advantage for scientists.

7 Conclusion and need for future research

The role of new research managers emerged because the cognitive structure of science and the social structure of research are by no means identical (as it was assumed in the sociology of science for a long time). The couplings between science and other parts of society has to be constantly created, maintained, and recreated—typically through decision-making processes within complex organizations and increasingly in interorganizational networks. The recent transition in the institutionalization of science within society can be described by changing priorities within decision-making processes at several levels: science policy, the university as an organization, and the research group.

Starting from a functionalist perspective, this review departed somewhat from most of the literature on research and university administration that is usually written from a practitioners view. Nevertheless, these works are very useful as data for future research on the role of new management positions within a framework informed by both organizational theory and science studies. The discussion of research manager's role in mediating the complex relationship of science and society and within research organizations is still at the beginning. Many conflicts have to be ne-

gotiated, e.g. between the ideal of flat hierarchies and the complex power distribution within universities, between the innovative capacity and institutional inertia, and between professional autonomy and the resource dependency of modern research. These conflicts can be seen as the 'essential tension' (Kuhn 1977; Hackett 2005) that drives modern scientific research. These tensions that sometimes produce open conflicts generate problems that have to be solved and managed within specific contexts. For these reasons, the tasks of research management are way to manifold to introduce them all within one single review. For the time being, I tried to sketch a conceptual approach that might be a fruitful starting point for further work.

I introduced research management as a decision-making process that brings together resources, scientists, personnel, knowledge, and collaborators to realize research projects. These decisions are made with reference to scientific knowledge *and* the wider society. The overall function of research management cannot be attributed to a single role. Research is managed by scientists, research managers, university administrations, and on the level of science policy. The leading hypothesis of this review has been that some of these functions are distributed to new professional roles that mediate between the increased control and evaluation demands of research at the university level at one hand and the centrifugal tendencies on the level of chairs and departments on the other. A working hypothesis for a future study could be that the university administrations are able to tighten control and formal evaluation because the most influential scientists gained more independence from the university due to external resources and networks. Part of this independence is the development of management and administrative capacities at the chair, center, or department creating so called quasi-firms that can be considered as almost fully functional units managing the relationship of a research context with the industry, research politicians, and other stakeholders.

To prove the conceptual ideas developed in this paper, more empirical research must be done. One important task is to describe in more detail the shift in power distribution at the university. Despite the general tendencies caused by the growth of science and the quest for external funding, there are still huge differences between the university systems in different countries. The distribution of power among administrators, professors, and new research managers varies widely (Ben-David 1984). The position of the university within society as a whole as well as the inner constitution of universities are anchored in the legal system of nation states and determined by forces within complex institutional fields. Even if the forces that determine the transition of the university systems are quite similar, the organizational adaption is different in various countries.

Most of the literature does not take this variety into account and is characterized instead by the idea of a global change toward knowledge society in which the traditional structures of university matter less. However, there is evidence that the development in Britain, Australia (and other Commonwealth countries), and in the US is fundamentally different. The top-down managerialism of the British system is almost unknown in the US, where the faculty autonomy is still a highly prioritized value at the university. Of course, in both systems more managerial work has to be done for successful research. The places and positions where these management capacities are created and where influence is lost distinguish both systems. The institutional change in the US is much more driven by a bottom-up process. Autonomy is a function of the availability of resources. Faculty autonomy rarely conflicts with the commercialization of research or social engagement. Many scientists consider their laboratory (or even the department) as quasi-firms that are managed with an entrepreneurial attitude. If enough income can be generated, scientists are able to build up administrative and managerial capacities at the research center or department level. Some authors state a declining influence on the level of central administration and more powerful schools and departments (Alpert 1985). In contrast to the individual entrepreneurs typi-

cal for US universities, British universities are managed more like corporations with elaborate systems of accounting and control within a centralized administration. MBAs and business managers replace scientists in many positions of British university administrations.

Even though rarely exemplified, the literature reflects this differences in the understanding of research management in the US and Britain. Most of the literature about university management is British while much of the literature about research management at the research group or at the department is of US origin. But how is the situation in Germany? The German research system seems to be in a transition period with several role models. Interviews conducted in an explorative study show that the ideal of the scientists is the American model while university administrators and the policy of higher education tend to a British approach. The latter influences most European countries and the European research policy. Nevertheless, the signs within the research policy seem to be mixed. This provides us with relevant and provocative research questions related to how these tensions will reshape research management at the university in the future.

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